

Factor Analysis of Regional Productive Forces

Anna Glebova

Department of World Economy and World Finance
Financial University under the Government of the Russian
Federation
Moscow, Russia
nauka_rf@mail.ru

Konstantin Kotelnikov

Department of Economics and Production Management
Tver State Technical University
Tver, Russia
ikostey@live.ru

Alexey Lebedev

Department of Economics and Production Management
Tver State Technical University
Tver, Russia
l_alex@mail.ru

Vera Nikolskaya

Department of Economics and Production Management
Tver State Technical University
Tver, Russia
nbvas@mail.ru

Abstract—The social and economic development of the territory depends on that of productive forces, the activity and rationality of their location and distribution, i.e. the stimulation of all productive forces of the region makes it possible to regulate reasonably and consciously production processes and, consequently, the growth of the gross regional product (GRP). The object of this study is productive forces of the region. The purpose is to develop diagnostic techniques to assess the factor activity of regional productive forces (using Tver Oblast as an example). The authors propose a mathematical model to correlate complex indicators of the regional production development with the main economic indicator of the region, GRP. In addition, they provide a multifactor model to measure the impact of each factor included in the model on the resulting indicator, i.e. to learn how much the activity of a particular element of regional productive forces affects the increase or decrease in the GRP value. The algorithm proposed will allow regional productive forces to be identified and their condition to be analyzed in an integrated and comprehensive manner. This, together with the consequent assessment of the mutual impact of the regional production and social and economic spheres, will address a number of practical issues of the regional development.

Keywords: *regional productive forces, gross regional product, development of the region*

I. INTRODUCTION

Today, the theory and practice of regional economy pays, in our opinion, insufficient attention to the assessment of the current state and prospects of local productive force development and distribution. We believe that these issues are of particular relevance, since regional productive forces are fundamental for the crucial economic indicators, namely, the gross regional product (GRP) and all derivatives.

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II. LITERATURE REVIEW

International literature do not provide any relevant findings on the topic either. A significant part of foreign researchers considers the theory of productive force development and distribution in the historical context of the socialist theory [1; 2; 3]. These researches allow us to rethink the factor composition of the productive forces and identify new aspects of the regional productive force development.

Of particular interest is the analysis of individual factors of productive forces in the context of economic development. Thus, Orlando Gomes correlates the change in the demographic factor (labor resources) with that in the technological level of the society, the digitalization of the economy, etc. According to the author, the efficiency of productive forces, on the one hand, is determined by the degree in which available technologies have already been mastered by labor resources. On the other hand, some labor skills may become obsolete and jeopardize the capacity of labor costs to create value, especially when there is a transition between technological modes [4].

The growth issues of the economy of productive force assessment, distribution and development are intensely studied by Chinese scientists [5; 6; 7], which is largely due to the search for reserves to increase the growth rate of China's GDP.

There is no doubt that the continuous search for ways to improve the efficiency of productive forces, as well as their

rational distribution on the territory, is of great scientific and practical interest for this country. Therefore, Academician A. G. Granberg, the chairperson of the Council for Productive Force Researches, member of the USSR Academy of Sciences (the Russian Academy of Sciences since 1991) says, “The study of productive forces, a process of natural or targeted distribution of objects and phenomena on the territory, is traditionally included in the subject of regional economy” [8, p. 14]. The objective evaluation of the state and development prospects of the productive forces of the territory is becoming increasingly relevant and urgent.

III. RESULTS AND DISCUSSION

It is expedient to identify the following basic elements of productive forces: labor resources of the territory, a financial and credit system of the region, a logistic system of the region, complex natural resources, science as an element of regional productive forces [9, p. 431]. All the structural elements largely determine and shape the trends in the productive force development. The impact of the factor activity of regional productive forces on GRP is discussed further by the example of the Tver region.

