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Labour productivity in agricultural production system: the case of Russia

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Abstract

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The article presents the results of a complex space-time empirical study of labour productivity in agriculture of the Russian Federation as an indicator of production efficiency. The index analysis of factors influence on the size of production volume of branch and level of labour productivity in dynamics was carried out. The increase in the cost of agricultural produce in the Russian Federation was due to the growth of labour productivity. The share of workers of agricultural enterprises in the regions, which have reached the highest level of productivity and efficiency, is increasing. As a result of grouping the Russian Federation regions on the level of labour productivity in agriculture and summary data on subjects with the maximum and minimum level of efficiency of agricultural production, the generalized characteristics of prospects of increase in labour productivity are received. The trend of changing in this indicator generally reflects changes in other indicators of production. However, the increase in labour productivity is not followed by a corresponding increase in wages. The choice of exogenous variables is substantiated and correlation and regression models of labour productivity are constructed. The analysis of the dependence of the level of labour productivity on the factors led to the conclusion that the course chosen in modern conditions for technical equipment, the introduction of digital technologies in crop and livestock production, elements of precision farming while maintaining the identified patterns will lead to increased productivity in agriculture.

Keywords: production efficiency; agriculture; labour productivity; wages; performance indicators; activities; complex analysis

Introduction

The issues of agricultural production efficiency and labour productivity are currently relevant for many countries of the world. Despite significant increases in production, food shortages and poverty remain are still alarming in many regions. Agriculture faces many challenges, including loss of biodiversity and soil fertility, global warming, and labour force reduction (Todorovska et al., 2018). Research priorities in the economy of agriculture of different countries include increasing productivity and economic efficiency of resources (Featherstone, 2018), improving the competitiveness of agricultural products by reducing labour costs compared to other countries (Blanc et al., 2018), the study and measuring the role of biological resources, capital and labour in production (Iqbali & Sial, 2018), their values and potential (Timofti et al., 2018), the theoretical issues of the use of labour-saving technologies and their socio-economic consequences (Gallardo & Sauer, 2018), the use of hired labour in production (Iqbali & Sial, 2018).

The most acute and urgent challenges of our time are issues of improving not only economic but also environmental

efficiency of agricultural production (Moutinho et al., 2018). For the preservation of the environment in the organization of modern agricultural production is vital to the formation of a highly skilled workforce. Issues of quality training, quality agricultural education around the world are also relevant (Quinones Pena et al., 2018), as in Russia.

Today, in the context of structural changes in the world economy, the development of the Russian Federation economic growth is possible only with growth rates ahead of the world (Official Website of the Federal State Statistics Service; Zinchenko, 2017). Being rich in a variety of natural resources, land resources and human capital, the country should have a developed agriculture that can provide the population with food and industry with raw materials (Gabitov et al., 2014). An important direction of ensuring the growth of the national economy is the growth of labour productivity that is a significant indicator of efficiency and effectiveness of one of the main factors of production (Gabitov et al., 2014).

The calculation of the statistical informative indicator should be preceded by a thorough identification of the essence of the presented economic category or the analyzed economic process which is supposed to be measured with its help. Since statistics as a science in determining the calculated quantitative side of the existing mass social phenomena is inherently based on their qualitative component, on the essence of the economic phenomenon, the economic process (Tinbergen, 1940). However, any problems connected with the economy in today's rapidly changing conditions of development cannot be analyzed and solved only on the basis of theoretical reasoning and conclusions. Qualitative empirical research is required.

