Journal of History Culture and Art Research (ISSN: 2147-0626)

Tarih Kültür ve Sanat Araştırmaları Dergisi
Revue des Recherches en Histoire Culture et Art
مجلة البحوث التاريخية والثقافية والفنية

Vol. 7, No. 3, September 2018

http://kutaksam.karabuk.edu.tr

DOI: 10.7596/taksad.v7i3.1706

Citation: Pinkovetskaia, I., Gromova, T., & Nikitina, I. (2018). Production Functions: Entrepreneurial Sector of Russia's Regions. Journal of History Culture and Art Research, 7(3), 493-504. doi:http://dx.doi.org/10.7596/taksad.v7i3.1706

Production Functions: Entrepreneurial Sector of Russia's Regions

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Abstract

In the context of transformation of the Russian economy there is an urgent need for accelerated development of small and medium enterprises. Solving this problem is very urgent in each of Russia's regions. The aim of the study was to assess the two-factor production functions that describe the dependence of the volume of production (turnover) of small and medium enterprises on the wages of their employees and investments in fixed assets. The study was based on empirical spatial data characterizing the activities of medium enterprises, small enterprises and microenterprises. Official statistical information on 82 regions of Russia for 2016 was used. The study allowed to determine the factors influencing turnover of SMEs located in all regions, to prove the high quality of approximation of the initial data by the two-factor production functions, to prove that the economy of the Russian regions has not reached saturation with small and medium enterprises. The results of the study, namely new knowledge and tools for assessing production activities of small and medium enterprises in the regions, are of scientific and practical importance. They can be used in monitoring of business climate in regions, determining resource needs, as well as the implementation of the Russian strategy for its development up to 2030.

Keywords: Production function, Small enterprises, Medium enterprises, Microenterprises, Investments in fixed capital, Wages, Regions of Russia.

JEL Classification: L26; C31.

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Introduction

Today, numerous small and medium enterprises (SMEs) are operating in the Russian business sector. In 2016, their number exceeded 2784 thousand, and 12784 thousand employees worked for them. At the same time, small and medium enterprises have not yet been developed in Russia; their share is less than 20% of gross domestic product and employees' number of all enterprises and organizations in Russia. For comparison, it can be noted that in the European Union countries, SMEs have a much larger share in the economy. They provide jobs for about 67% of the working population and produce 58% of gross domestic product (Development of Small and Medium Enterprises, 2015). In Germany these figures are 60% and 48% respectively (Sollner, 2014).

Solving management problems in the national economy requires an understanding of the factors that influence the volume of SMEs production. At the same time, experience shows that it is business sector that is the main driver of regional development, especially in underdeveloped areas, and business sector creates conditions for restructuring of the economy (Mosina, 2016; Safiullin et al., 2016; Chepurenko, 2017; Acs et al., 2008; Baumol, 2004; Decker et al., 2014). Thereby, in Russia there is an urgent need for accelerated development of SMEs. Therefore, in recent years, one of the most urgent problems is to determine the growth reserves of such enterprises in each of the regions. The rationale for these reserves, as well as the resources required for the effective functioning of SMEs, can be based on mathematical models such as production functions. Proceeding from it, the purpose of the study was to assess factors influencing SMEs turnover with use of production functions.

Literature review

The experience gained so far has shown the possibility of wide application of production functions in economic analysis and management. Production functions are economic and mathematical models of production processes and they quantify stable natural relationship between the factors describing the cost of capital and labor, and the indicator characterizing the production volume (Bessonov and Tsukhlo, 2002; Kleiner, 1986; Douglas, 1967). Production functions are the basis for modeling the activities of various economic and business complexes and systems, from individual enterprises and organizations to regions, sectors and the economy as a whole. Power functions are most widely used. Table 1 shows the analysis of the existing methods of evaluation of power production functions on the examples of Russian studies conducted in recent years.

Table 1. Characteristics of Russian studies

Authors	Factor of capital	Factor of labor	Production volume	Initial data	Restrictions on the sum of powers	Object of studying
1	2	3	4	5	6	7
Nosov V. V., Aznabaeva A. M. (2016)	fixed assets	number of employees	GDP	time series	no	BRICS countries
Sokol A. G., Kutychkin A. V., Petrov A. A. (2017)	investment in fixed capital	labor costs	GRP	time series	yes	one region-Yugra

