The development of a forecast model of labour productivity management at industrial enterprises

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Abstract – **The article gives the analysis of the applicability of the concepts "labour productivity" and "productivity of an economic system" at different stages of creating added value in the new industrialization. The main tools for managing productivity have been identified and those that can be applied in short term and with minimal costs by identifying internal production reserves have been selected. The structuring of short-term and long-term goals of increasing labour productivity has been carried out, and tools for managing labour productivity that are effective in short term have been proposed. On the basis of the study of the level and dynamics of labour productivity at some enterprises of the machine-building complex of Samara region and with the use of economic and statistical methods of analysis, namely, time series analysis, index method and factor analysis forecast tools have been developed. The constructed econometric model of the correlation dependence of labour productivity on the capital productivity index has a high degree of approximation and can be recommended as a model for forecasting labour productivity at industrial enterprises. This is especially important when developing a strategy for the transition to digital industrialization.**

Keywords– labour productivity, investment tools, new industrialization, econometric modelling

I. INTRODUCTION

The long-term development strategy of Samara Region sets high parameters of economic growth rates: at least 5% of gross domestic product annually which to a large extent depend on the growth rates of labour productivity. High rates of economic growth are also determined by the emerging new economic structure - new industrialization or the fourth industrial structure [1]. Opportunities for labour productivity increase are determined by the developed regional production infrastructure which is characterized by industrial diversity, high level of labour potential, good possibilities for transport communications development and many other advantages of the economic and social life of the region.

At the same time this potential is not used to full extent; in recent years there has been a decrease in the pace of development in many spheres of the economy. For example, the rate of labour productivity is not more than 1.3% per year.

This is an extremely low figure which can not provide the necessary economic growth.

One of the priority clusters of Samara Region is machine-building cluster; the increase of labour productivity in this sector of the economy can become a driving force for related industries, services and education. The increase of labor productivity serves as a benchmark for new industrialization for other sectors of the economy.

Low labour productivity at many Russian enterprises is stipulated not only by the high degree of depreciation of equipment, but to a large extent to the high level of losses of various kinds, including defects, equipment downtime, poor product quality, inefficient organization of work, low motivation of personnel and other factors which determine production culture.

II. LITERATURE REVIEW

Theoretical studies of labour productivity have had rich historical roots since the beginning of the twentieth century both in Russia [2, 3] and in other countries [4, 5, 6, 7] but still the subject of research provides good opportunities for discussion on various aspects characterizing labour productivity. For example, it is interesting to reveal if labour productivity can be considered a factor of production or its indicator [8, 9], how to measure labour productivity [10] or what influences the growth of labour productivity [11].

Most often we can notice the obscurity of the concepts of labour productivity and productivity of the production system in general: economic literature shows the distinction between these concepts [12, 13, 14] but at the mesoeconomic and macroeconomic management levels these concepts are often interchanged [15]. This leads to inadequate interpretation of cause and effect, complicates the searching of managerial decisions, reduces a serious economic problem to populist statements and waste of funds [16]. In this study we conducted research of labour productivity as an element of economic system productivity.

Modern Russian authors generally have similar positions in the interpretation of the goals of increasing labour

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productivity: reducing the cost of production while improving its quality [17-20]. In general, we can agree with them, but our position has a broader interpretation: the highest labour productivity indicators can be obtained with a high added value of goods, as indicated in various studies, but with other accents [21].

We consider it necessary to present the process of creating added value as the process consisting of two parallel processes of creating new high-tech products and output of products with the use of traditional technologies. And when these two processes are superimposed over time, there is a uniform increase in labour productivity both in short-term and in long-term. In the long run research and innovations will become the basis for new products and technologies creation and the centre of added value creation.

In the long run, the main quantity and quality of workplaces will be concentrated at this stage, while at the production stage, due to new automated and robotic technologies, the number of jobs will be reduced, labour in this system will have different character and the requirements to the quality of workforce will be higher. However, in short term, the production phase, when traditional technologies are used, is decisive and it is necessary to look for ways to increase labour productivity here that is proved by previous studies [22].To coordinate the parallel processes of creating new technologies and increasing labour productivity with the use of traditional technologies, managerial and guiding actions are needed which allow comparing and synchronizing the multidirectional actions of numerous participants and interested parties, both individuals and legal entities. When the efficiency of existing industries using traditional technologies is increased, we can expect 5–7% increase of labour productivity during the first three years after the activities aimed at the increase of labour productivity at a particular enterprise are started. In such a situation, forecasting the rate of increase of labour productivity becomes a topical scientific task that can be solved by managerial, economic, and economic-mathematical methods.

