“Problems of statistical study of labor productivity in construction”

AUTHORS	Alina A. Kamalova Wilfred Isioma Ukpere https://orcid.org/0000-0002-3308-0081

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Alina A. Kamalova (Russia), Wilfred Isioma Ukpere (South Africa)

Problems of statistical study of labor productivity in construction

Abstract

The article focuses on the problems of statistical measurement of labor productivity in construction, as recent years saw the most significant changes in the methodology of calculating construction products. The study examined the factors affecting the dynamics of labor productivity in construction, calculated by the volume of work at estimate piece that is at the index known as "average output per worker" in the practice of planning and statistics. Labor productivity is a complex qualitative index, which is influenced by numerous factors. Therefore, the most effective method for studying the dynamics of labor productivity is the use of the index method. The index method seems to be widely used in statistical research of labor productivity in construction.

Keywords: productivity, construction, factors, index method, value indice, economic and statistical analysis.
JEL Classification: J01.

Introduction

Productivity growth is essential for the development of construction industry. The entire increase in the volume of construction and installation works can be obtained due to this factor. In this regard, statistical study of labor productivity is of particular relevance in the construction where, in our opinion, the main directions that should be considered are:

- evidence-based selection of methods for measuring labor productivity;
- designing a system of labor productivity indices which provides control of labor productivity growth in all sectors of the construction industry; and
- studying the effect of factors that shape and determine the level of the dynamics of labor productivity in construction.

In solving the problems that are central to the statistical study of labor productivity, it is necessary to take into account peculiarities of the construction, which are primarily associated with manufacturing of construction products.

1. Problem statement

Labor productivity is a complex, multifaceted phenomenon, whose level and dynamics are affected by a variety of factors. Therefore, it is necessary to study statistically this phenomenon taking into account the hierarchical structure of the sector's management. The methods used in measuring productivity in the construction company cannot be the same for other workplaces. This is due to the very nature of labor productivity as a qualitative category (Parrotta, Pozzoli & Pytlikova, 2014). It is known that labor productivity is calculated as the ratio of the result and the cost of labor. Performance, i.e., products passing through certain stages and has a variety of forms. In this part, the statistics of labor productivity depends largely on methods of production account which, in essence, determine the existing methods of measuring productivity. The current study looks into these problems of statistical measurement of labor productivity in construction, as recent years saw the most significant changes in methodology of calculation of construction products (Hamouda & Abu-Shaaban, 2014).

2. Research objectives

The objectives of the study are:

- To examine the statistical measurement of labor productivity in construction.
- To identify the system of labor productivity indices, which provides for controlling labor productivity growth in all sectors of the construction industry.
- To investigate the influence of factors that significantly affects productivity in construction.
- To proffer measures for improving productivity in construction.

3. Theoretical foundation

National and foreign scholars are continuing research into the calculation methodology of labor productivity in present conditions of economic development. Some scholars have suggested highlighting key (through) and additional (analytical) indexes of labor productivity. In construction, the role of key indices in the system is given to the output index by estimate price. This is due to several factors. This index fully reflects, as if accumulating, at the level of labor productivity at all stages of the finished construction products (Bondarenko, 2000; Choi, Haque, Lee, Cho, Kwak, 2013).

Alina A. Kamalova, Ph.D., Senior Lecturer, Kazan Federal University, Institute of Management, Economics and Finance, Russia.
Wilfred Isioma Ukpere, Department of Industrial Psychology & People Management, Faculty of Management University of Johannesburg, South Africa.

Marx wrote that "during the labor process work constantly changes from the form of activities into the form of existence; from the forms of motion into the form of thingness". So there must be an index of labor productivity which would reflect the whole work that is materialized in the construction of production of both past and live (Marx & Engels, 1968). National economists, Klyuyev and Zaitsev conducted an experiment on the use of net production index in 12 construction companies. And they concluded that the net material product cannot be clearly separated from the traditional indices to assess the production activities of the organization (Klyuyev & Zaitsev, 2014).

