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Building of the Production Function for the Production Sector of the Country

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Abstract: This article introduces a result of performed correlation-regression analysis of the performance indexes of three Russian industry segments: manufacturing activities, non-renewal exploitation enterprises and electric-power, gas and water production and distribution enterprises. Based upon this analysis, the authors built the Cobb-Douglas function for these sectors. The analysis of the obtained functions showed, that the key factor of the production ramp-up in manufacturing is the increase of labour quantity. For extractive enterprises, the capital has a higher value, which is caused by traditional capital intensity in this sector. In the third sector, we didn't obtain models with a high coefficient of determination. Thus, this article offers the approach of production functions building for the Russian industry sectors, which takes into account statistical data limitations. Conclusions are made on factors of growth of the Russian manufacturing plants and extractive enterprises.

Key words: Production function · Cobb-Douglas production function · Panel data · The Russian industry

INTRODUCTION

Production functions are an important instrument of modelling and analysis of the relationship between productive factors dynamics and change of turnout. Therefore, this study is designed to build production functions for three Russian industry sectors. Based on these functions, conclusions will be made, first, on the actuality of this approach to industrial research and second, on factors, which affect the Russian production development.

To achieve this purpose in work, we will first consider different types of production functions. The most known production functions, which are used for analysis of regional and national economics, are the Cobb-Douglas function [1] and the CES function. Considering the latest research in this area, the R. Hall and Ch. Jones function [2] should be noted, which takes into account the social infrastructure and the D. Oliner and E. Sichel function [3], which added the list of the considered factors.

The selection of one of these functions will be explained further in this article. Then the results of the correlation-regression analysis will be presented, using which the production functions for three Russian industry sectors are built. In summary, the conclusions will be made on applicability of this instrument for the industry research and on production factors, which determine the development of Russian industry.

Procedure: The production function describes the relationship between the production outcome (it is GRP for the region, it is the quantity of output for an enterprise or industry sector) and the quantity of factors used for this production. The most known production functions used in the regional economics are:

- The Cobb-Douglas function [1].
- The Leontief function, which is based on the precondition, that resources are not interchangeable [4].
- The Allen function, which is used for the description of the economical processes, which the overgrowth of any factor adversely affects the production output in [5].

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- The production function of constant elasticity of substitution (CES), which may be used, if the production factors interchangeability level does not change significantly with change of quantity of factors involved.
- The production function with the linear elasticity of substitution (LÅS), which is recommended for description of economical processes, where the possibility of substitution of involved factors depends on their proportion.
- The multimode production function. It is used for description of economical processes, which the level of return of each new resource entity changes intermittently in, depending on the factors relationship.
- Functions, which consider the influence of scientific and technological progress on the production outcome: The Hicks model [6], the Solow function [7], the Harrod function [8].
- The R. Hall and Ch. Jones function [2], which considers the social infrastructure as the key efficiency factor.

The latest directions in the production function development include the research of influence of information technologies on products output growth rate. The study of D. Oliner and E. Sichel [3] is one of the most interesting studies in this area. The offered by the authors model evaluates the influence of following factors: The capital, invested into PC; the capital, invested into software; the capital, invested into communications devices, the remaining capital and the labour costs.

This study offers to consider the simplest version of the production function, which has two production factors (labour and capital), which are interchangeable. This kind of selection is made to evaluate, whether the considered factors are fundamental for manufacturing enterprises in Russia and based on this evaluation, to make a conclusion on the practicality of further research using more complex production functions, described above. Thus, the Cobb-Douglas production function will be introduced in this article [1]:

$$Y = A * L^a C^b$$

where,

Y - Quantity of the own make products shipped, executed works and services under own steam, million rouble;

L - Labour costs (average annual number of people employed in the industry sector, multiplied by the nominal gross payroll), million rouble;

C - Capital funds of organizations (according to the full carrying value; year end), million rouble.