The topic of labour productivity, the prospects of increasing its level is discussed by many domestic and foreign scientists. Thus, Lavrovskii (2015) evaluates long-term trends in labour productivity in the world and in Russia on the basis of a wide information base. Melin et al. (2018) make the calculations of the characteristics of labour productivity in Russia. Mkhitarian et al. (2016) analyze labour productivity in Russian companies in relation to some of the largest economies. Zinchenko (2017) analyzes the dynamics of production, issues of added value formation and reproduction of resources in agriculture of Russia for the transition period 1990-2014. Aganbegyan (2017), Ayvazyan and Afanasyev (2015) emphasize the primary need to enhance the contribution of the "knowledge economy" in GDP which is still 13% in Russia compared to 30% in Western Europe and the United States. They note that the solution of the problems of human capital in the long term is closely connected with the growth of labour productivity, rising wages, levelling unjustified differentiation of incomes to a level comparable with Western European countries. Brezis and Gilad (2018) state that the greatest growth is observed in the sphere of trade as a result of the analysis of labour productivity in various sectors of the economy and according types of economic activity. In production labour productivity growth is less. Emran and Shilpi (2018) analyze the impact of labour productivity on the level of wages and living standards of the population in Bangladesh with the help of a wide aspect of research methods. For several years representatives of the team of authors of this article have conducted and are conducting numerous studies of the dependence of wages and living standards of the rural population on the level of productivity on the basis of a set of methods (Lukmanov et al., 2018). At the most serious level we study the model dependence of the results of production, productivity and living standards of the population (Pospelov & Radionov, 2015) carried out by choice (Thaler & Sunstein, 2008). Constantly, in the long-term dynamics the methodology of the empirical analysis of the economics is analyzed, updated, refined and improved by well-known foreign (Tinbergen, 1940) and Russian scientists (Zinchenko, 2017).

At the same time, there is an urgent need to develop a methodology for analyzing the level of labour productivity as an indicator of the efficiency of agricultural production. The goal of this study is to improve the comprehensive analysis of labour productivity in agriculture and develop new ways to increase the level of labour productivity.

Material and Methods

This study presents an empirical analysis of the level of productivity as an indicator of the efficiency of agricultural production which has its own characteristics. Namely, the level of productivity is studied in the spatial aspect for a set of regions added to studying its changes in the dynamics usually prevailing in research and national statistics. Efficiency of agricultural production is a complex economic category that reflects its effectiveness. To study the efficiency of production we need a system of indicators that reflect the influence of various factors on the production process. Only the system of indicators allows for a comprehensive analysis and reliable results. The criterion of economic efficiency of the whole national economy is the amount of national income per capita. In agriculture the criterion of efficiency is the increase in net production (gross income) at the minimum cost of living materialized labour (Ableeva et al., 2017).

In our opinion the level of labour productivity as an indicator of production efficiency should be characterized by a system of indicators. In the construction of a system of

statistical indicators one takes into account the target orientation of the development of agricultural production, the problem of providing the appropriate resources necessary for the implementation of the goals and obtaining positive results.

In the system of indicators that comprehensively characterize the enterprise as a complex system, their condition, development, relationships, patterns of development, the whole system of indicators of production efficiency one can refer the whole system of indicators obtained by comparing the volumes of products of different types and incomes with the volumes of resources used and costs (Salimova & Rafikova, 2007):

• with labour-gross output (in current prices) per average annual worker employed in agriculture (productivity of living labour), labour intensity of production of a production unit, for example, grain and milk;

• with land – crop yields;

• with livestock – productivity of livestock and poultry;

• with fixed assets – return on assets;

• with costs – the cost of production of a unit of production, the return on their production costs;

• profit with costs – profitability of production, profitability of sales.

Meanwhile the results of economic activity are most often expressed in terms of output and profit. Therefore the most important performance indicators are productivity (productivity) and profitability (Aganbegyan, 2017). The dynamics of labour productivity of workers in the industry in statistics is carried out using the index method (Zinchenko, 2017). From 2003 till 2017 the indexes of labour productivity in general on economy of Russia and on types of economic activity are presented. They give a generalized picture, reflect the role and place of agriculture in the development of the country's economy.