It is necessary to agree with Krasnopevtseva, who states: *"But just as it is impossible to bury performance index taking into account all labor input, so you cannot do with labor productivity indexes, taking into account only the living labor which has a cognitive nature and economic content"* (Krasnopevtseva, 2011). Thus, for the objective characteristics of construction company operations as a complex socio-economic system, one should use an index system of productivity. It is necessary, to consider that the volume of production is a general characteristic of any organization, and the amount of production work is only individual (particular). In this context, labor productivity index calculated at an estimate price enables its uniform development for all levels of construction management (Polovkina & Badreeva, 2014).

4. Research methods

To calculate labor productivity index of the traditional pattern, it is necessary to solve the issues related to the methods of measuring labor costs with the denominator of the fraction. The most important two of them are:

- Firstly, the number of employees to be included in the calculation of labor productivity in construction.
- Secondly, the "dimensionality" of working time fund and its influence exerted on the level and dynamics of labor productivity.

The first issue relates to the fact that in the construction industry it is customary to calculate labor productivity of only the so-called core production workers, i.e. those employed in the construction and assembly works and auxiliary production owned by the construction companies. This calculation does not include a significant group of workers of "other productions" working mainly in procuring and storage and transport facilities. This poses a number of methodological and practical difficulties in calculating labor productivity in construction. In the first place, the very division of workers into "core" and "temporary" raises some doubts (Gagarinskiy, 2013).

5. Literature review

In modern conditions, logistical support in construction increasingly takes on the form of production and technological equipment of construction projects, where workers of the procuring and storage and transport facilities are involved in a single process with hardly distinguishable engineering functions of the process participants. Therefore, in our view, one would calculate the labor productivity of "a collective worker" employed in the construction without a conventional division of workers into the core and temporary. This would eliminate the possibility of distorting the level and dynamics of this index when allocating workers to "other facilities".

As for the "dimensionality" of working time fund, we will consider the matter in the near future, in connection with the study of how the factors influence productivity. However, it is important to focus on the main issue – the numerator i.e. to the measurement of performance. It is known that performance and products can be measured by various methods. In essence, the methods of calculating labor productivity are determined by differences in methods of measurement, namely, of comparing products, and in particular construction ones. In construction, as in other sectors, it is customary to apply physical, labor and value methods of measuring products, and consequently productivity (Simar & Wilson, 2015).

However, the role, significance, limitations of each of the above methods is different in construction. The very measurement of construction products within the specific methods differs depending on the level of construction management. This is due to technological specialization in the manufacture of construction products. Most of construction and installation work is performed by specialized construction companies. Naturally, physical and value parameters of construction products are different for each of the cooperating participants in creation of the final product, namely buildings to use for their designated purpose.

The difference between the methods of measuring labor productivity and variation within meters of each method necessitate developing a system of labor productivity indices that manage the process of its growth at all levels of the construction industry. We attempted to develop a system of labor productivity indices in construction as a matrix that displays the basic levels of the organization and

management of construction and indices of construction products and labor productivity corresponding to them (see Table 1).

In the construction industry the most widespread and important are value indices of labor productivity, with the prevailing ones calculated on the basis of measuring gross construction products in the estimate prices. This is due to several factors including primarily construction features and its products. Therefore, it can be said that such a complex economic phenomenon as productivity cannot be adequately quantified only by one index, for there is no "ideal" index in all respects; it is necessary to create a system of differentiated labor productivity indices, because different levels of management and organization of the construction change the requirements for them. If at the industry level generalization is acceptable to measure the level and dynamics of labor productivity, at the level of the enterprise, the site and workplace indices should have more precise specific content. However, all the indices included in the system must have a common methodological development principle, and the whole system of labor productivity indices should reflect the progressive tendencies in the measurement of construction products.

