Econometric modeling of the calculation of gross domestic product with the expense method

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Abstract. The results of the correlation between the factors affecting the gross domestic product were calculated on the basis of the methodology of the national accounting system, a regression equation was identified, and short-term alternative forecasting issues were clarified using a statistical index of GDP growth in 1997-2019 of the Republic of Uzbekistan in this article.

1 Introduction

It plays an important role in ensuring the stability of the country's economy, statistical assessment of development factors and trends at different levels, development of a statistical index system, development of statistical models of economic development strategies and improving the scientific and methodological basis of statistical forecasting. To conform to the activities of the State Statistics System directly related to the third and fourth of these areas in line with modern requirements and international standards, the President of the Republic of Uzbekistan adopted Resolution PQ-№3165 of July 31, 2017, "On measures to improve the State Statistics Committee". The resolution sets tasks to radically improve the system of state statistics, to introduce modern methods of statistical analysis, indexes, evaluation criteria and reporting forms, tested in practice, widely used in international statistics, in accordance with international requirements and standards.

Furthermore, in his Address to the Oliy Majlis on the most important priorities for 2019, the President said that "To objectively assess the gross domestic product, we must fully implement the system of national accounts of the United Nations and the International Monetary Fund in the country from January 1, 2020" [1]. Effective implementation of these tasks requires the full development of the National Accounting System (NAS) in accordance with the standards adopted in international practice in Uzbekistan and the use of new methods of statistical data analysis for our national statistics in the introduction of SMEs in statistical practice.

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2 Research literature

Theoretical-methodological issues on the methods of statistical accounting of macroeconomic indexes of the NAS have been deeply studied in the scientific works of foreign scientists R. Stoun, J. Keyns, V. Leontev, J. Marshall, and others [2-5].

The issues of indicating theoretical principles of NAS and international compari-sons of macroeconomic indexes were widely studied in scientific works of B.I. Bashkatov, V.I. Jerebin, V.K. Zaytsev and others, scientists of countries of the Com-monwealth of Independent States (CIS) [6-8].

Issues regarding the introduction of the national accounting system in Uzbekistan and the counting, analysis and forecasting of its macroeconomic indexes have been studied by scientific works scientists such as S.S. Gulomov, B.K. Goyibnazarov, B.J. Mirzanov [9-12].

However, in the scientific studies of the scientists mentioned above, the issues on the improvement of macroeconomic indexes of statistical accounts have not been widely studied in the new standard of the national accounting system in 2008. In this regard, based on the standard "NAS-2008", the statistical calculation of macroeconomy indexes of the country, the analysis of the factors influencing it, and the statistical forecasting of future development trends are important.

3 Research methodology

In the process of the research, the methods of empirical research, logistic function and correlative-regressive analysis were used.

4 Results and analysis

To quantify the impact of factors of production on the results of economic activity, the study of interrelated economic indexes of the NAS is of paramount importance. In this case, the indexes of gross production, gross domestic product and national income are selected as the result. It should be noted that the concept of "fac-tor and result" is comparatively accounted for; that is, based on the analysis of issues, these indexes are expressed as a factor and an outcome indicator.

The use of correlation-regression analysis to statistically study the interrelationships between the generalized indexes of the NAS is also important. In this case, the correlation determines the degree of correlation between the interrelated factors and the resulting factor, whereas regression factors determine how factors are functionally related to the outcome factor and how these factors are effective. In the research, as a resulting factor GDP and influencing factors, expenditure for final consumption-X_1, investment for the main capital-X_2, changes in reserves-X_3 and export-import balances of goods and services-X_4 were selected. The correlation between the resulting factor and the influencing factors was examined. The result is reflected in Table 1 below.

Table 3.2 shows that there is a strong connection between the gross domestic product (GDP) and all factors other than the export-import balance of goods and services (0,316028), including final consumption (0,998817), investment in the main capital (0,99954) and changes in reserves (0,86997). It should be noted that multicollinearity did not exist when |r_(〖x_(1) x〗_2) |<0,8 terms of selected factors were performed.

Table 1. The results of correlation [18].

Indexes	Gross domestic product	Final consumption	Investment on the main capital	Changes in reserves	Export-import balance of goods and services
Gross domestic product	1				
Final consumption	0,998	1			
Investment on the main capital	0,999	0,998	1		
Changes in reserves	0,869	0,872	0,865	1	
Export-import balance of goods and services	0,316	0,282	0,308	0,221	1

This shows that it is possible to ensure the participation of all factors except the export-import balance of services in the construction of the regression equation, which represents the observed process.