A. Labour resources of the territory.

A demographic factor consists of quantitative and qualitative characteristics and properties of the labor resource, which determine the composition and structure of a production process, act as a prerequisite and a capacity of the distribution of agricultural and industrial enterprises on a territory. The impact of labor resources on GRP is determined with the calculation of the factor activity index.

Individual indices, as relative characteristics, are often calculated for selected homogeneous populations to solve one problem – the study of trends. This study evaluates the activity of each factor element with the data provided by the regional official statistics for the period in the dynamics, both in kind and in value terms.

To characterize the factor activity of a productive force element (for example, labor resources) we present the obtained indicative index in the form of an individual factor activity index of the j -th element of productive forces as a percentage of the base period (equation 1).

$$I_A^j = Q_{t_1}^j / Q_{t_0}^j \times 100 \quad (1)$$

where I_A^j is an individual index of factorial activity of the j -th element of productive forces for the accounting t_1 period, in %; Q^j is an indexed indicator (quantitative, qualitative, quantitative and qualitative) of the j -th productive force element; $Q_{t_1}^j$ is a value of the j -th productive force element in absolute values for the t_1 period (the accounting period); $Q_{t_0}^j$ is the value of the j -th productive force element in absolute values for the t_0 base period.

B. A financial and credit system of the region.

Today a financial and credit infrastructure, as a factor element of the productive forces, is known to be one of the starting points of the productive force formation, a condition for the existence of a regional social and economic system as a whole. Moreover, the stable functioning of the financial system itself is a direct result of both the indicator growth of the regional productive force activity in aggregated terms and the extent of financial and credit institution participation in the activities and development of the regional production sector.

The status of regional economic organizations' accounts is the size of their total indebtedness to financial institutions for loans and borrowings. It might be advisable to choose its trend as a reference indicator of the financial institution participation in the activities of a regional production sector.

C. A logistic system of the region.

The baseline of effective logistics is a total cargo turnover. The regional one based on a dominant (road or rail) type of transport communications should be chosen as a key indicator. The indicator, in accordance with a concept of integrated logistics in the region, accurately reflects the activity level of consolidated and closely linked areas of a logistic system without any regard for their functional nature.

A material flow is known to form because of certain cumulative actions with material objects. Being a basic value of the activity of this regional productive force element, the indicator of a cargo turnover measured in million tons per kilometer is used, the average journey of a ton of cargo being taken into account. Therefore, it is possible to determine the final output volume of the material flow by the integrated logistics types at the regional level as the quotient of turnover to the average journey.

D. Complex natural resources.

Natural resources are basic conditions of humanity who is increasingly using them, molding their needs, setting goals and choosing methods of their immediate achievement. Currently, the category of ‘complex natural resources’ is quite extensive and includes, first of all, land (territorial) resources as well as mineral, biological, energy, and water ones which are derived from them and closely related to them due to location. This study requires a single indicator of complex natural resource utilization in the regional economy. Based on the approach to analyze the factor activities of the productive forces of this category, a weight unit is taken as bulk values of the reporting and previous years, which is derived from the value of the development of certain resources during the production process. The Federal State Statistics Service (Rosstat) is known to put the land reserves of the Russian Federation into three major categories: land of forests, agricultural land, and surface water (including bogs and swamps). In addition, Rosstat uses a composite index of industrial production and an index of agricultural production, which reflect the activity of regional economic entities in the development and use of land [10, p. 492]. Hence, the index of integrated use of natural resources can be calculated as follows (equation 2).

$$I_{N(t)} = E_{i(t)} / E_{i(t-1)} (I_{up} \times I_{ak}) \times 100 \quad (2)$$

where $I_{N(t)}$ is an index of complex use of natural resources; E is land resources; i is an indication of land resources as part of category E ; I_{up} is a composite index of industrial production; I_{ak} is an index of agricultural production; $E_{i(t)}$ is the value of an index at t and $t-1$ respectively.