Table 1. The indices system of construction products and labor productivity

The level of construction organization and management	Index of construction products volume			
	Physical	Labor	Value	
			In estimate prices	Net output
Workplace Gang Site	Work volume in physical terms	Work labor input in physical terms	Value volume of the work done	The same by the convention of net output
Construction enterprise	Completed construction and installation works on the facilities and construction sites – finished products	Labor input of finished goods of construction enterprises	Gross construction products Plant construction products	The same by the convention of net output
Industry	Completed facilities and construction projects	Labor input of units of completed facilities and construction projects	Gross construction products of the industry Finished construction products	Net output of the industry, national income generated in construction
The level of construction organization and management	Labor productivity index			
	Physical	Labor	In estimate prices	Net output
Workplace Gang Site	The average worker productivity in physical units by type of activity	The average labor input of work volume in physical terms	The average worker productivity	The average worker productivity by the convention of net output
Construction enterprise	The average worker productivity in units of finished products	The average labor input of units of finished products	The average worker productivity by gross construction products The average worker productivity by plant construction products	The average worker productivity by the convention of net output
Industry	The average worker productivity in units of measuring orientation of finished construction products	Average labor input of units of measuring orientation of finished construction	The average worker productivity by gross construction products The average worker productivity by plant construction products	Average national income generated in the industry per one worker

Source: authors' fieldwork.

In our opinion, a distinctive feature of the indices system proposed in the study of labor productivity is its consistency with the main objective of activities of construction enterprise and the industry in general whose goal is to give final economic results.

6. Results

The study examined the factors affecting the dynamics of labor productivity in construction calculated by the volume of work at estimate piece that is at index known as "average output per worker" in the practice of planning and statistics. The statistical study of the factors affecting the dynamics of the average output per worker is extremely important because many of the shortcomings attributed to this index are the result not of the index inadequacy, but of the imperfections in methods to identify factors affecting its level and dynamics, and most importantly, ways to eliminate their negative influence. Among the main factors affecting the dynamics of labor productivity in construction, the following are noted:

- Changes in the structure of construction products that is a set of construction and installation work on the project or the ratio of different types of projects with different labor and materials consumption.
- Change in the design considerations made in the construction of buildings and facilities. The influence of this factor is great in construction, but unfortunately, its statistical study is not widely delivered.

- Since the average output index is calculated in construction per worker employed in the construction and assembly work and auxiliary industrial productions, the level and dynamics of this index in many cases depend on the starting point of the production process, i.e. on the change in the number of employees in auxiliary industrial productions.
- The average output index calculated per average payroll worker depends on the proportion of administrative staff in the number of employees and on the use of working time funds.

The statistical study of these factors is important because they significantly affect the dynamics of labor productivity in construction. Labor productivity is a complex qualitative index exposed to influence on numerous factors. Therefore, the most effective method for studying the dynamics of labor productivity is the use of the index method. The index method is widely used in statistical research of labor productivity and in construction. The study found that to eliminate structural shifts in the composition of construction and installation works it is advanced to apply the average index, namely the index calculated according to the formula proposed by S.G. Strumilin:

$$I_{lab.prod} = \frac{\sum \frac{B_1}{B_0} T_1}{\sum T_1} = \frac{\sum iT_1}{\sum T_1}, \quad (1)$$

where B_0 and B_1 – the average output per individual types of work, types of construction and types of projects respectively in the reference and reporting periods; T_1 – work time expenditure (as a rule, it is not work time expenditure, but the average payroll number of workers) for each type of work (a construction, project type) in the reporting period.

Repeated use of this index to measure the dynamics of labor productivity instead of (or rather, in addition to) commonly used index (of variable composition) in various construction companies gave good results. Effect of changes in design considerations on the dynamics of labor productivity can be measured by our proposed system of indices based on the fact that the index of labor productivity is essentially the ratio of the volume of production index and the index of working time expenditure:

$$I_{lab.prod} = \frac{\sum Q_1 P_{est}}{\sum Q_0 P_{est}} : \frac{\sum T_1}{\sum T_0}, \quad (2)$$

where Q = volume of construction and installation works, P_{est} = fixed (comparable) estimate price. Therefore, it is possible to eliminate the influence of changes in design considerations on the dynamics of labor productivity by calculating changes in estimated price of works and labor input index of these works (in the reporting period compared with reference one). Hence:

$$I_{\substack{Labor\ productivity\ due \\ to\ design\ considerations}} = \frac{I_{Estimate\ price}}{I_{Labor\ intensity}}. \quad (3)$$

We have tested this technique on one of the construction companies where the index of labor productivity due to design considerations made 0.82. Thus, as a result of an unfavorable combination of dynamics of estimate price and labor input per 1 m^2 of the total area, the output decreased by 18%. The average annual output of Construction Company increased by 19%. In order to eliminate the impact of changes in design considerations, it is necessary to divide the index of total output by the index of change in labor productivity due to design considerations: 1.19: 0.82 = 1.45. So, without taking into account changes in the design considerations, the average annual output of the company for the 2010-2014 increased by 45%. Effect of shifts in the starting point of the production process is easily avoided as in dynamical comparing of labor productivity indexes, the latter should be calculated only for the workers employed in the construction and installation works.