If sum of powers (a + b) is equal to unity, the function shows the constant return from production scale. It was like this in the original work of Ch. Cobb and P. Douglas [1].

In spite of long life of the Cobb-Douglas production function and availability of large amount of new functions, we can say, that this instrument is still applicable today. Many scientists use this production function in their research. For example, L. Morel [9], built an empirical model based on the data for Canada, which shows the share of income, which is supplied by labour. In their article, D. Hajkova and Zh. Hornik [10] describe the possibilities of use this function for description of transition type economics (Czechia as an example). J. 11.

Biddle describes the possibilities and experience of building the Cobb-Douglas function for the agricultural sector [11].

Thus, it is possible to say, that the Cobb-Douglas function is the actual instrument. The calculation of a and b coefficients on the basis of the Russian data will allow us to evaluate, which influence both considered production factors have on the final output. These data allow us to make conclusions, whether the labour and the capital are still the key factors increasing the intensity of the national production and, if so, which of them is more important.

The imperfection of the Russian statistics data should be taken into account during analysis of the obtained results. For example, the product price production depends on the market situation and not only on the prime cost. In accordance, the dynamics of quantity of the own make products shipped in roubles does not always present fairly the dynamics of the physical quantity. A high percentage of illegal salaries may still seriously mispresent the data on the expenses of manufacturers for the labour compensation of employees. Also, the growth of labour expenses does not always mean the increase of physical quantity of labour input during production. The growth may be related to the raise in wages. The data on the capital funds of enterprises also contain some defects. In particular, knowing the capital fund amount, it is impossible to determine, which part of them is used in manufacture of products, because a part of funds may be idle, another part may be let to other enterprises.

Another serious problem of the Russian statistics is the limited years number of data availability. The new Russian economics only exists since 1991, which is an objective limitation for the researchers. Also, after introduction of the All-Russia classifier of industry instead of the All-Russia classifier of sectors of national economy in 2003, names of many industries (kinds of activity) changed and this even more reduced the list of the data, available for calculation.

To eliminate this limitation, in their study, V.K. and O.V. Bulgakov [12] offer to use the modified production function during the analysis of the Russian regions' economy.

In this research, we propose to compensate the limitations by number of years, which the data is available for, using panel data. All Russian regions are considered as panels. The data for an industry branch are taken for several years, so we can obtain some hundreds observations. At that, each region has its specific nature and that is a problem. First, all regions are be specialized on their specific sub-branches, which are not easy to compare. Also, the most Russian regions don't have any strongly marked specialization. Therefore, the production scale may be dramatically different in each region, which may be a determining factor for scale effect arising. Second, the Russian regions develop diversely for certain reasons (historical development factors, geographic location, transport availability, nearness to other countries borders and such things named in this context).

That is why we should use the model building instruments, which allow us to perform evaluation regardless of these regions' factors, which are unrelated to the common rules of influence of labour and capital on the production output, as far as possible. In this context, the evaluation was carried out in the "R" packet using four models: *random*, *between*, *within*, *pooling*. The models of following kinds of activity were built: manufacturing, non-renewal exploitation and production and distribution of electric-power, gas and water. The data for the 2005–2011 period was analyzed [13]. All four model types were built for each kind of activity. In each case, the model was selected, which had the approbation results nearest to actual values of quantity of products shipped in the considered activity kinds.

Main Part: The table shows the values obtained for manufacturing, for the, *"Random"* model.

We can see from the regression analysis results presented in the table, that the labour is more significant than the capital in the production function built for the manufacturing activities. The comparison of the experimental value of the *t*-statistics with its critical value shows the significance of the obtained coefficients A and a with the error probability equal to 0.05. At that, the coefficient of determination is equal to 0.96, which shows strong relation between examined coefficients. At the same time, the b coefficient is not significant based on the t-statistics data.