III. METHODOLOGY OF RESEARCH

The task of increasing labour productivity in short term is placed at the managerial level of problem solving, which is an integral part of the strategic management goal of improving production efficiency, and is solved with the use of appropriate tools.

In the given research productivity management tools are understood as a set of economic and managerial means and methods used to increase the level of labour productivity at an enterprise in specific organizational and technical conditions of production with a deficit of financial, labour and other resources.

A number of calculations having methodological character are based on real examples of manufacturing enterprises of Samara Region. When solving the tasks, time series method, factor method, index method and other methods of analysis were used. Monitoring of data collection, analysis and evaluation of statistical information on the dynamics of labour productivity and analysis of individual

factors affecting changes in labour productivity were performed with the use of natural method, cost method, factor method and index method. To determine the relationship of the factors and to identify the degree of their influence, econometric and economic-mathematical methods and models were used, including correlation analysis, regression analysis, method of qualitative analysis and comparisons of labour productivity, as well as panel data analysis.

IV. THE RESULTS OF THE RESEARCH

The operational level of labour productivity increase is the area with the most measurable indicators and the ability to achieve measurable results. These results are a combination of several parameters: the added value per employee, revenue per employee, the coefficient of fixed assets use. In the given research the analysis of the level and dynamics of labour productivity at the machine-building enterprise of Samara region was made through the indicator of output - the number of products per unit of time in value terms quarterly during the period of 2015-2017 (Fig.1). Cost method is a universal way of measuring labour productivity, in which the volumes of all types of products are expressed in monetary units which makes them comparable and makes it possible to summarize them into one general indicator.

For example, during the analyzed period there was more than 2 times decrease in the rate of output growth. The forecast of labour productivity growth showed that the tendency for decrease at the enterprise observed in recent years will continue in 2018. This situation may be caused by a number of reasons. First, the growth of labour productivity of workers in 2015 was affected by the renovation and modernization of the material and technical base of production.
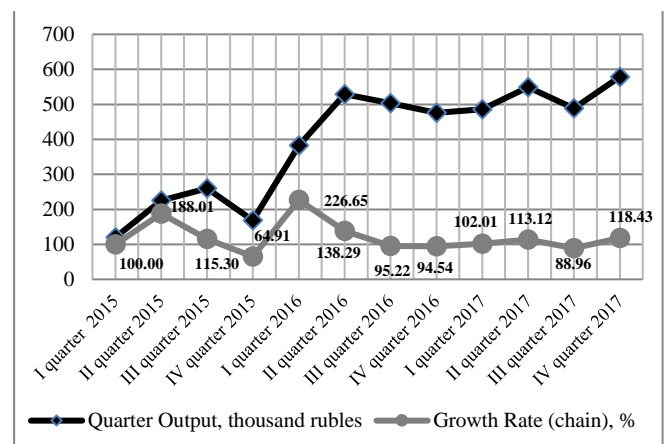

Fig. 1.

Substantial additional investments in fixed capital led to almost 3.5 times increase of labour productivity. Secondly, the decrease of productivity growth rates in subsequent years can be explained by the fact that organizational and socio-economic factors without which it is impossible to improve the use of production assets were not taken into consideration.

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The indicator of output in terms of value, calculated by the volume of finished and sold products in current prices, has a wavy dynamics. Such a situation may be connected with the increase of inflation rate, the changes in the structure of the product mix or the increase of the material costs of its production.

In order to analyze and estimate the level and dynamics of labour productivity it is necessary to study the influence of material and technical factors on labour productivity which is connected with additional investments. The criterion of the effectiveness of material and technical factors is the dynamics of capital productivity index which characterizes the volume of production from each ruble of fixed production assets. The increase of the technical level of production is reflected in the growth of the ratio showing the value of fixed assets per employee.

The calculations showed that the capital-labour ratio increased by 18.65 in 2017 compared to 2015 while capital productivity, on the contrary, decreased by 63.5. Accordingly, the level of use of fixed assets decreased which resulted in the decrease of the volume of production without additional capital investments and a longer period of its sales. This is confirmed by the data in Fig. 2 showing that the low rate of growth of the capital productivity (103.2%) and the decline in the growth of the capital-labour ratio by 19.7% in 2017 affected the labour productivity.