In our example, the average annual output figures calculated in this manner are as follows: 2010 – 276300 rubles, 2011 – 281060 rubles, 2012 – 300100 rubles. As such, the figures, of course, are comparable and give a real idea of the dynamics of labor productivity.

Special attention should be paid to the study of the influence of factors of working time expenditure on the dynamics of labor productivity in construction. This industry is characterized by significant loss of working time, which has a negative impact on labor productivity. The most effective method of economic and statistical analysis of the factors influences the use of a system of interconnected factor indices. The most methodologically important and yet controversial issue of using interconnected factor indices is the selecting of transformation system of total index of labor productivity into the sub-indices. Although the number of patterns can be formally big, not all of them have a real economic content. The sequence of factors transformation should be such that the accession of each factor to the previous or to the product of the preceding factors would lead to an economically meaningful value, and in each pair one of the factors is considered as a quality index, and the other against it as quantitative one. We have proposed the following system of interrelated factor indices:

$$I_0 = \frac{a_1 * b_1 * c_1 * d_1 * e_1}{a_0 * b_0 * c_0 * d_0 * e_0}, \quad (4)$$

where 0 – the annual volume of work; a – the average payroll number of employees; b – the proportion of workers in the number of employees; c – the average number of days worked (attendance) of a payroll worker per year; d – the average length of the working day; e – average hourly output per worker.

The value (c, d, e) is the average annual output per worker, and (a, b) – the number of workers. It is proposed to develop the system of sub-indices as follows:

$$I_0 = \frac{a_1 * b_0 * c_0 * d_0 * e_0}{a_0 * b_0 * c_0 * d_0 * e_0} * \frac{a_1 * b_1 * c_0 * d_0 * e_0}{a_1 * b_0 * c_0 * d_0 * e_0} * \frac{a_1 * b_1 * c_1 * d_0 * e_0}{a_1 * b_1 * c_0 * d_0 * e_0} * \frac{a_1 * b_1 * c_1 * d_1 * e_0}{a_1 * b_1 * c_1 * d_0 * e_0} * \frac{a_1 * b_1 * c_1 * d_1 * e_1}{a_1 * b_1 * c_1 * d_1 * e_0}. \quad (5)$$

Transformation started with the quantitative factor, namely the number of employees, and in the group of sub-indices of labor productivity it also started with a quantitative factor – the average attendance per worker. The chain is closed with quality factor, namely the average hourly output per worker. This quality factor is taken at the level of the reference period and the quantitative one – at level of the reporting period. The choice of such sequences is due to the following reasons. To the greatest extent we are interested in the influence of the dynamics of the average hourly output (i.e., "net work") on labor productivity. However, the reported average hourly output is inextricably linked to the number of man hours worked during the reporting period, i.e. with a product of $a_1*b_1*c_1*d_1$. Therefore, first it is necessary to consistently determine this value, and only then to adjust to the index of average hourly output. The chain is closed by an average hourly output index where a factor (weights) is the quantity of man-hours in the reporting period. Average hourly output is weighed on the basis of man-hours. Therefore, the substitution of production index into the formula as the first reported value is not correct.

Conclusion

Thus, the purpose of the analysis, which determines its internal logic, in our opinion, is that it is necessary to determine how change in quality factor affects the level of the average annual output per employee at the current level of quantitative factors. In other words, it is important to determine how the impact of extensive factors distorts the change level of average annual output value of the employee due to the intensive factors.

It is of great importance to determine growth trends of labor productivity in construction, since improving the quantitative values of extensive factors has objective limitations (for example, working hours are strictly determined by the labor legislation and it is possible to increase the share of workers in total employment only to a certain limit), and improvements in the intensive productivity growth depend on the achievements of scientific and technical progress. The statistical study of labor productivity should contribute significantly to its growth in such important sphere of material production as capital construction.

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