Научный результат. Экономические исследования. Т. 8. № 2. 2022. С. 85-96
Research Result. Economic Research. Vol. 8. № 2. 2022. P. 85-96

85

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ИСПОЛЬЗОВАНИЕ ФУНКЦИИ КОББА-ДУГЛАСА В ИНФОРМАЦИОННОМ ОБЕСПЕЧЕНИИ ГОСУДАРСТВЕННОГО ПЛАНИРОВАНИЯ

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Аннотация.
Целью исследования является проверка гипотезы о целесообразности использования функции Кобба-Дугласа в информационном обеспечении государственного планирования в качестве метода численного анализа в региональном управлении государственного управления. В первой части статьи объясняется обоснование разработки цифровых моделей в государственном управлении, результаты анализа современных публикаций по изучению факторов роста и сдерживания экономического развития и методы, используемые для этих исследований. Вторая часть статьи содержит цель и задачи исследования, основную гипотезу исследования. В третьей части статьи представлены результаты проведенного исследования влияния основных факторов производства, труда и капитала на объем оборота предприятий с использованием производственной функции Кобба-Дугласа на примере пяти отраслей экономики Волгоградской области. В последней части статьи обобщаются результаты исследования. В частности, отмечается, что на рост оборота предприятий региона положительно повлияло как увеличение стоимости основных производственных фондов, так и рост заработной платы. Однако тенденция снижения средней эффективности основных производственных фондов во всех секторах и тот факт, что показатели оборачиваемости выше, чем стоимость основных производственных фондов, могут указывать на неэффективность их использования. В двух секторах региона, добывающей промышленности и строительстве, наблюдается снижение средней эффективности заработной платы, что может свидетельствовать о неэффективном управлении материальными стимулами для работы в секторах. По результатам проведенного исследования сделан вывод о целесообразности использования функции Кобба-Дугласа в качестве численного метода анализа при информировании государственного планирования, в том числе при управлении государственными программами на уровне регионального управления для проверки методов и инструментов экономического регулирования.
Ключевые слова: методы цифрового анализа, факторы экономического роста, цифровизация государственного управления.

Научный результат. Экономические исследования. Т. 8. № 2. 2022. С. 85-96
Research Result. Economic Research. Vol. 8. № 2. 2022. P. 85-96

86

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THE USE OF THE COBB-DOUGLAS FUNCTION IN THE INFORMATION SUPPORT OF STATE PLANNING

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Abstract.
The goal of the study is to test the hypothesis on the practicality of using the Cobb-Douglas function in the information support of state planning as a method of numerical analysis at the regional management of government. The first part of the article explains the rationale for the development of digital models in public administration, the results of the analysis of modern publications on the study of factors of growth and constraint of economic development and the methods used for these studies. The second part of the article contains the goal and tasks of the study, the basic hypothesis of the study. The third part of the article presents the results of the research carried out on the influence of the main factors of production, labour and capital on the volume of turnover of enterprises using the Cobb-Douglas production function on the example of five branches of economy of Volgograd oblast. The last part of the article summarizes the results of the study. In particular, it is noted that the growth of the turnover of enterprises in the region was positively influenced by both the increase in the value of fixed production assets and wage growth. However, the pattern of declining average efficiency of fixed production assets in all sectors and the fact that turnover rates are higher than the value of fixed production assets may indicate inefficiencies in their use. In two sectors of the region, the extractive industry and construction, there is a decrease in the average efficiency of wages, which may indicate ineffective management material incentives to work in the sectors. Based on the results of the research conducted it is concluded that it is appropriate to use the Cobb-Douglas function as a numerical method of analysis in informing state planning, including in the management of state programmes at the regional management level to validate the methods and instruments of economic regulation.
Key words: methods of digital analysis; economic growth factors; digitalization of public administration

Introduction

Achieving the sustainable development of the country is one of the priorities of the Russian Government. However, resolving this issue depends on many parts of the entire process of public administration. One such part or component is information support for state planning.

Currently, information support for the management of social and economic policies at the regional level involves the use of multiple methods of processing economic infor-

Научный результат. Экономические исследования. Т. 8. № 2. 2022. С. 85-96
Research Result. Economic Research. Vol. 8. № 2. 2022. P. 85-96

87

mation, but these are often limited to the simplest operations of economic and statistical analysis. With the digitization of public administration, the use of more complex methods, including modelling, will not affect the length and complexity of the analysis procedures. Therefore, the integration of more complex information processing techniques into public administration is obvious but requires a prior assessment of their feasibility.