Next we analyze the relationship between the average labour productivity *LP*, the average number of employees *T* and the volume of agricultural production *VP* which can be represented with the following formula: $VP = \overline{LP} \cdot T$, i.e. the change in the value of agricultural production is due to the changes in the level of productivity of workers or under the influence of changes in the number of workers (Official Website of the Federal State Statistics Service; Ayvazyan & Afanasyev, 2015; Aganbegyan, 2017). Calculations by formulas allow evaluating the impact of each of the factors in absolute terms:

$$\Delta VP_{(\overline{LP})} = (\overline{LP}_1 - \overline{LP}_0) \cdot T_1, \quad (1)$$

$$\Delta VP_{(T)} = (T_1 - T_0) \cdot \overline{LP}_0, \quad (2)$$

where $\Delta VP_{(\overline{LP})}$, $\Delta VP_{(T)}$ is the absolute increase (decrease) in the value of agricultural produce due to the growth (decrease) in average productivity and increase (decrease) in the number of employees; $\overline{LP}_1$, $\overline{LP}_0$ – average productivity of workers in the industry in the reporting and base periods; T_1, T_0 – the average number of agricultural workers in the reporting and base periods.

The aggregate form of the agricultural value index is expressed as follows:

$$I_{VP} = \frac{VP_1}{VP_0}, \quad (3)$$

where VP_1, VP_0 are agricultural products in the reporting and base periods.

If we assume that agricultural produce is equal to the product of the average number of employees at the average level of labour productivity, this formula will take this form:

$$I_{VP} = \frac{\sum \overline{LP}_1 T_1}{\sum \overline{LP}_0 T_0}. \quad (4)$$

The index of agricultural produce due to changes in the average level of labour productivity is indicated by the following formula:

$$I_{VP} = \frac{\sum \overline{LP}_1 T_1}{\sum LP_0 T_1}. \quad (5)$$

The index of agricultural production due to changes in the average number of employees of enterprises is determined by the formula:

$$I_{VP} = \frac{\sum LP_0 T_1}{\sum \overline{LP}_0 T_0}. \quad (6)$$

This study analyzes the change in gross output of agricultural organizations in all regions of the Russian Federation.

The system of indices of variable, constant composition and structural shifts is used to study the dynamics of the average level of labour productivity. The variable composition index is the ratio of average levels of labour productivity in the reporting and base periods:

$$I_{variable} = \frac{\sum LP_1 T_1}{\sum T_1} : \frac{\sum LP_0 T_0}{\sum T_0}, \quad (7)$$

where LP_1, LP_0 is the average productivity of workers (by region) in the reporting and base periods; T_1, T_0 is the average number of employees of agricultural enterprises in the region.

The change in the average level of labour productivity is influenced by two factors:

•changes in average labour productivity in certain regions;

•structural changes in the workers staff i.e. changes in the proportion of workers in regions with different levels of average labour productivity in the total number of workers in the country's industry.

The separate influence of each of these two factors on the dynamics of the average level of labour productivity is reflected in the indices of constant composition and structural shifts:

$$I_{cont.comp} = \frac{\sum LP_1 T_1}{\sum T_1} : \frac{\sum LP_0 T_1}{\sum T_1}, \quad (8)$$

$$I_{struct.shift} = \frac{\sum LP_0 T_1}{\sum T_1} : \frac{\sum LP_0 T_0}{\sum T_0}, \quad (9)$$

All three indices are linked to the system:

$$I_{variable} = I_{cont.comp} \cdot I_{struct.shift}. \quad (10)$$

In this study the average labour productivity indices were calculated according to the data of agricultural organizations in 71 regions of Russia. From the general population of all regions it was those excluded for the dynamics that was not fully presented the statistical information, as well as atypical ones for agriculture. Further research is also carried out on a set of agricultural organizations in 71 regions of Russia.

Statistics as a science in its conclusions is based on the results obtained in the generalization of mass observations. One of the ways of such generalization is a statistical grouping of primary data. In our analysis this method gives an idea of the nature of the distribution of the country's regions in terms of labour productivity in agricultural production in 2017. It is the basis for further work with the collected information. The choice of the number of groups in each group is due to the nature of the distribution of farms by grouping indicators that is equal to the grouping interval in order to be more convenient for visual perception of the results and identifying trends in changing of indicators during the transition from group to group.

