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FORMATION MULTIFACTOR ECONOMETRIC MODEL OF SUSTAINABLE DEVELOPMENT OF ECONOMIC SYSTEM OF THE REGION

[1]Ilyos Sultonovich Abdullaev, [2]Tukhtabek Jumaboyevich Rakhimov

[1]Doctor of Economic Sciences, Associate Professor, Dean of the Faculty of Tourism and Economics, Urgench State University, Urgench, Uzbekistan.

[2]PhD student in speciality of Econometrics and statistics, Urgench State University, Urgench, Uzbekistan.

Abstract: Methods for choosing the best multiple regression models in the sustainable development of the region's economic system are considered and the forecast of the processes of economic dynamics of the built models will be analyzed. Econometric modelling of sustainable development of economic systems of the region uses multivariate regression analysis and the method of least squares. These methods will help to identify the factors influencing the sustainable development of the economic system and assess their impact. In addition, when analyzing the sustainable development of the economic systems of the region, the degree of interconnections of influencing factors was calculated using the method of statistical grouping. These methods determine the prospects for the sustainable development of economic systems. Several econometric models have been developed for forecasting GRP using data that fully reflect the dynamics of sustainable development of economic system of the region. The relationship between investment, capital and labour force, affecting the sustainable development of economic system of the region, has been studied. The results of the work can be applied by scientists and practitioners interested in issues for predicting the sustainable development of economic systems in the region using econometric models. The forecasts obtained using these models are quite reliable from the point of view of statistical estimates. Based on this, the Cobb-Douglas three-factor production function describes well the sustainable development of economic system of the region. First of all, for the sustainable development of the economic systems of the region, it is necessary, taking into account the specific features of the region, to develop a map of the GRP spheres, on which slowly developing, rapidly developing and spheres in need of development emerge.

Key words: multi-factor model, sustainable development, economic system, GRP, production function, least squares method, arithmetic mean, forecasting, investment, capital, labour force.

INTRODUCTION

Taking into account the sustainable development of economic system of the region, regulation of economic processes in the region and the complex structure of the economic system of the region, it is necessary to use multifactor econometric models in the sustainable development of the system. Therefore, in the conditions of sustainable development of the economic system of the region, first of all, it is necessary to analyze the dynamics of GRP. It is known that one of the most important results of economic reforms is a sharp increase in the share of the private sector in the GRP. The processes of localization of industrial production, industrialization of agricultural products are happening at a fast pace. According to the analysis, the map shows which sectors of the GRP are developing slowly, which are developing rapidly or needs development? However, particular attention should also be paid to the concept of sustainability.

MATERIAL AND METHODS

A. Anderson, J. Mantsinen showed several innovative models of regional growth in their investigations. They consider 2 groups as factors of innovative development of the region:

1. Factors of production
- amount of capital
- size of savings
- accumulated scientific potential

2. Environmental factors
- distance between territorial units
- access of regional units to scientific sources.

According to the main conclusions of A. Anderson and J. Mantsinen, that the growth trend of savings will increase the amount of capital and scientific potential. The model they proposed is generally based on the introduction of a new type of modern organization of the regional economy into the regional industrial complex and emphasizes the role of science, maintaining a high level of competitiveness of the regional unit [1]. Sustainable development of economic system of the region depends on the development of small and medium-sized businesses in the region. In the paper J. Harris showed that these two trends are interconnected and business is expanding production capabilities [2].

In the last decade, econometric models have been applied in national economic processes, which means that models obtained for a specific region can be a way to solve global problems of sustainable development [3]. Using mathematical methods to analyze the problems of sustainable development and elaboration optimal solutions allows us to identify common factors that affect the level of socio-economic development [4]. Full data will be required when implementing econometric models. Because full data gives the researcher information about the object. But in order to understand the available data, correctly interpret its meaning, it is necessary to evaluate the data, and only then it will be possible to comment on it [5].

The economic system is a complex of the productive forces of society and the establishment of production relations between them. The mechanism of action of such a system is based on the resources available in it and, therefore, in a certain form of consumption, exchange or distribution when carrying out its activities.