Nikonorov V. M. (2017)	fixed assets	number of employees	volume of retail trade	time series	no	trade sector of Russia
Pshenichnikova S. N., Romanyuk I. D. (2017)	gross capital accumulation	number of employees	GDP	time series	no	Russia
Adamadziev K.R., Khalilov M.A. (2016)	investment in fixed capital	number of employees	GRP	spatial data	no	regions of Russia
Sadovin N.S., Kokotkina T.N. (2017)	fixed assets	number of employees	GRP	time series	no	regions of Russia
Afanasiev, A.A., Ponomareva O.S. (2014)	fixed assets	number of employees	GDP	time series	no	Russia
Antipov V.I. (2012)	fixed assets	number of employees	GDP	time series	yes	Russia
Gafarova E.A. (2013)	fixed assets	number of employees	GRP	time series	no	one region-Bashkortostan
Baranov S.V. (2014)	fixed assets	number of employees	GRP	time series	no	regions of Russia

The data given in Table 1 shows that in most cases the economies of Russian regions (5 cases), Russia (3 cases), BRICS countries and trade enterprises located in Russia are the objects of the research. Gross domestic product (GDP) of the countries, gross regional product (GRP) of the regions and the volume of retail trade are respectively studied. Fixed assets of enterprises and organizations in 7 works, flows of investments in fixed capital in 2 works, gross capital accumulation in 1 article are considered as factors describing capital. In absolute majority of the works (9) the number of employees occupied in the considered productions and only in one case – labor costs were used as labor factors. Initial data in 9 researches represented time series while only in one work spatial data in one year were used. In all the works listed in Table 1, power production functions were considered, while in 8 cases no restrictions on the sum of powers were imposed. That is, we evaluated the production functions, in which increasing, constant and decreasing returns to scale were allowed.

Studies based on production functions using the data of SMEs have also achieved some progress. In most cases, the factors that determine the volume of production are capital costs (the cost of all machines, equipment and buildings) and labor costs. Different indicators are discussed in scientific research. Thus, V. Bohórquez and J. Esteves (2008), S. Husain and M. S. Islam (2016) used the number of permanent employees to describe the labor costs. And A. P. Sage & W. B. Rouse (2011) considered such indicator as total number of the man-hours within a year. In most works observations are based on time series. So, T. Khatun and S. Afroze (2016) show the impact of employees' number and fixed capital on real GDP in Asian countries such as Bangladesh, India, China, Malaysia and Thailand, based on the use of time series data for 1990-2014. S. Batool and S. Zulfiqar (2013) present the analysis of interrelation of the same indicators on

the production volume of small and medium enterprises in Pakistan. It should be noted that studies on the assessment of production functions describing the activity of SMEs in Russia haven't yet gained essential development. At the same time, it is possible to note the pilot work of I. S. Pinkovetskaia (2014) in which the method of developing production functions according to the data of small and medium enterprises in the regions was considered in detail.

The analysis of the works stated above shows that assessment of production functions is related with a number of problems which are discussed below. The use of basic data for ten and more years (time series) is complicated by the need to take into account inflation processes. In addition, it is necessary to assume that operating conditions of the considered research object for the considered interval of time will be identical or, at least, undergo few changes that in practice are not always fulfilled. Time series are often limited in length, and dynamics change of indicators experiences especially essential fluctuations because of crisis phenomena in the economy. When used as a factor describing the cost of capital and values of fixed assets, the main problem is the reliability of information on the actual share of fixed assets in production. The assumption of full use of fixed assets does not always correspond to their actual loading. The situation is similar with the second factor. The number of employees directly occupied in production processes does not always coincide with the actual labor costs, as often employees are not busy all day (working week). It leads to erroneous indicators in the evaluation of labor factors. In recent years, the trend of modifications of production functions by supplementing the list of factors leads to the appearance of multicollinearity, and requires a theoretical justification for the possibility of using them.

Methodical approach to assessment of production functions

Small and medium enterprises located in each of Russia's regions were considered as a research object. The current law (On the development of small and medium enterprises in the Russian Federation, 2017) has established the main criterion for classifying enterprises as small and medium ones. It is proposed to consider the number of employees engaged in SMEs as this criterion. Thus, the number of employees for microenterprises should not exceed 15 people, for small businesses (without microenterprises) this figure ranges from 16 to 100 people, and for medium enterprises - from 101 to 250 people.

Taking into account the approach accepted in Russian statistics, the volume of production of small and medium enterprises can be characterized by the total turnover which consists of the cost of goods of their own production and proceeds from the sale of the purchased goods.