The method of grouping revealed the existence of a relationship between the indicators characterizing the results of production, and consequently the efficiency of agricultural producers. There is a question about the quantitative expression of this dependence, multiple correlations and regression analysis will allow measuring it. As experts in the field of statistical methods note, all phenomena and processes of the boundless real world are interconnected. And there are no finite numbers of variables that completely determine the dependent value. Therefore multiple functional dependence of variables is also an abstraction that simplifies reality. However the method of correlation and regression analysis will determine the most significant and stable relationships between socio-economic phenomena occurring in the regions under consideration. Multiple regression allows you to ask a question (and probably get an answer) about what is the best regressor for the dependent variable (Arefiev et al., 2015).

Correlation analysis begins with the establishment of causative relationships between the studied features. Turning to the theory of statistics, it can be noted that theoretically the regression model allows taking into account any number of factors. In practice there is no need. The selection of factors is based on qualitative theoretical and economic analysis. However theoretical analysis does not allow answering the question unambiguously of the quantitative relationship of the considered characteristics and the usefulness of including the factor in the model. Therefore the selection of factors is usually carried out in two stages: on the first stage factors are selected based on the essence of the problem; on the second one – on the basis of the matrix of correlation indicators they determine t–statistics for regression parameters (Danko et al., 2016). The purpose of the correlation and regression analysis is to show the quantitative relationship between the levels of labour productivity. It is one of the main indicators of agricultural production efficiency and factors (among them we select those that show more obvious trend of change in the transition from group to group and can affect the level of labour productivity). The model of dependence was based on the data set from 71 regions of the Russian Federation in 2017. It includes 7 factors, the final model is 4 the most important factors. We can observe the requirements of statistical science to the load of observations on the factors.

Based on the results of the grouping we believe theoretically that the labour productivity indicator is a consequence of the wages rate (wage increase stimulates the growth of labour productivity that is a manifestation of the stimulating function of the wage category), crop yields and animal productivity (output is a resource efficiency), the produced volume per employee engaged in agriculture, grain and milk in physical terms, capital and energy as a necessary basis for the organization of production and increase productivity in modern conditions. Let's imagine this dependence as a model:

$$\check{Y} = a_0 + a_1X_1 + a_2X_2 + a_3X_3 + a_4X_4 + a_5X_5 + a_6X_6 + a_7X_7, \quad (11)$$

where $\check{Y}$ – agricultural products were produced per one average annual worker (labour productivity) in 2017, thousand roubles.

As the factorial signs are: X_1 – the average monthly salary of one average annual employee of the enterprise roubles; X_2 – grain yield,1 centner from 1 ha; X_3 – average annual milk yield

per cow, kg; X_4 – produced grain per worker employed in agriculture, C; X_5 – produced milk per one worker employed in agriculture, C; X_6 – capital labour ratio, thousand roubles per 1 employee; X_7 – energy intensity of labour, hp per 1 employee.

The sources of information for all calculations were the official data of the Federal State Statistics Service of the Russian Federation (Official Website of the Federal State Statistics Service).

Results and Discussion

The category of labour productivity is the ratio of the received volume of production and the amount of resource costs. It is one of the reserves, opportunities to increase wages, the standard of living of the country's population, the level of its development (Ableeva et al., 2017).

Table 1 provides information on the dynamics of labour productivity in the economy of the Russian Federation.

During the period from 2003 (from this year the Federal State Statistics Service began to calculate labour productivity indices) till 2014 labour productivity in the country's economy increased (with the exception of the post-crisis 2009). In 2015 the overall labour productivity in the economy decreased by 1.9%, in 2016 – by 0.3%. However in 2015 and 2016 the growth of this indicator in agriculture have been observed with the highest relative value (Gabitov et al., 2014; Aganbegyan, 2017) (Figure 1).