One of the problems in shaping economic policy in the region is the lack of objective information on factors of development or constraint of the economy and its economic actors. This problem has been in the focus of attention of scientists from all over the world for many years. Various factors are analysed. For example, the impact of external and internal factors on the efficiency of enterprises in a volatile Russian economy is analysed in publications of E.N. Kadyshev, V.V. Smirnov and V.L. Smirnov [Smirnov, V. V., Semenov, V. L., Kadyshev, E. N., 2014]. The influence of market factors on business safety is described by researchers O.B. Khoroshilova and N.B. Bokovaya [Khoroshilova O. V., Bokovaya N. V., Kavyrshina O. A., 2020]. The results of the analysis of the strategic management impact on performance are presented in the publications of A.A. Lubnina, M.V. Shinkevich and E.N. Yalunina [Lubnina A.A., Shinkevich M. V., Yalunina E. N., 2018]. Evaluation of the communication efficiency impact on the business processes performance is investigated by O.A. Pobegaylov, G.I. Myasishchev and O.E. Gaybarian [Pobegaylov O. A., Myasishchev G. I., Gaybarian, O. E., 2016]. The results of studies on the expert systems role as a tool for improving management efficiency are given in the works of A.A. Zhivotova and V.D. Berdonosov [Zhivotova, A. A., Berdonosov, V. D., Zhivotova, A. A., 2018]. The effectiveness of the production resources use is investigated in the publications of I.S. Sharov [Zharov, V. S., 2020]. The nature of the influence of production efficiency and labour productivity on the results of entrepreneurial activity is analysed in the publications of E.G. Grigoreva, E.N. Gubaidullina and E.A. Polovkina

[Grigoreva, E. A., Polovkina, E. A. Gubaidullina, T. N., 2019]. P. Kazaryan and S. Lyovin cite the results of studies of the impact of the quality management system introduction in enterprises on the outcome of business entities [Kazaryan, R., Lyovin, S., Yusupov, R., 2020]. Analysis of the impact of the business entity, benchmarking, and talent management in enterprises on results and efficiency is presented in the publications of P. Gallo, J. Dobrovits and P. Partlova [Gallo, P., Dobrovits, J., Pártlová, P., 2021].

As follows from the list of works presented, the problem of the influence of various factors on production efficiency indicators is the subject of extensive discussion in the scientific literature. Factors of production such as labour and capital are particularly important. The state indirectly influences the formation and change of these factors through investment policy and wage regulation systems, including through subsidy instruments, soft loans, taxes, minimum wages, etc.

The methodology for assessing the labour and capital impact on economic performance is not fundamentally new in economic science. A variety of methods are used for analysis. These include simulation techniques, factor analysis, index method and others. The Cobb-Douglas production function is a very common method of factor analysis. For example, it is the main method of analysis of production volumes depending on the irrigation factor of the land in the work of S.A. Hatchett [Hatchett S. A., 1986]. B.L. Nerrie uses this function to predict fish catches in agricultural cooperatives based on cost and capital analysis [Nerrie B. L., 2007]. T. Dawan, S. Darana and W. Setiyadi predict business efficiency and profit factors in duck-broiler production [Dawan T., Darana S., Setiyadi W., 2020].

In this study, the Cobb-Douglas production function model is used to analyse the impact of investment in fixed capital and material remuneration of labour on output in branches of the economy, using the example of Volgograd oblast.

The main goal of the study is to assess the possibilities of using the Cobb-Douglas

Научный результат. Экономические исследования. Т. 8. № 2. 2022. С. 85-96
Research Result. Economic Research. Vol. 8. № 2. 2022. P. 85-96

88

production function in the information support of state planning at the regional level of government.

To achieve this goal, the following tasks had to be accomplished:

- to develop a methodology for analysing the impact of the cost of fixed production assets and wages on the volume of production in the region's economic sectors;

- to analyse trends in the average efficiency changes of fixed production assets and wages in the region's economic sectors in relation to the rate of change in business turnover and inflation rate;

- to assess the problems of curbing the turnover growth in the sectors of the economy and the possibility of using the information obtained in pre-plan studies at the regional level of government.

The main hypothesis of the study was that the information obtained from the analysis of the average efficiency of fixed production assets and wages in the region's economic sectors, can be used in pre-plan studies to develop adequate government regulatory tools and techniques.