In accordance with the recommendation of A. G. Granberg (1988), the number of factors in the production function must be small, since in this case necessary calculations and interpretation of the results are simplified. Given the analysis, we considered investments in fixed assets and employees' wages as factors of production functions. Correlation analysis showed that these factors have the greatest impact on SMEs turnover. At the same time, there is no mutual connection (collinearity) between them. It should be noted that the investment flow provides more acceptable results compared to such factor as fixed assets. As we indicated earlier, this conclusion was made by V. A. Bessonov & S. V. Tsukhlo (2002) and E. E. Gavrilenkov (2000) on the basis of incomplete use of fixed assets in SMEs. Wages of employees in SMEs represent a comprehensive indicator which considers not only the labor costs of production, but also the characteristics of a particular region (price level, employment and other socio-economic aspects). In addition, the use of employees' wages as a factor ensures identical dimension of all indicators of production functions. The identical dimension of all indicators of the production function, as shown in the article (Felipe & McCombie, 2012), provides high quality of the relevant models.

In our research we used spatial data characterizing the considered factors and the resulting indicators for all SMEs located in each Russia's region. This approach is caused by the following. The criteria for classifying

enterprises as SMEs have changed many times in recent years. The current criteria have been used since 2008. Accounting for SMEs is carried out once a year, and the data are submitted to statistical bodies. Therefore, modeling of indicators characterizing the activities of such enterprises using time series is possible only for 9 years (from 2008 to 2016). Accordingly, the number of observations is equal to nine, which is less than the minimum acceptable value, which according to the criterion proposed by G. B. Khodasevich (2017) should be at least 16 for the two-factor function. Therefore, the production functions of SMEs based on time series data contradict this criterion. It should be noted that spatial data allow avoiding problems that are characteristic of time series, as mentioned in the literature review. Even the founder of the theory of production functions P. Douglas (1967) specified that at the same time functioning objects for one certain period are interesting to consider. Advantages of using spatial data in assessment of production functions are described in detail in the paper (Charoenrat & Harvie, 2013).

Our research included the following steps:

1. Collection and procession of initial statistical data. Formation of information arrays based on the data characterizing the sets of SMEs, located in each of Russia's regions. These arrays describe the values of SMEs turnover, flow of investment and wages for 2016.

2. Linearization of the data obtained at the first stage, which characterize independent factors and resulting variables for SMEs.

3. Development of production functions using the method of least squares.

4. Assessment of quality of functions using correlation and determination coefficients, Fisher-Snedecor and Student's tests as well as corresponding significance levels.

5. Verification of the developed functions for the presence of autocorrelation, heteroscedasticity and multicollinearity, and also verification of hypothesis that the distributions of the remains for each of the regressions are normal distribution functions.

6. Consideration of the theoretical and practical results following the analysis of the developed production functions and opportunities of their use.

In the research official statistics of Federal State Statistics Service (Federal Service of State Statistics, 2018) on activities of small and medium enterprises in Russia for 2016 was used. The research is based on data from 82 regions of Russia.

In the course of our research four production functions reflecting dependence of SMEs turnover on fixed capital investment and employees' wages in all regions of Russia have been developed. The functions constructed by the authors have the specification similar to the well-known Cobb-Douglas functions. The parameters of production functions were determined using the regression analysis methodology (Pindyck & Rubinfeld, 2013). The first function describes the activity of all SMEs located in each region. Three other functions correspond to three SMEs groups that were formed according to the above-mentioned size categories: medium enterprises, small enterprises (except microenterprises) and microenterprises.

The results of modeling

In the process of the computational experiment four production functions reflecting the dependence of turnover (volume of production) of small and medium enterprises on fixed capital investment and employees' wages were developed. The formulas and tables given in the article were developed by the authors.

The first function describes the turnover of all SMEs located in each region:

$$y_1(x_1, x_2) = 14.336 \times x_1^{0.135} \times x_2^{0.909}, \quad (1)$$

where y_1 - turnover of all SMEs located in the region of Russia for the year, billion rubles; x_1 - investments in fixed capital of all SMEs in this region for the year, billion rubles; x_2 - employees' wages of all SMEs in this region for the year, billion rubles.

The second function describes the turnover of medium enterprises located in each of the regions:

$$y_2(x_3, x_4) = 13.029 \times x_3^{0.108} \times x_4^{0.900}, \quad (2)$$

where y_2 - turnover of medium enterprises located in the region of Russia for the year, billions of rubles; x_3 - investment in fixed capital of medium enterprises in the region for the year, billions of rubles; x_4 - employees' wages of medium enterprises in the region for the year, billions of rubles.

The third function describes the turnover of small enterprises (excluding micro-enterprises) located in each region:

$$y_3(x_5, x_6) = 13.898 \times x_5^{0.115} \times x_6^{0.916}, \quad (3)$$

where y_3 - turnover of small enterprises (excluding microenterprises) located in the region of Russia for the year, billion rubles; x_5 - investment in fixed assets of small enterprises (excluding microenterprises) in this region for the year, billions of rubles; x_6 - employees' wages of small enterprises (excluding microenterprises) of this region for the year, billions of rubles.