To construct a regression equation, it is appropriate to use the program Eviews, which is currently the most convenient. Accordingly, the following regression equation was determined using the statistical indexes of the dynamics of change of the indexes in 1997-2019 selected from the above:

$$Y_{GDP} = 664{,}02 + 0{,}319 * X_1 + 2{,}86 * X_2 + 0{,}722X_3 \quad (1)$$

where: Y_{GDP}- the amount of gross domestic production;
X_1 – expenditures of final consumption;
X_2 – investment in the main capital;
X_3 – changes in reserves;

In this case, of course, it is necessary to check the reliability and adequacy of the identified regression equations in terms of criteria (Table 2). According to the criteria «Akaike», «Schwarz» and «Hannan-Quinn» identified in the evaluation of model (1), the model can be said to be reliable, but it is advisable to eliminate the misunderstanding of the criteria of t-statics given in Table 2. The significance of the parameter of the equation determined by the fact that the value of the degree of significance $\alpha = 0{,}05$ and the degree of freedom $df = 21$ in the table on the t-criterion of the student presentation is equal to $t_{table} = 2{,}0796$, $t_{X_1} = 1{,}042$, $t_{X_1} < t_{tab}$, should be checked against the criteria for determining the quality of the forecast model.

Table 2. (1)-reliability and adequacy check of the regression equation.

R-square	0,999641	Dependent variable average	63213,14	t-statistics	
Flattened R-square	0,999552	Standard deviation of dependent variable	74641,9	X_1	1,042
Standard regression error	2057,69	Information criterion of Akaike	17,77353	X_2	1,975
Sum of the squares of remnants	71979240	Criterion of Schwarz	18,02223	X_3	6,717

Continuation of Table 2.

Proximity to logarithmic reality	-181,6221	**Criterion of Hannan-Quinn**	17,82750	X_4	-
F-statistics	8772,368	**Statistics of Darbin-Wotson**	1,18	C	1,042

Since the change in GDP determines $\text{TIC} = 0{,}0072$ and the quality of the forecast model is $\text{MAPE} < 10\%$ and $0 \leq \text{TIC} \leq 1, \text{MAPE} = 6{,}468 < 10\%$, as well as in the process under consideration, the forecast quality is very high, and the equation (1) -regression is reliable and adequate.

According to the defined model values, the change in cost and reserves per unit of final consumption leads to a decrease in GDP by 0,32 units and an increase of 0,72 units. As a result of this process, it was found that the factor that has the potential to increase GDP relative to all factors is investment in capital, and if this factor is increased by one unit, GDP can be increased by an additional 2.9 units.

According to the analysis, among the indexes of the selected factor, there is multicollinearity in all except the export-import balance of goods and services. The correlation between final consumption and investment in fixed assets is 0,998, and the correlation between investment in fixed assets and changes in reserves is 0,865. The development of industries is expressed by the following exponential equations:

$$\begin{cases} Y^{(p)}_{\text{indust.}} = Y^{(0)}_{\text{indust.}} e^{b_1 t} \\ Y^{(p)}_{\text{agricul.}} = Y^{(0)}_{\text{agricul.}} e^{b_2 t} \\ Y^{(p)}_{\text{serv.}} = Y^{(0)}_{\text{serv.}} e^{b_3 t} \end{cases} \quad (2)$$

where: $Y^{(p)}_{\text{indus.}}$, $Y^{(p)}_{\text{agricul.}}$, $Y^{(p)}_{\text{serv.}}$ - gross added cost of industry, agriculture, forestry and fisheries and services for the forecast period;

$Y^{(0)}_{\text{indust.}}$, $Y^{(0)}_{\text{agricul.}}$, $Y^{(0)}_{\text{serv.}}$– gross added cost of industry, agriculture, forestry and fisheries and services in the initial period in 2019 prices; b1, b2, b3- parameters of functions; t - time.

Additionally, the share of industries in GDP was approximated by the following logistics function [13]:

$$Y_{st} = Y^{(0)}_{st} \cdot \frac{1+a}{1+\exp[-b(t-t_0)]} \quad (3)$$

Yst– initial cost (t = t0), a– constant amount, was determined according to the given initial term; b - diffusion coefficient was determined using “technology addition” in traditional industries.

In the research, the Eviews program was used to construct a regression equation. Accordingly, the following regression equations were constructed using the statistical indexes of the dynamics of change of the indexes selected above in 1991-2019. The reliability and adequacy of the identified regression equations were tested on the basis of the criteria (Table 3).