Agriculture is in the form of heart rate, "the heart of the economy". Until 2007, the growth was lower than in the economy as a whole. In 2008-2009 it exceeded the average economic growth of labour productivity, then it was a sharp "pulsating" jump, and since 2013 it is steadily higher than

Table 1. Dynamics of labour productivity in the economy of the Russian Federation (2003-2017, in % to the previous year)

Indicators	2003	2005	2009	2010	2014	2015	2016	2017
In whole economy	107.0	105.5	95.9	103.2	100.7	98.1	99.7	101.5
Agriculture, hunting and forestry	105.6	101.8	104.6	88.3	103.3	104.5	103.5	103.8
Fishing, fisheries	102.1	96.5	106.3	97.0	96.1	99.9	95.6	99.8
Mining	109.2	106.3	108.5	104.3	102.8	98.3	100.3	100.4
Manufacturing	108.8	106.0	95.9	105.2	102.5	97.1	99.3	99.7
Construction	105.3	105.9	94.4	99.6	98.4	100.8	99.9	98.8
Wholesale and retail trade, repair of motor vehicles, motorcycles, household goods and personal items	109.8	105.1	99.0	103.6	98.7	93.4	94.4	101.5
Hotels and restaurants	100.3	108.5	86.7	101.7	99.8	96.2	94.3	101.7
Real estate transactions, leasing and provision of services	102.5	112.4	97.5	104.0	98.6	100.2	100.2	99.6

Source: Official website of the Federal State Statistics Service

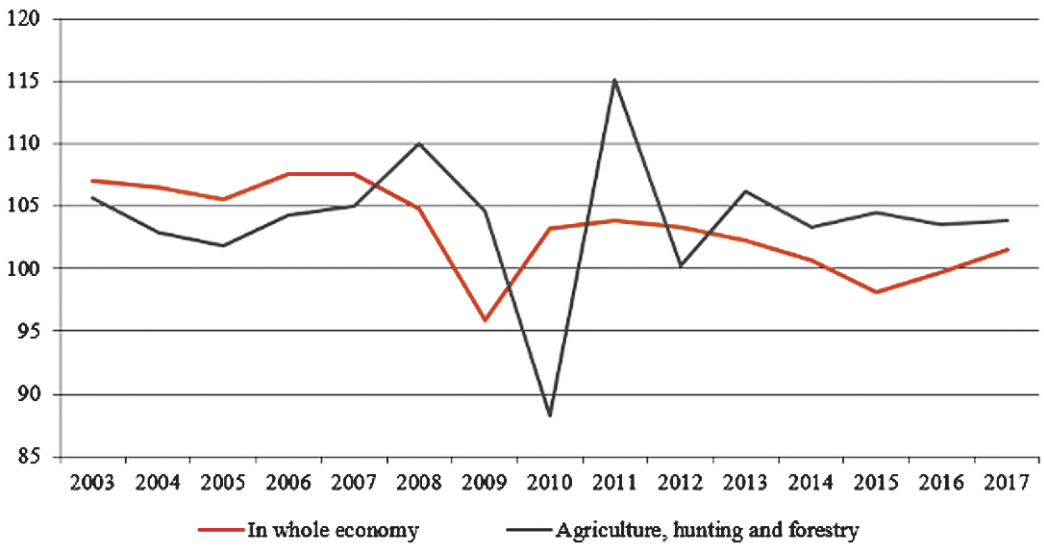

Fig. 1. Dynamics of labour productivity in the Russian Federation (in % to the previous year)

in the economy as a whole. After the "lost" rhythm in 2010-2012 we can see stable steady growth.

Since 2016, the Federal State Statistics Service has included agricultural organizations in the federal statistical observation of innovative activity of enterprises. In 2016 in plant growing the value of innovative goods, works, services, newly introduced or underwent considerable technological changes for the Russian Federation amounted to 5781.3 million rubles, in livestock it was 12119.0 million rubles, in mixed farming (crop combined with livestock) it was 618.9 million rubles (Official Website of the Federal State Statistics Service). In total, this is only 0.58% of the economy. However the inclusion of the type of activity in the reporting forms indicates the increasing importance of agriculture for the country, the need for measures to support the industry as statistics is a "mirror" of society, of the processes taking place in it. The industry's contribution to the country's gross domestic product is increasing. The share of agriculture in GDP in 2016 was 5.1% (Official Website of the Federal State Statistics Service), it was higher compared to previous years.