The fourth function describes the turnover of microenterprises located in each region:

$$y_4(x_7, x_8) = 23.082 \times x_7^{0.128} \times x_8^{0.856}, \quad (4)$$

where y_4 - turnover of microenterprises located in the region of Russia for the year, billion rubles; x_7 - investments in fixed assets of microenterprises of this region for the year, billion rubles; x_8 - employees' wages of microenterprises of this region for the year, billion rubles.

The assessment of the quality of the obtained functions was carried out using correlation and determination coefficients, Fisher-Snedecor and Student's tests.

Logical analysis of production functions showed that they adequately describe the turnover of relevant small and medium enterprises in regions over the entire range of factors. Table 2 shows the calculated values corresponding to the specified coefficients and tests to verify the quality of all four production functions presented in this article.

Table 2. Calculated values on coefficients and tests

Quality indicators	Number of production function			
	(1)	(2)	(3)	(4)
Determination coefficient	0.959	0.923	0.965	0.936
Correlation coefficient	0.979	0.961	0.982	0.968
Calculated value according to Fischer-Snedekor's test	890.247	441.314	1062.462	564.481
Calculated value according to Student's test for y - intersection	33.837	42.380	42.317	41.575
Calculated value according to Student's test for the first factor	3.572	3.126	5.258	3.643
Calculated value according to Student's test for the second factor	21.672	15.715	29.204	18.161

Comparison of the calculated values given in table 2 with the values of the tests presented in the literature showed that the production functions (1) - (4) are of high quality. The correlation coefficients are close to 1. The closer the coefficient of determination to 1, the closer it to the functional relationship between the volume of production and factors. According to N. Draper and G. Smith (1998), the functions are successful when determination coefficients exceed 0.8. In our case, they are above 0.923. The difference between 1 and the determination coefficient characterizes a share of dispersion which is caused by influence of other factors which are not included in the functions. That is, we can conclude that the functions (1) - (4) account for more than 92% of the variation of the dependent variables. Other factors which are not considered here account for 8%. The calculated values of all statistics are significantly higher than the tabulated value of Fisher-Snedekor's test, which is 3.98 with a significance level of 0.05. All calculated values of the Student's test are greater than the tabulated value, which with a significance level of 0.05 is 1.99. Thus, functions (1) - (4) well approximate the empirical data.

The verification of functions (1) - (4) using Darbin-Watson test showed that there is no autocorrelation, and Breusch-Pagan test showed the absence of heteroscedasticity. There is no multicollinearity that is there is no dependence between the factors, which is confirmed by the VIF test. In the process of initial data approximation using the method of least squares, the residues showing deviations of calculated values from the initial data have been received. Verification of distribution of these remainders for each of the four production functions was conducted on the basis of assessment of histograms graphs, normal distribution functions and tests of normality. Graphs of histograms of residues showed that all of them lumpy in the middle with thin, symmetrical tails. Residues concentrated about zero, because normal distribution functions have mean values near to zero. Tests of Shapiro-Vilk, Pearson and Kolmogorov-Smirnov showed the normality of the distribution of residuals. In general, it can be concluded that the developed functions fully satisfy the econometric requirements and therefore can be used for the interpretation of the studied phenomena.

Results and discussion

The developed production functions (1) - (4) prove the influence of the considered factors on the turnover of enterprises relating to the entrepreneurial sector of Russian regions' economy. Values of degrees for both factors in functions are positive, therefore, it can be stated that the stimulation of small and medium enterprises can be provided with increase in wage costs and growth of investment in fixed assets. Production functions for all considered factor values do not reach their maximum. This is confirmed by the fact that the values of the maximum return on both factors for all functions are positive on the considered ranges of the factors values change. Therefore, it can be concluded that the economy of Russian regions has not reached saturation with products of small and medium enterprises, and they have significant reserves for further development. That is, in all regions there are opportunities to increase the number of SMEs and the number of employees in them.