Table 1. Construction of regression equations and evaluation of their significance.

№	Type of model	Algebraic form of the model	R^2	F	Pa	Pb
1	linear	Ys=272323+6372,4*t	0,8502	103	0,001	0,000

Continuation of Table 3.

№	Type of model	Algebraic form of the model	R^2	F	Pa	Pb
2	exponential	$Ys=1453232*S^{1,7273}$	0,918	202,7	0,000	0,000
3	linear	Yp=22024,18+4851,7*t	0,767	60,5	0,006	0,0005
4	exponential	$Yp=289968*P^{1,8638}$	0,925	225,2	0,000	0,000
5	linear	Yq=20267,07+4140,36*t	0,536	21,8	0,006	0,0002
6	exponential	$Yq=1146566*Q^{1,5002}$	0,849	102	0,000	0,000

If we observe the change in GDP in relation to households– X_1, government administration bodies-X_2, noncommerce organizations that serve households -X_3, gross reserves-X_4, we will certainly have a change on some sides. This, of course, reflects the impact of selected factors on GDP [14].

Table 2. Correlation of GDP with factors.

	Y_{GDP}	X_1	X_2	X_3	X_4
Y_{GDP}	1				
X_1	0,999	1			
X_2	0,998	0,99987976	1		
X_3	0,996	0,99618068	0,9966743	1	
X_4	0,999	0,99828169	0,998533443	0,997484294	1

From the data in Table 3, it can be seen that the factors influencing GDP were selected correctly. According to it:

$$Y_{GDP\,1} = 712.107 + 2{,}772 * X_1 - 7{,}211 * X_2 - 9{,}325 * X_3 + 3{,}003 * X_4 \quad (4)$$

The normalized regression equation emerged.
where: X_1 – households;
X_2–government administration bodies;
X_3– noncommerce (social) organizations that serve households;
X_4–gross reserves.

Surely, it is necessary to check the reliability and adequacy of the identified (2) model based on the criteria, and this is done through the EVIEWS 9 program. The results are shown in Table 5 below.

Table 3. The result of checking the adequacy of model (2) according to the criteria.

Variable	Coefficient	Standard error	t-statistics	Probability
X1	2,772	0,743	3,732	0,002
X2	-7,211	2,522	-2,860	0,011
X3	-9,325	8,908	-1,047	0,311
X4	3,003	0,448	6,705	0,000
C	712,107	611,419	1,165	0,261
R-square	0,998897	Dependent variable average		63213.14
Flattened R-square	0,998621	Standard deviation of dependent variable		74645,41854

Continuation of Table 5.

Variable	Coefficient	Standard error	t-statistics	Probability
Standard regression error	1964,49601	Information criterion of Akaike		18.89755
Sum of the squares of remnants	61747912,924	Criterion of Schwarz		19.14624
Proximity to logarithmic reality	7218,950	Criterion of Hannan-Quinn		18.95152
F-statistics	0.000000	Statistics of Darbin-Wotson		2,316

The results of Table 5 show that the parameter X_1 was found to be insignificant according to the $t_{X_1} < t_{tab.}$ term. However, it is advisable to check whether this parameter is significant or insignificant with another criterion indicator MAPE $< 10\%$ and $0 \leq \text{TIC} \leq 1$, which defines the quality of the forecast model and the criteria.

According to the results of testing the (2) model with MAPE $= 0{,}53335 < 10\%$ and $0 \leq 0.0126 \leq 1$ criteria, which define predictive quality, all the parameters selected for the identified model are important, and the (2) model can be called reliable and adequate.

The model explains that if gross savings are increased by one percent, GDP will increase by 3.0 percent. If expenditures on households, government administration bodies, and noncommerce (social) organizations serve to households increase by one percent, the amount of GDP will decrease by 2,8 percent, 7,2 percent, 9,3 percent.

Multifactor forecast of gross domestic product in model (1):$Y_{GDP} = 664{,}02 + 0{,}319 * X_1 + 2{,}86 * X_2 + 0{,}722X_3$

When the expenditure for final consumption is $R^2 = 0{,}95$; $X_1 = 19602.89 - 7927.45 * t + 708.45 * t2$

When investment in the main capital is $R^2 = 0{,}99$ $X_2$298,21 * exp (0.27 * t)

When changes in savings are $R^2 = 0{,}7064$ $X_3 = -899{,}98 + 208{,}566 *$ t;

The multifactor forecast of GDP by the regression equations stated above is given in Tables 6–7.