The Cobb-Douglas production function was used to analyse the influence of factors on output in Volgograd oblast.

The cost indicators of fixed production assets – K (gross book value, million rubles) and average wages in the relevant industry – L (million rubles) were analyzed as factors affecting the turnover of enterprises – Y (million rubles).

In the first stage of the analysis, the production function was transformed to a linear type. For this purpose, the production function was logarithmed by natural logarithm

$$Ln(Y) = Ln(a_0)+a_1 Ln(K)+a_2 Ln(L) \quad (1)$$

To obtain a linear function, the variables were then replaced

$$Ln(Y)=Y' \quad (2)$$
$$Ln(a_0)=a'_0 \quad (3)$$
$$Ln(K)=K' \quad (4)$$
$$Ln(L)=L' \quad (5)$$

The result of this substitution was a linear function

$$Y'=a'_0+a_1 K'+a_2 L' \quad (6)$$

To calculate coefficients a_0, a_1, a_2 the method of least squares (built-in function of Exel) was applied.

The transformations resulted in a function of the form

$$Y=a_0*K^{a_1}*L^{a_2} \quad (7)$$

where
Y – total agricultural production;
a_0 – gross factor productivity;
K – amount of capital employed;
L – labour contribution;
a_1 и a_2 – labour and capital elasticity, respectively.

To verify the model adequacy, a visual analysis of actual and estimated agricultural production and the Fisher's criterion was carried out with 99 per cent reliability. The calculated value of Fisher's criterion was compared with the table value (built-in function of Exel).

The model was considered adequate, provided that $F_{calculated} > F_{table}$.

Average resource efficiency was estimated using the formulas

$$\mu_K = a_0 * K^{a_1-1} * L^{a_2} \quad (8)$$
$$\mu_L = a_0 * K^{a_1} * L^{a_2-1} \quad (9)$$

The rates of growth of fixed production assets and average wages were then calculated and compared with the rates of changes in turnover and inflation in the retail price index.

As an empirical base, statistical data on turnover, the cost of fixed production assets and wages in agriculture, extractive industry, manufacturing, construction and trade in Volgograd oblast in 2010-2019 were used.

Main part
The economy of Volgograd oblast is represented by a wide range of different branches. The region's specialization is industrial and agricultural. In the industrial structure of gross value added, the largest share is accounted for by the primary and secondary industries – about 30 per cent, agriculture – about 13 per cent, construction – about 10 per cent, and trade – about 12 per cent.

The extractive industry is represented in Volgograd oblast by enterprises producing

Научный результат. Экономические исследования. Т. 8. № 2. 2022. C. 85-96
Research Result. Economic Research. Vol. 8. № 2. 2022. P. 85-96

89

oil, gas, table and stone salt, magnesium salt-bischofite, phosphorites, peat, etc. Oil and gas account for about 95 per cent of total turnover. Mineral output accounts for about 11 per cent of the total volume in the Southern Federal District. The industry currently employs about 0.4 per cent of the total labour force.

The Cobb-Douglas production function's raw data and calculations for the extractive industry are presented in Table 1.

Таблица 1

Исходные и расчетные данные для добывающей промышленности

Table 1

Raw and calculation data for the extractive industry

Years	Y actual	K	L	Y calculated	μ_k	μ_L
2010	24.6	16.11	0.03	11.3	5.62	270.20
2011	7.3	18.77	0.04	10.8	4.67	228.99
2012	8.3	24.80	0.05	11.7	3.85	222.14
2013	12.0	33.78	0.05	13.8	3.33	242.04
2014	13.0	36.80	0.05	13.2	2.94	212.53
2015	12.0	40.85	0.06	12.9	2.61	193.00
2016	13.0	46.23	0.06	12.6	2.27	172.81
2017	13.0	57.49	0.07	13.8	2.01	177.23
2018	16.0	65.54	0.08	13.3	1.70	151.79
2019	16.6	74.14	0.08	13.3	1.52	141.92

The Cobb-Douglas production function according to extractive industry data is:

$$Y=0.013*K^{0.93}*L^{1.37} \qquad (10)$$

Visual evaluation of the production function and its testing according to the Fisher's criterion (*F calculated* -25.4; *F table* – 0.01.) makes it possible to speak about the adequacy of the calculations made.