The comparison of the production output values, obtained through the calculation using the built Cobb-Douglas function with the realistic dynamics for the 2005 – 2011 period, is shown in the Figure 1. As we see in the diagram, the calculated values are approximately equal to the actual values and the function generally follows the actual dynamics.

The sum of the a and b coefficient is equal to one. That is why we can say, that the obtained function is classical. In their study, Cobb and Douglas name the following coefficient values: a =0.75 and b=0.25 [1]. They gave the following interpretation. Engaging of additional employees to production is more profitable for an enterprise, than an additional application of capital, because the labour brings 75% of additional revenue and the capital brings only 25%. In our function, this spread is even more large. It may be partly explained by the above-mentioned imperfection of the initial statistical data. Particularly, we can suppose, that the capital fund data don't actually represent the process of use of these funds in manufacturing activities. That is indicated by the fact, that the b coefficient appeared not significant. Respectively, a conclusion can be made on practicability of consideration of other production functions for manufacturing activities research.

And with it, the role of labour in changing of products output by manufacturing enterprises is significant enough. For this reason, this factor of production should be left in the model. In further researches, it seems to be interesting to use the above mentioned R. Hall' and Ch. Jones' approach [4], which considers the social infrastructure. Also, it makes sense to consider other important characteristics of the Russian regions, which differentiate them: transport infrastructure, the distance from international boundaries and from the capital of Russia.

The *"Pooling"* model was chosen for the analysis of extractive enterprises.

Table 1: Point estimates of the general regression coefficients for manufacturing activities and non-renewal exploitation and examination of their significance

	Coefficients					
	Manufacturing			Extractive enterprises		
	A	a	b	A	a	b
Coefficients	3.05	1.01	0.04	2.08	0.42	0.62
Standard error	0.21	0.03	0.02	0.12	0.04	0.03
T-statistics (critical value – 1,96)	5.39	30.46	1.87	5.90	11.54	23.87

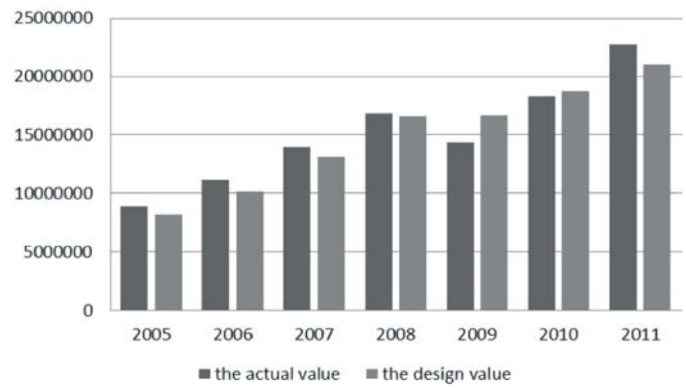

Fig. 1: The quantity of the products shipped by the Russian manufacturing enterprises (comparison of the actual data with the values, calculated using the built function)

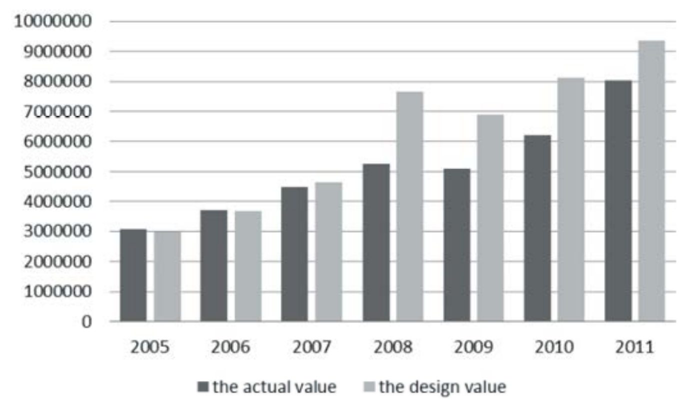

Fig. 2: The quantity of the products shipped by the Russian extractive enterprises (comparison of the actual data with the values, calculated using the built function)