The sum of the degree values in the coefficients of the production functions (1)-(3) is more than 1, which indicates an increasing return to scale. A similar trend was observed in Asian countries (Khatun & Afroze, 2016). With the increase of both factors (fixed capital investment and employees' wages), production growth is faster than the factors growth. For example, with the growth of both factors in function (1) by 10% production increases by 10.44%. The accelerated increase in production volumes with the growth of factors is of economic and social importance. For a rapid increase in SMEs production in Russian regions, it is advisable to provide the simultaneous growth of these both factors. It will increase the returns to scale. It should be noted that for the regions with an excess of the working population (on the example of the republics of North Caucasus), the main direction of business development is connected with increase in employment and creation of family business. In regions where there are not enough potential employees (Siberia and the Far East), the main direction of increasing SMEs production is associated with an increase in investment in fixed assets. Cross derivatives of the production functions for each of the two factors are positive for all values of the range of changing factors, therefore the increase in one factor improves conditions for using the other factor. Thus, the growth of employees' wages increases the return on investment in fixed assets. Conversely, increased investment in fixed capital increases the wages level. The second derivatives of all isoquants are positive. The level of bulge decreases with the growth production volume of SMEs, which indicates an increase in the elasticity of substitutive factors: with the growth of production in entrepreneurial structures, the possibility of replacing one factor with another increases. The factor of employees' wages in all production functions affects turnover to a greater extent than the factor of investment in fixed assets.

The use of production functions is possible when solving such a vital problem as ranking the regions based on the efficiency of using resources such as investment in fixed capital and SMEs employees' wages. At the same time a comparative analysis of the actual turnover of all SMEs in the region and the value of turnover in the same region predicted on the basis of the production function can be used. In our opinion, the relatively great positive meaning of this value (that is, the excess of the actual turnover over the estimated one) indicates good business climate in the region. And accordingly, a large negative meaning of this value allows concluding that there are problems with the business climate in the relevant region.

The comparative analysis of the empirical data used when developing production function (1) and the predicted values for the same function showed a high level of business climate in Ivanovo, Irkutsk oblasts, the cities of Moscow and St. Petersburg, and Primorsky Krai. The low level of business climate according to the criterion of efficiency of the considered factors was noted in such regions as Tyumen, Kemerovo, Leningrad oblasts, Komi and Chuvash Republics, as well as Chukotka Autonomous Okrug.

Conclusion

The conducted research has a certain scientific and practical significance.

The scientific significance of the study is as follows:

- Methodical aspects of evaluation of production functions are considered. The problems arising from the use of fixed assets as a factor of capital and the number of employees engaged in production processes as a labor factor, as well as data generated in the form of temporary ranks are analyzed. The advantages of choosing investment flow and employees' wages and spatial data for one year as a factor in assessing production functions are shown;

- 4 two-factor production functions similar to Cobb-Douglas functions are developed during the research. These functions describe dependence of SMEs turnover on the considered factors for all regional SMEs in general, and for medium enterprises, small enterprises and microenterprises in particular. With the use of a number of tests, high quality of all developed production functions and their good approximation of the initial data are confirmed;

- Production functions prove that there are significant reserves for further development of business sector of the economy, namely, in all Russian regions, the saturation with SMEs goods and services has not been achieved. Increase in one of the factors of production function improves conditions of using the other factor. The factor of employees' wages in all production functions affects the turnover to a greater extent than the factor of investment in fixed assets. An increasing return to scale of small and medium enterprises is observed;

- Using production functions, regions of Russia with a high and low level of efficiency in the use of available resources (business climate) are identified.

The practical significance of the research can be realized in the activities of government bodies, in business sector of the national economy, as well as in educational activities in the following areas.

The new knowledge can be used in scientific research, in educational process while solving problems of small and medium enterprises.

The proposed methodological approach and tools for assessing production functions describing the activities of SMEs in the regions can be used in research on business problems, as well as in justification of the development programs of this sector of the economy at the federal and regional levels. The methodology and tools that were used in the research process can be applied to similar researches in countries with a significant amount of territorial (administrative) units.

The conducted research provides government, regional authorities and other administrative bodies with information on possible ways to increase the production of SMEs. The developed production functions are effective management tools that allow assessing the level of financial and labor resources of SMEs in Russia and particular regions. The results of the work can be used in the current activities of state, municipal and public organizations connected with regulation and support of small and medium enterprises.

The practical significance of the study is the possibility of using the results obtained to justify resources and monitor the business climate. The results of the study can be used by state and regional authorities to monitor the efficiency of investments in fixed assets and labor resources. That is, they can be used to assess the efficiency level of each of the discussed factors and also the revealed imbalance in factors values for each region. The functions can be used in justifying investments in fixed capital and labor resources, in developing plans and programs for the further SMEs development. The results of the study should ensure the implementation of the Federal Strategy for the Development of SMEs for the period till 2030 (the Federal Strategy for the Development of SMEs for the period till 2030, 2017).

Further research is connected with assessment of production functions of SMEs which are specialized in various types of economic activity and located in municipalities of particular regions.

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