The index obtained in this way is an exception to the calculation model presented previously and characterizes the total load on the land and natural resources located in space. However, it is worth remembering that the auxiliary indicators used in its calculation are derived from cost values, therefore, a deflator should be applied, first, to convert the chain system of indexes into the base one and, then, to derive the index of factor activity by the productive forces element 'complex natural resources'.

E. Science as an element of territorial productive forces

The close integration of science and industry began a little over a hundred years ago. It would be no exaggeration to say that their integration has been the main supporting structure of the industrial society. We should not forget that science has a comprehensive and fundamental character, therefore, in order to assess its impact on GRP we propose to consider the number of patents granted for utility models, advanced production technologies and inventions. This activity indicator should be used to calculate an individual index of the factor activity of science as an element of regional productive forces.

In order to obtain the data reflecting fairly the activity of productive force elements in the years, quantitative (in this case, cost) indicators of the productive force activity are to be reduced to those of the base period.

A GRP deflator, which characterizes the average price fluctuations in the regional economy for a certain period, is known to be the ratio of a nominal GRP, expressed in the market prices of the current reporting year, to a real GRP, expressed in the prices of the base year. It is obtained by dividing a GRP cost index (in current prices) by a GRP volume index or by dividing the GRP cost in the current period by its current cost estimated in the prices of the base period.

A GRP volume index is calculated by dividing the GRP cost in the current period, estimated in the prices of the base period, by its cost in the base period.

In the process of constructing an indexing system, we might use a system with both constant and variable bases of comparison (weights). An indexing system with constant weights is referred to as a system of general indices of the same phenomenon. The indices are calculated with the weights not changing in the conversion from one index to another. The study uses an index of a GRP physical volume to represent a system with a constant base of comparison. The use of constant weights eliminates the impact of structural changes on the index value.

The product of two or more consecutive chain indices with constant weights is known to give a base index of the final

period. Conversely, the ratio of a base index of the reporting period to a base index of the previous period gives a chain index of the reporting period. In other words, the quotient of a consequent base index with constant weights by a previous base index with constant weights gives a relevant chain index.

An indexing system with variable weights is a system of general indices of the same phenomenon or process calculated with weights that change sequentially from one index to another. The elements of this system are deflator indices, which are important for converting the cost indicators of the system of national accounts into comparable prices. Systems of general indices have the same properties as systems of individual indices, i.e. knowing the base ones we can find the chain ones and vice versa the knowledge of chain indices helps to get the relevant base ones.

Therefore, a GDP cumulative deflator index is a correction value to correlate the values of the factor activity of the selected productive force elements in the current and base periods.

On the assumption of the premise that the degree of social and economic development of a territory depends on the level of its productive force development, distribution activity and expediency, we can determine the relationship between complex indices of a regional production development (factor x) and the main result indicator of a regional economic development, GRP (factor y).

A correlation coefficient is calculated with the assessment of the degree in which the directions of individual values of determinant and effective indicators deviate from the corresponding mean values.

The Fechner correlation coefficient is calculated to identify the relationship between complex indicators of a regional production development (factor x) and the main resulting indicator of economic development or GRP (factor y) by the example of the Tver region (Table 1).

When determining the closeness and nature of the relationship by calculating K_f (the Fechner correlation coefficient), we reject the value of the base period indicators because they show non-transitivity properties and do not reflect the trends of the process under study.

The mean values are the following:

$$x_m = (\sum x_i) / n = 4.503 / 5 = 0.9$$

$$y_m = (\sum y_i) / n = 5.025 / 5 = 1.01$$

The Fechner correlation coefficient is calculated as the ratio of the difference between the number of pairs of sign concordance and discordance to their sum, i.e. to the total number of the units observed:

$$K_f = (\sum n_a - \sum n_b) / (\sum n_a + \sum n_b) = (5 - 0) / (5 + 0) = 1$$

Correspondingly, the value of the coefficient indicates that a high level of direct correlation of the indicators under study is highly likely.