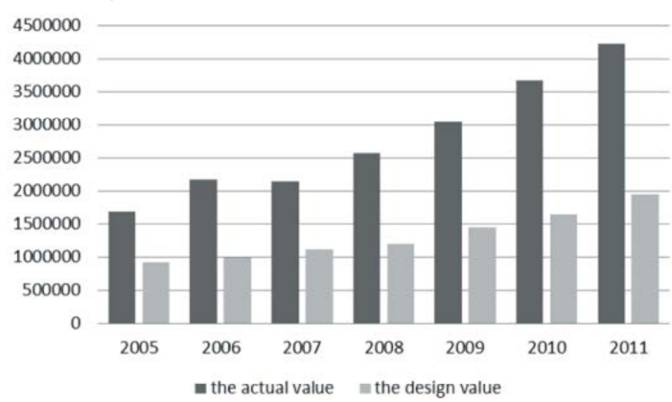

Fig. 3: The quantity of the products shipped by the Russian enterprises for the production and distribution of electric power, gas and water (comparison of the actual data with the values, calculated using the built function)

The table above provides the results of the calculation of coefficients for the Cobb-Douglas function for the extractive enterprises. As in the previous case, the coefficient of determination is high enough – 0.89 – and all obtained regression coefficients are significant. At the same time, we can see, how the distribution of significance of the labour and the capital in the obtained function differs from the manufacturing activities. In the non-renewal exploitation, the capital is more significant than the labour. This is primarily explained by the branch specifity itself. But at the same time, the value of the labour is high enough.

The comparison of the shipped products quantity values, calculated according to the model, with the actual values (Figure 2) allows us to make a conclusion, that the model shows the relation between the characteristic values exactly enough, although there are less matches, than in case of the manufacturing activities.

For production and distribution of electric power, gas and water, the *random*" model turned out to be less able to forecast values based on the actual values (Figure 3). This difference is even higher for other models available for this branch. That is, the coefficient values, obtained through the regression analysis of the panel data for the Russian regions, don't show the general dynamics of the branch in Russia. The coefficient of determination for the "*random*" model is not high – 0.68.

That allows us to say, that it is difficult to make any conclusions from the obtained model for this branch.

Summary: The purpose of this study to build production functions for three Russian industry sectors is achieved. To achieve this purpose, the Cobb-Douglas production function was used. The statistics for the Russian regions served as the initial data. The coefficients for the selected function were obtained using the correlation-regression analysis approach. Using the obtained functions, we can make conclusions regarding the possibility of using the Cobb-Douglas function to research the Russian industry and regarding factors, which influence the development of the Russian production.

CONCLUSIONS

We can say that the Cobb-Douglas function, though may be used, but is not the best instrument in this case. The calculations showed that, when models are used with panel data and with the Russian regions as panels, we can obtain models, which represent the general dynamics for Russia for the manufacturing and extractive industries exactly enough.

However, the data for the manufacturing industry turned out to be contradictory enough. On the one hand, the approbation of the model showed, that the calculated data exactly show the actual dynamics of the shipped products quantity. On the other hand, the capital coefficient turned out to be not significant. That means, only the labour actually remained from two factors of the classical Cobb-Douglas function in the resulting model. The role of the capital is not significant at all. Therefore, we can make a conclusion on practicability of consideration of a production function with other factors on the next research step, for example, the R. Hall and Ch. Jones [4] function.

The extractive enterprises show another situation. The capital has the greater influence on the final output in the obtained function, than the labour. This fact is explained by specificity of the branch, which is more capital-intensive, than manufacturing enterprises. It would be interesting to compare the obtained results with the analogous numbers for the extractive industry in other countries, but the search didn't succeed. Searching of source information, carrying out calculations and following comparative analysis of the obtained production functions of the extractive enterprises for other countries may continue the research, presented in this article.

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