We conducted a correlation-regression analysis of the impact of capital productivity on labor productivity based on a statistical data set (36 observations monthly for the period 2015-2017). At the same time, the paired correlation coefficient between labor productivity and capital productivity was 0.94 *** (statistical significance at the level of 0.05).
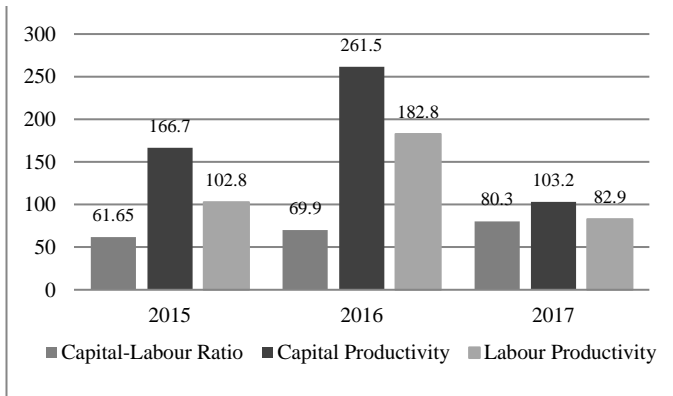

Fig. 2

Econometric calculations were carried out in the GRETL using the work [23, 24, 25]. So the selective regression equation of dependence of labor productivity (Y) on capital productivity (X) has the form of a second degree polynomial:

$$\hat{Y} = 3.85 + 732.2X - 710.984X^2 \qquad (1)$$

$$(7.13) \qquad (89.44) \qquad (225.28)$$

The obtained estimates of theoretical regression coefficients are statistically significant at a significance level

of 5%. The econometric model as a whole is significant and has a high explanatory ability: $\bar{R}^2 = 0.89; F(2,33) = 204.34$.

So, if capital productivity increases by 1 conventional unit, labor productivity will increase by 732.2 rubles and the growth rate of labour productivity will decrease. Productivity growth will slow down significantly. This fact requires further studying and revealing additional factors contributing to this! The 89.4% equation explains the increase of labour productivity by the increase of capital productivity. The remaining 10.6% increase in labour productivity is explained by other factors (human capital, organizational structure, etc.).

Using the constructed model, it is possible to carry out a forecast of labour productivity at Samara machine-building enterprises preserving the increasing trend of capital productivity of production in the new industrialization (Fig. 3).

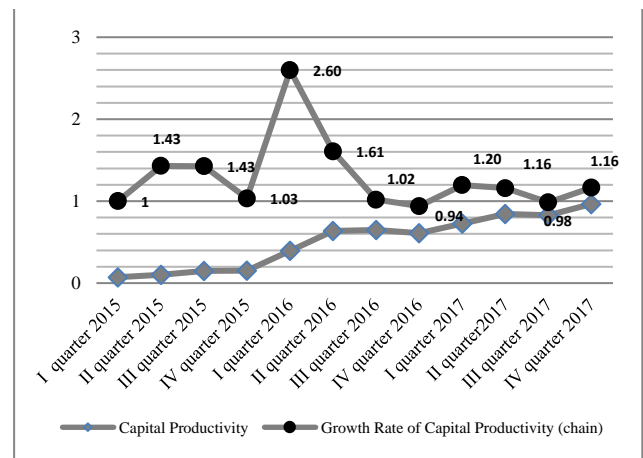The increasing capital productivity trend was modeled using the least squares method in the GRETL.

Fig. 3

Autoregression model of the first order AR1 was estimated:

$$\hat{X}_t = 0.0225 + 0.904X_{t-1}. \qquad (2)$$

$$(0.02) \qquad (0.07)$$

The estimation of the theoretical autoregression coefficient with the explained variable is significant at the level of 5%. The explanatory ability of the AR1 model is high - 81.5%. The model in general is statistically significant (p-value of F = 1.75e-15≪0.05), i.e. model can be used for forecasting.

The forecasted value of capital productivity in January 2018 can be obtained on the basis of the value of the capital productivity of December 2017, etc. The probability of coincidence of calculated data with real data is very high - 95%. Having the forecasted value of capital productivity in January 2018 obtained with the use of equation (2), we can forecast labour productivity during the same period, i.e. in January 2018 with the use of equation (1).

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V. CONCLUSIONS

So, the developed econometric models can have direct practical application in the activities of industrial enterprises in the new industrialization. The forecast of labour productivity, made according to these models, will have high accuracy, which will minimize the risks when making a certain kind of production and management decisions in practice.

VI. THE DISCUSSION OF THE RESULTS

In conclusion we would like to mention that low investment tools of labour productivity management can be used to reach a high level only in short term.

In middle and long term the task of increasing labour productivity should be solved by creating new, high-tech products and technologies, that is, by intensifying the second flow of added value creation, in which it is necessary to build a different forecasted model based on other economic principles, which is the subject of our further research.

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