As can be seen from the calculations made, the turnover of extractive industries during the period under review is extremely volatile. At the same time, turnover in the last year of the period under review decreased by 62 per cent in relation to the starting year. Judging by the indicators characterizing the average efficiency of resources, the efficiency of fixed production assets and average wages is decreasing. At the same time, the average efficiency of wages is much higher than the average efficiency of fixed production assets. The value of fixed production assets and wages is increasing rapidly. When comparing the growth rates of inflation, turnover, fixed pro-duction assets and average wages, it can be assumed that, given the lower growth rate of business turnover, the high growth rate of production assets value suggests rather extensive development of the industry. The growth rate of wages and turnover is about the same as the growth rate of prices.

The manufacturing industry in Volgograd oblast is represented mainly by the production of petroleum products (about 54 per cent in the structure of turnover), metallurgical production (about 20 per cent in the structure of turnover), food industry enterprises (about 8 per cent in the structure of turnover), the chemical industry entrprises (about 6.5 per cent in the structure of turnover). The manufacturing sector in the Southern Federal District accounts for an estimated 16 per cent of the total. The industry employs about 17 per cent of the region's able-bodied population.

The Cobb-Douglas production function's raw data and calculations for the manufacturing industry are presented in Table 2.

Научный результат. Экономические исследования. Т. 8. № 2. 2022. С. 85-96
Research Result. Economic Research. Vol. 8. № 2. 2022. P. 85-96

90

Таблица 2

Исходные и расчетные данные для производства рассчитанных

Table 2

Raw and calculation data for manufacturing calculated

Years	Y actual	K	L	Y calculated	μ_k	μ_L
2010	338.3	115.77	0.01	339.8	2.93	17897
2011	397.3	140.73	0.02	391.1	2.77	17957
2012	427.7	160.86	0.02	446.3	2.77	18208
2013	428.0	183.72	0.02	494.7	2.69	18294
2014	512.0	205.93	0.02	542.7	2.63	18392
2015	519.0	241.42	0.03	579.1	2.39	18148
2016	506.0	354.0	0.03	581.22	1.64	16726
2017	586.6	402.35	0.03	649.74	1.61	16869
2018	743.2	414.07	0.04	699.09	1.68	17167
2019	789.9	433.81	0.04	768.60	1.77	17526

The Cobb-Douglas production function according to manufacturing industry data is:

$$Y=548848.64*K^{0.32}*L^{1.48} \quad (11)$$

Visual evaluation of the production function and its testing according to the Fisher's criterion (*F calculated* -26.9; *F table* – 0.01.) makes it possible to speak about the adequacy of the calculations made.

The following conclusions can be drawn from the analysis of performance indicators of the business function.

According to the initial data, the volume of turnover in the period under review increased more than 2.3 times, the value of fixed production assets increased 3.7 times, and wages – 2.3 times. An assessment of average resource efficiency shows that average wage efficiency is higher than average fixed production asset efficiency. Comparison of the base year and the reporting year shows a decrease in the average efficiency of resources. However, there has been a more than 1.6-fold decline in the efficiency of fixed production assets. A comparison of the rate of change may indicate that the rate of growth in turnover does not exceed the rate of increase in the value of fixed production assets. Wage hike was similar to price and turnover increases, which may indicate inefficient management of labour and capital.

Another traditional branch of the economy in Volgograd oblast is agriculture. According to data provided by Rosstat, the total land area in the region is 10,096.7 thousand hectares. Sown area in the region covers about 3,146.1 thousand hectares.

The contribution of Volgograd oblast to the agricultural production of the Southern Federal District is about 14 per cent. The region has developed crops, livestock and fisheries. Volgograd oblast ranks third in the Southern Federal District in terms of cattle numbers and milk production. Agriculture currently employs about 13 per cent of the total employment in the economy.

The Cobb-Douglas production function's raw data and calculations for the manufacturing industry are presented in Table 3.