Table 4. GDP of the Republic of Uzbekistan and its forecast of sectoral structure for 2019-2025 (billion sums).

Year	Industry (together with the field of construction)	Agriculture, forestry and fishing industry	Services	Real export	GDP
2020	166650	165296	182594	64781	579321
2021	178020	172905	192148	68445	611518
2022	190165	180863	202201	72319	645548
2023	203140	189188	212781	76335	681444
2024	216999	197896	223914	80573	719382
2025	231804	207005	235630	85047	759486
2026	247620	216533	247959	89770	801882

Multifactor forecast of gross domestic product according to model (2):

$$Y_{GDP\,1} = 712.107 + 2{,}772 * X_1 - 7{,}211 * X_2 - 9{,}325 * X_3 + 3{,}003 * X_4 \quad (5)$$

when households are $R^2 = 0{,}787$ $X_1 = 14776.26 - 5959.895 * t + 530.34 * t2$

Table 5. The multifactor forecast of GDP of the Republic of Uzbekistan for 2020-2025 (billion sums).

Year	Scenario of the forecast			
	When there is optimistic convenient condition	**When there is pessimistic inconvenient condition**	**When there is normal condition**	**Proportional increase coefficient of GDP**
2020	579322,49	602972	591147	0,8674
2021	611519,19	610204	610862	0,9014
2022	645550,84	627558	636554	0,9145
2023	681445,38	644238	662842	0,9233
2024	719384,83	661142	690263	0,9311
2025	759488,56	678280	718884	0,9388
2026	801883,09	695667	748775	0,9401

When government administration bodies are $R^2 = 0{,}792$ $X_2 = -9642{,}916 + 1843{,}242 * t$;

When noncommerce organizations that serve households are $R^2 = 0{,}826$ $X_3 = -548{,}227 + 166{,}883 * \mathrm{t}$;

When gross savings are: $R^2 = 0{,}99$ $X_4 = -157.48 + 473.27 * t - 91.31 * t2 + 10.7577 * t3$

Based on the analytical capabilities of the NAS, it is important to ensure that the national accounting system should consider the methodological principles of accounting for all stages of macroeconomic indexes (beginning with obtaining primary data and ending with the construction of balance tables). It is also necessary to formulate macroeconomic equations in the concept of NAS, the relationship between monetary sectors, the balance of payments and production with the state budget, the distribution of income, redistribution and balance of use.

5 Conclusions

In this article, based on the study of theoretical and methodological aspects of the statistical analysis of macroeconomic indexes and the international comparison and forecasting of the main indexes of the national accounting system of the Republic of Uzbekistan, the following conclusions have been made, problems have been defined, and scientific recommendations and suggestions have been made.

1. The research examines the role of national statistics in the economy, the application of the law on statistics in the field, the reforms carried out in recent years to improve the system, the implementation of state programs on the transition to international statistics, and the assessment of macroeconomic indexes in the national system.
2. The construction of national accounts primarily depends on the quality of the data used to compose them. Often, errors in national accounts are the result of incomplete data or little data. Thus, to ensure the completeness of statistical information, the basic tasks of statistical services should be direct to create a system of a new type of index using new tips and concepts to adapt the data collection and processing tips in accordance with international standards.
3. Gross domestic product is one of the main indexes of NAS, which represents the final result of production activities of resident economic units and is measured by the value of goods and services produced by these units for final use. GDP is widely used in international practice, and it serves as an indicator of the final results of economic production activities in international and national practice. The main content of this indicator is directly determined by the cost of all final goods and services produced and used (consumed) in the

territory of the country at market prices. It should be noted that just final (intended for direct consumption) products and services are taken into account, not the nationality or citizenship of the people who produce these products.

4. According to our analysis, from 1996 to 2019, the share of services in GDP increased from 43,4% to 47,3%. This growth is characterized by the expansion of fi-nancial transactions, trade intensification, expansion of transport and communication services and an increase in various other services. The share of production in GDP was 56,6% in 1996 and 52,7% in 2019. This decline was due to the expansion of the field of services. The share of industrial production in 2019 was 26.7%, an increase of 5.9% compared to the level of 20.8% in 1996. If the share of the agricultural sector in GDP was 26.2% in 1996, in 2019, it was 19.2%. These statistics, particularly the growing share of the field of services, also show the importance of the use of NAS principles in GDP analysis.

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