Social, economic and environmental elements, which are a structural component of the sustainable development of the regional economic system, can never be developed in practice alone, if these elements are not in harmony with each other, will lead to the spread of social, economic or environmental problems. In this regard, they will always be inextricably linked with other elements of society and control centres. In general, a system can never develop on its own. During the development of the system, rules and regulations are formed that all market participants must follow.

In the economic system, the compositions of the sources of resources change over time. It depends on the development of the economic system. The more complex the economic system, the more resources it requires. Hidden resources are of particular importance. In this regard, with the sustainable development of the region's economic system, it is easier to determine the most alternative development paths in multifactor relations than in unvaried relations based on econometric models. It is clear that one-factor models can more accurately represent socio-economic phenomena than trend models in terms of the content of relations. But when creating one-factor models, it still needs to be simplified to show its authenticity, that is, to choose one factor.

Hence, multifactor econometric models have higher accuracy than single-factor models, that is, they reveal specific features and are modelled in more detail on economic reality.

RESULTS AND DISCUSSION

Based on the above considerations, we consider the sustainable development of the economic system in econometric analysis by analyzing the gross regional product of the Khorezm region. We calculate this model in two different ways and compare them with each other. Here Y - gross regional product, I - investment in fixed assets, K -the value of main fixed assets, L-employed in the economy.

Table-1

Factors affecting the economic system of the Khorezm region and the three-factor model of GRP in the form of Cobb Douglas

t	Y	K	I	L	2005 price deflator
2005	595.2	893.8	7.3	559.3	100.0
2006	803.0	1 062.3	18.4	561.0	107.3
2007	1 040.1	1 230.5	44.7	565.6	127.1
2008	1 255.3	1 502.0	114.3	569.1	164.8
2009	1 534.0	1 863.8	149.6	571.2	197.1
2010	2 058.0	2 170.7	190.3	576.7	240.7
2011	2 624.6	2 939.6	442.9	595.2	410.1
2012	3 326.8	3 767.2	657.4	611.4	548.3
2013	4 129.6	4 321.7	983.3	635.4	686.6
2014	5 061.0	5 184.1	1220.6	650.6	848.5
2015	6 167.7	6 034.0	1352.3	678.0	1062.7

2016	6 778.8	7 441.5	1868.8	703.3	1357.0
2017	11457.2	9 462.6	2350.7	719.3	1568.9
2018	15154.2	11045.7	2980.0	738.5	1868.8

Y at prices 2005	y'	Ai	(y-y')^2	(y-y(mean))^2
595.20	535.22	10.08	3597.982	11245766.8
638.80	660.91	3.46	488.9039	10955245.1
756.38	795.39	5.16	1521.565	10190695.0
980.76	1014.84	3.48	1161.453	8808472.3
1173.43	1304.23	11.15	17107.65	7701962.9
1432.87	1566.69	9.34	17908.51	6329277.0
2441.15	2289.65	6.21	22952.82	2272627.1
3263.24	3112.54	4.62	22710.94	469813.1
4086.63	3766.79	7.83	102296.4	19031.9
5050.17	4727.72	6.39	103968.3	1213290.9
6325.11	5803.85	8.24	271709.8	5647448.9
8076.59	7603.79	5.85	223542.9	17039703
9338.12	10187.42	9.09	721306.9	29046172.9
11122.95	12427.43	11.72	1701659	51470290.5
		7.33	3211934	162409797.3

For convenience, we denote the I, K, L shown in Table 1 as x_1, x_2, x_3 respectively. As the first multifactor model, we determine the coefficients of the level model.

$$Y = A * I^{\alpha} * K^{\beta} * L^{\lambda} \quad (1)$$

To determine the coefficients of this model, we naturally logarithm both sides of the equation to determine the equation reduced to the following linear form:

$$\ln(Y) = \ln(A) + \alpha \ln(I) + \beta \ln(K) + \lambda \ln(L)$$

In Table 1, y, x_1, x_2, x_3. the values of the series are the natural logarithmic values of the actual values, and we denote ln (A) by the letter a. Using the least squares method, we construct the following normal equation for determining the coefficients of a multifactor econometric model:

$$\begin{cases} na+\alpha\sum_t x_1+\beta\sum_t x_2+\lambda\sum_t x_3=\sum_t y \\ a\sum_t x_1+\alpha\sum_t x_1^2+\beta\sum_t x_1x_2+\lambda\sum_t x_1x_3=\sum_t yx_1 \\ a\sum_t x_2+\alpha\sum_t x_1x_2+\beta\sum_t x_2^2+\lambda\sum_t x_2x_3=\sum_t yx_2 \\ a\sum_t x_3+\alpha\sum_t x_1x_3+\beta\sum_t x_2x_3+\lambda\sum_t x_3^2=\sum_t yx_3 \end{cases} \quad (2)$$