Научный результат. Экономические исследования. Т. 8. № 2. 2022. С. 85-96
Research Result. Economic Research. Vol. 8. № 2. 2022. P. 85-96

91

Таблица 3

Исходные и расчетные данные по сельскому хозяйству

Table 3

Raw and calculation data on agriculture

Years	Y actual	K	L	Y calculated	μk	μL
2010	14.3	61.84	0.01	17.1	0.26	2.6
2011	15.8	62.78	0.02	16.9	0.25	2.1
2012	19.6	68.25	0.01	18.4	0.25	2.6
2013	21.0	74.20	0.01	19.6	0.25	2.8
2014	26.0	81.45	0.01	21.1	0.24	2.9
2015	27.0	89.65	0.01	22.7	0.24	3.1
2016	28.0	91.98	0.02	23.1	0.24	3.0
2017	28.1	127.6	0.02	30.0	0.22	3.8
2018	29.4	135.7	0.02	31.4	0.22	3.9
2019	32.3	138.8	0.03	31.9	0.21	3.8

The Cobb-Douglas production function according to agricultural data, is as follows:

$$Y=0.53*K^{0.813}*L^{-0.03} \qquad (12)$$

Visual evaluation of the production function and its testing according to the Fisher's criterion (*F calculated* -26.9; *F table* – 0.01.) makes it possible to speak about the adequacy of the calculations made.

The following conclusions can be drawn from the analysis of performance indicators of the business function.

During the period under review, there has been an increase in the turnover of enterprises, capital, and labour. Average resource efficiency values with positive sign.

This may mean that the increase in the value of fixed production assets and in wages has contributed to the increase in the turnover of agricultural enterprises.

This could mean that an increase in the value of fixed production assets and wage growth contributed to the growth of the turnover of agricultural enterprises. Judging by the average factors efficiency, the efficiency of the fixed production assets use is gradually decreasing and the efficiency of the average wage is increasing.

An analysis of the rate of change in the indicators of turnover, fixed production assets, wages and price index shows that all the indicators considered, with a few exceptions in some periods, show approximately the same rate of growth, which can also mean poor management of labour and capital.

The construction industry in the region is represented by the construction of residential and non-residential buildings. In the total area to be commissioned, Volgograd oblast ranks fourth in the Southern Federal District. The total area of buildings is about 10 per cent of the total commissioned area in the Southern Federal District. The sector employs about 7 per cent of the economically active population.

The Cobb-Douglas production function's raw data and calculations for construction are presented in Table 4.

Научный результат. Экономические исследования. Т. 8. № 2. 2022. С. 85-96
Research Result. Economic Research. Vol. 8. № 2. 2022. P. 85-96

92

Таблица 4

Исходные и расчетные данные для строительства

Table 4

Raw and calculation data for construction

Years	Y actual	K	L	Y calculated	μk	μL
2010	22.6	16.8	0.021	29.3	1.8	34.8
2011	23.9	18.0	0.023	28.8	1.6	34.1
2012	27.7	21.9	0.025	24.7	1.1	29.1
2013	29.0	18.9	0.027	29.9	1.6	35.2
2014	35.0	21.9	0.029	26.4	1.2	31.0
2015	40.0	23.7	0.029	24.5	1.0	28.7
2016	34.0	23.9	0.032	25.3	1.1	29.5
2017	15.8	24.0	0.034	26.2	1.1	30.5
2018	14.7	41.5	0.038	15.6	0.3	18.1
2019	14.2	42.4	0.042	16.2	0.4	18.7

The Cobb-Douglas production function according to construction industry data is as follows:

$$Y=4617.19*K^{1.04}*L^{0.54} \qquad (13)$$

Visual evaluation of the production function and its testing according to the Fisher's criterion (*F calculated* -1.063; *F table* – 0.01.) makes it possible to speak about the adequacy of the calculations made.

The following conclusions can be drawn from the analysis of performance indicators of the business function.

During the period under review, there has been a decline in the turnover and an increase in the value of fixed production assets and wages at the enterprises in the sector. The value of fixed production assets is rising more rapidly (almost 2.5 times).

As the value of fixed production assets and wages increases, the average efficiency of these resources declines.

Average wage efficiency is almost 60 times higher in certain periods than the aver-age efficiency of fixed production assets. With a few exceptions, in each year of the period under review the growth rate of fixed production assets was higher than the growth rate of turnover. Wage growth is equivalent to rising retail prices.

The trade sector in the region is represented by retailers and wholesalers. Retail turnover in Volgograd oblast is about 11 per cent of retail turnover in the Southern Federal District. Wholesale turnover is 16 per cent of wholesale turnover in the Southern Federal District. The region ranks fifth in the Southern Federal District and 60th in the Russian Federation in terms of retail turnover per capita. The industry currently employs approximately 19 per cent of the economically active population.