In this regard, it might be appropriate to estimate the sign correlation coefficient and determine its significance. The significance of the Fechner coefficient is verified with Student's t-test:

$$t_{calc} K_f \times [\sqrt{(n-2)} / \sqrt{(1-K_f^2)}] = 1 \times [\sqrt{3} / \sqrt{(1-1^2)}] = 173.21$$

With Student's table we can find table:

$$t_{table}(n - m - 1; a) = (3; 0.05) = 2.353$$

Since $t_{calc} > t_{table}$ we reject the hypothesis that the correlation coefficient is equal to 0. In other words, the Fechner coefficient is statistically significant (with 95% probability).

An economic interpretation of the model parameters is also possible: increasing 'x' by one unit of measurement leads to increasing 'y' by one unit of measurement. Thus, the Fechner coefficient is statistically significant and the established correlation between the estimates of the initial data with the two tests is direct and significant.

The described method of analysis makes sense both for multiplicative and multiple as well as rigidly deterministic (multifactor) models.

TABLE I. VALUES OF DETERMINANT AND EFFECTIVE INDICATORS *

Period (year)	x_i	y_i	Signs of deviations from the mean 'x'	Signs of deviations from the mean 'y'	Concordance (a) or discordance (b) of signs
2013	0.948	1.010	+	+	a
2014	0.767	0.998	-	-	a
2015	0.899	0.992	-	-	a
2016	0.982	1.007	+	+	a
2017	0.907	1.018	+	+	a
Σ	4.503	5.025			

* the calculation is carried out by K. A. Kotelnikov in the preparation of his PhD in Economics thesis

It is obvious that the process of studying the impact of any group of factors on GRP of the territory requires their organization, i.e. their analysis so that to take into account their internal and external relations, interactions, and hierarchies. This is achieved by systematization with the identification of their relationship and subordination. Sampling and consequent evaluation of different variants of multifactor models allow the correlation coefficient to be identified and justified.

IV. CONCLUSION

Thus, the result of the correlation analysis allows us, with a certain degree of confidence, to conclude that there is a direct dependence of the effective indicator 'y' on the determinant of the regional productive force activity by the factor 'x'. Correspondingly, as we presumed earlier, the degree of social and economic development is directly dependent on the level of regional productive force development, distribution rationality, as well as the activity and efficiency of their application.

Based on the statement already proven that the activity of regional productive forces is, by convention, the final value of GRP in absolute terms, with a known proviso within the theoretical model, we have the following identity (equation 3).

$$A^* \propto GRP^* \text{ or } I_A^* \times GRP_0 \approx GRP^* \Rightarrow GRP^* - GRP_0 \approx \square GRP$$

where GRP_0 is the value of GRP in absolute terms for the base period.

Naturally, all the phenomena and processes of the regional economy are interrelated and interdependent. Some of them are directly related to each other, others are related indirectly. Hence, an essential methodological issue of the economic analysis is to study and measure the impact of factors on the value of the economic indicators under study.

The logic of our study stipulates that the primary task of a factor analysis is to build a model defined by a strict logical analysis. The details of the factor analysis are largely determined by the number of factors as well as the extent of their impact on the resulting indicator. At the same time, the method of assessing the impact of factor productive force elements is based on the elimination principle where the impact of factors on the resulting indicator value is estimated with alternate exclusion. Hence, the research methodology of this multifactorial model is of interest, first of all, as the way of determining the degree of an impact of each of the factors included in the model on the resulting indicator, i.e. determining how much the activity of a particular productive force element determines the increase or decrease in a GRP value.

Therefore, to create a general theoretical model and analyze the impact of selected factor elements of productive forces on the resulting indicator of regional development we should, at this stage of the study, put aside other, not yet selected, factor elements of productive forces. Then we should accept the absolute value of GRP as a complex effective index of the productive force activity, the absolute value of GRP being derived from the activity of the productive forces of the territory.

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