By solving this system of normal equations using the Kramer method, the model parameters are determined:

$$\alpha=\frac{\Delta_\alpha}{\Delta},\ \beta=\frac{\Delta_\beta}{\Delta},\ \lambda=\frac{\Delta_\lambda}{\Delta}$$

$$a=\bar{y}-\alpha*\bar{x}_1-\beta*\bar{x}_2-\lambda*\bar{x}_3$$

$$\alpha=\frac{\Delta_\alpha}{\Delta}=\frac{1.05}{0,93}=1.13$$

$$\beta=\frac{\Delta_\beta}{\Delta}=\frac{0.013}{0.93}=0.014$$

$$\lambda=\frac{\Delta_\lambda}{\Delta}=\frac{0.72}{0.93}=0.77$$

$$a=\bar{y}-\alpha*\bar{x}_1-\beta*\bar{x}_2-\lambda*\bar{x}_3=-6.31$$

To determine the true coefficient A shown in the model, we use the inverse of natural logarithm:

$$A=\exp(-6.31)=0.0018$$

Now we write an overview of the multifactor level function:

$$Y=0.0018*I^{0.014}*K^{1.13}*L^{0.77} \quad (3)$$

According to table 1, the approximation error of this model is less than 10 percent, or 7.33 percent. This means that the quality of the model is very high.

$$A_i=\frac{1}{n}\sum\left|\frac{y_i-\tilde{y}_i}{y_i}\right|*100\% \quad (4)$$

Now we determine the coefficient of multifactorial correlation of the model. For this, we rely on the data in table 1, i.e.:

$$R=\sqrt{1-\frac{\sum(y-\hat{y})^2}{\sum(y-\bar{y})^2}}=\sqrt{1-\frac{3211934}{162409797.\ 3}}=0.98$$

The multiple determination coefficient is 0.98, with 98.0 percent of factors included in the model and 1.97 percent of factors not included in the model.

Now we are testing according to the Fisher criterion.

$$F_{real} = \frac{R^2_{yx_1x_2}}{1-R^2_{yx_1x_2}} * \frac{n-m-1}{m} = \frac{0.98}{1-0.98} * \frac{14-3-1}{3} = 165.21$$

$$F_{tab}(\alpha = 0.05, k_1 = 3; k_2 = 14-3-1 = 10) = 3.71$$

Now we will determine the comparable parameters of multifactor models determined by the method of arithmetic progression in order to compare the parameters of the multifactorial power function. To do this, we construct a multifactorial regression equation based on the following formula, using separate factor models for each factor sign.

$$\hat{y} = \frac{1}{3}(a_0 + a_1 I + a_0 + a_2 K + a_0 + a_3 L)$$

Table-2

Factors affecting the economic system of the Khorezm region and three-factor model of arithmetic mean of GRP.

T	K	Y	y’	Ai
2005	893.8	595.2	358.8	39.7
2006	1 062.3	638.8	541.3	15.3
2007	1 230.5	756.4	723.5	4.4
2008	1 502.0	980.8	1017.5	3.7
2009	1 863.8	1173.4	1409.3	20.1
2010	2 170.7	1432.9	1741.8	21.6
2011	2 939.6	2441.1	2574.4	5.5
2012	3 767.2	3263.2	3470.7	6.4
2013	4 321.7	4086.6	4071.2	0.4
2014	5 184.1	5050.2	5005.2	0.9
2015	6 034.0	6325.1	5925.6	6.3
2016	7 441.5	8076.6	7450.0	7.8
2017	9 462.6	9338.1	9638.8	3.2
2018	11045.7	11123.0	11353.3	2.1
Mean				9.8

I	Y	Y’	Ai
7.3	595.2	725.1	21.8
18.4	638.8	766.1	19.9
44.7	756.4	862.7	14.1
114.3	980.8	1118.6	14.1