The Cobb-Douglas production function's raw data and calculations on trade in Table 5.

Научный результат. Экономические исследования. Т. 8. № 2. 2022. С. 85-96
Research Result. Economic Research. Vol. 8. № 2. 2022. P. 85-96

93

Таблица 5

Исходные и расчетные торговые данные

Table 5

Raw and calculation trade data

Years	Y actual	K	L	Y calculated	μ_k	μ_L
2010	120.5	23.5	0.018	146.2	8.6	93100036
2011	163.7	28.6	0.019	154.9	6.2	92027385
2012	189.9	35.3	0.021	164.7	4.7	90370074
2013	197.0	42.1	0.023	173.4	3.6	89230154
2014	227.0	54.9	0.025	187.4	2.4	87594226
2015	197.0	64.4	0.026	196.5	1.9	86766466
2016	187.0	68.1	0.029	199.8	2.0	85293821
2017	202.6	71.5	0.031	202.8	2.0	84355548
2018	144.2	77.3	0.035	207.6	2.2	82469853
2019	276.1	78.6	0.04	208.9	2.7	80591385

The Cobb-Douglas production function, according to the trade data, is as follows:

$$Y=60.66*K^{0.29}*L^{0.09} \qquad (14)$$

Visual evaluation of the production function and its testing according to the Fisher's criterion (*F calculated* -2.87; *F table* – 0.01.) makes it possible to speak about the adequacy of the calculations made.

The following conclusions can be drawn from the analysis of performance indicators of the business function.

The volume of the turnover for the period under review increased 2.3 times. The value of fixed production assets increased at a faster rate, almost 3.3. times. The rate of increase in wages was similar to the rate of increase in retail prices.

The average efficiency of fixed production assets and wages is positive, which is obviously linked to their positive impact on turnover growth.

At the same time, average wage efficiency is much higher than average efficiency of fixed production assets, that is, wage growth played a major role in the increase in turnover.

Conclusion

The results of the measurement of labour and capital factors show positive values for the average efficiency of resources, in other words, in all branches of the economy, the rise in the value of fixed production assets and the rise in wages played a positive role in the growth of turnover. In almost all of the industries considered, the average efficiency of fixed production assets is declining. At the same time the growth rate of turnover does not exceed the growth rate of fixed production assets. And with the rate of increase in the value of fixed production assets equal to or higher than the rate of growth in turnover, as calculated, it may indicate inefficient investment in fixed capital or poor management of enterprises. This trend is most pronounced in the extractive industries, which are likely to be extensive in nature. The average efficiency of the wage factor in all of the industries considered is higher than the average efficiency of fixed production assets. In two branches – agriculture and manufacturing industry – average wage efficiency is increasing during the period under review, which may indicate a positive impact of the material incentives on the growth of turnover. In other industries, such as extractive industry, manufacturing and construction, average wage efficiency declines, which may indicate poor management of material incentives to work.

Научный результат. Экономические исследования. Т. 8. № 2. 2022. С. 85-96
Research Result. Economic Research. Vol. 8. № 2. 2022. P. 85-96

94

The study shows that the improvement of the management of the main factors of production – capital and labour – in the region's enterprises is an important objective for improving the turnover of enterprises. In almost all industries, there has been a gradual decline in the efficiency of fixed production assets, which seems to require improvements in production and innovation management methods and tools. According to experts, this could be facilitated, for example, by the digitization of production, the wider development of fixed production assets intensification in the saving sector, the application of more productive innovative technologies than those already in place [Duttagupta R., Mlachila, M., 2008]. Another challenge forthe growth of turnover is the need to improve methods of organization and material incentives for labour. According to experts, this may involve improving the quality of work [Popova L.V., Gurnovich T.G., Dosova A.G., 2017], including through the upgrading of skills [Bogachev A.I., 2019], the setting of labour standards, the qualified division of labour and others [Parmakl, D.M., Dudoglo T.D., 2016].

The main conclusion of the work is that it is possible and appropriate to use the Cobb-Douglas production function to analyse the impact of labour and capital measures on the economic performance of enterprises in the region. This function, for example, can be used as a method of numerical analysis to inform strategies for the socio-economic development of the region. As well as to inform financial decisions on the management of public investment programmes at the regional level, for example, to substantiate the criteria for subsidies, tax concessions or guarantees on bank loans to enterprises in the region, regulation of wages in large government-sponsored enterprise, etc.

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96

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