149.6	1173.4	1248.3	6.4
190.3	1432.9	1398.0	2.4
442.9	2441.1	2326.1	4.7
657.4	3263.2	3114.5	4.6
983.3	4086.6	4312.4	5.5
1 220.6	5050.2	5184.5	2.7
1 352.3	6325.1	5668.6	10.4
1 868.8	8076.6	7567.2	6.3
2 350.7	9338.1	9338.1	0.0
2 980.0	11123.0	11651.1	4.7
			8.4

Continuation of Table-2

T	L	Y	y'	Ai
2005	559.3	595.2	385.1	35.3
2006	561.0	638.8	478.9	25.0
2007	565.6	756.4	732.6	3.1
2008	569.1	980.8	925.7	5.6
2009	571.2	1173.4	1041.5	11.2
2010	576.7	1432.9	1344.9	6.1
2011	595.2	2441.1	2365.4	3.1
2012	611.4	3263.2	3259.0	0.1
2013	635.4	4086.6	4582.9	12.1
2014	650.6	5050.2	5421.4	7.4
2015	678.0	6325.1	6932.8	9.6
2016	703.3	8076.6	8328.4	3.1
2017	719.3	9338.1	9211.0	1.4
2018	738.5	11123.0	10270.1	7.7
Mean				9.4

$y=(1/3)(a_0+a_1K+a_2+a_3I+a_4+a_5L)$	Ai	(y-y')^2	(y-y(mean))^2
489.7	17.7	11135.72	2990579588
595.4	6.8	1882.446	2985812853
772.9	2.2	273.4741	2972976484

1020.6	4.1	1585.7	2948558216
1233.0	5.1	3552.268	2927671566
1494.9	4.3	3848.269	2899663809
2422.0	0.8	367.2844	2792091448
3281.4	0.6	330.4339	2705887953
4322.2	5.8	55483.29	2620903946
5203.7	3.0	23574.74	2523176087
6175.7	2.4	22322.64	2396717831
7781.9	3.6	86859.39	2228293480
9396.0	0.6	3344.409	2110784146
11091.5	0.3	987.4224	1949967937
	4.1		

$$R = \sqrt{1 - \frac{\sum (y-\hat{y})^2}{\sum (y-\bar{y})^2}} = \sqrt{1 - \frac{215547.488\ 2}{3705308534\ 4}} = 0.999$$

According to Table 2 it can be seen that the approximation error is 4.1 percent, and the multidimensional determination coefficient is 0.999, with 99.9 percent of the factors included in the model, and 0.1 percent of the factors not included in the model.

Based on the least squares method for each of the above factors, we determine the predicted values using time series. Based on the regression equations determined on the basis of the analysis, the following table presents the predicted values of factors affecting the GRP in the following periods:

Table-3

Factors affecting the economic system of the Khorezm region and forecast values of the three-factor model of GRP in the form of Cobb-Douglas and arithmetic mean

Year	K	I	L
2020	11221.57	2916.59	762.987
2021	11959.78	3130.51	777.628
2022	12697.99	3344.43	792.269
2023	13436.2	3558.35	806.91
2024	14174.41	3772.27	821.551
2025	14912.62	3986.19	836.192

Forecast values on	Forecast values on

$Y = 0.001 * I^{0.01} * K^{1.13} * L^{0.77}$		$\hat{y} = \frac{1}{3}(a_0 + a_1 I + a_0 + a_2 K + a_0 + a_3 L)$	
At 2005 prices	At current prices	At 2005 prices	At current prices
12970.11741	17361.99	11527.6	15430.99
14159.93971	18698.86	12325.4	16511.16
15387.0459	20185.42	13123.1	17766.01
16651.19922	21881	13920.9	19187.29
17952.18649	23806.53	14718.7	20837.39
19289.81435	25972.92	15516.5	22712.76

CONCLUSION

The results of a comparative analysis show that a multifactor econometric model provides the most optimal solution for forecasting. In this regard, if investments in the economic system increase by 1%, GRP will increase by 0.01%, the value of fixed assets by 1%, by 1.13%, and the labour force by 1%, by 0.77%. Thus, according to multifactor econometric models, increasing the number of goods is more efficient than attracting investments, and the highest efficiency can be achieved by increasing the value of fixed assets.

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