Chain indices of the value of agricultural products in general and due to factors in the agricultural enterprises of the Russian Federation for a number of years are presented in Table 2.

The increase in the value of agricultural products in the Russian Federation was due to the growth of labour productivity (its average level) and the number of employees decreased almost from year to year. It is shown by the indices of the value of agricultural products due to changes in this indicator.

The chain indices of average labour productivity of constant, variable composition and structural shifts according to agricultural enterprises in the context of the Russian Federation regions are presented in Table 3.

The data show an increase in the average productivity of workers which was due to the growth of labour productivity, and due to changes in the number of employees it fluctuated. Indices of structural changes, mainly over the years more than 1.000, which is the proportion of the employees' number in the regions in which there was a higher level of labour productivity increased. Therefore structural changes also contributed to the growth of average labour productivity in the industry as a whole. We can make a conclusion that the share of workers in the regions who have reached the highest level of productivity and higher efficiency of agricultural production is increasing in agricultural enterprises. The discrepancy between the indices calculated and presented in Table 2 and Table 3 is explained by the fact that the regions for which the indices of average labour productivity of variable composition, constant composition and structural shifts were excluded from the general population of regions for which the information is not fully presented in dynamics, as well as

Table 2. Indices of agricultural output in agricultural enterprises of the Russian Federation (2003-2017)

Years	Indices of changes in agricultural production (to the previous year)		
	In total	Total including due to the changes	
		Average level of labour productivity	Average annual number of employees
2003	1.120	1.182	0.947
2004	1.251	1.313	0.953
2005	1.073	1.081	0.993
2006	1.144	1.183	0.967
2007	1.304	1.344	0.970
2008	1.289	1.337	0.964
2009	0.964	0.978	0.986
2010	1.007	1.001	1.006
2011	1.340	1.348	0.994
2012	1.039	1.058	0.982
2013	1.097	1.115	0.984
2014	1.218	1.241	0.982
2015	1.242	1.432	0.867
2016	1.088	1.097	0.992
2017	1.030	1.094	0.941

Table 3. Indices of constant, variable structure and structural shifts of average labour productivity of workers of the agricultural enterprises of the Russian Federation (2003-2017)

Years	Indices of average labour productivity (to the previous year)		
	Variable staff	Constant staff	Structural shifts
2003	1.18426	1.17951	1.00403
2004	1.21446	1.20608	1.00695
2005	0.99599	0.95412	1.04388
2006	1.19030	1.19692	0.99447
2007	1.27606	1.25900	1.01355
2008	1.32074	1.24133	1.06397
2009	1.03613	1.03213	1.00388
2010	1.02814	1.02422	1.00383
2011	1.27445	1.27614	0.99868
2012	1.03532	1.03932	0.99615
2013	1.12368	1.12393	0.99978
2014	1.18325	1.18230	1.00080
2015	1.42046	1.39949	1.01499
2016	1.07224	1.06555	1.00628
2017	1.01126	1.01031	1.00094

those that are not typical for the industry (for example, the northern regions). Thus, the total analysis, including further research, showed 71 subjects of the Russian Federation.

The productivity growth must be seen in close connection with changes in wages. To ensure expanded reproduction the rate of changes in labour productivity must be faster than the rate of changes in wages. However, the postulate says at first labour productivity grows and only then follows its payment. Among the economists of our time it was controversial. Let us see what is happening in the agriculture of the Russian Federation (Table 4).

As shown in Table 4, for 2003-2017, in the vast majority of years the growth of labour productivity rate lagged behind the growth rate of real wages in agriculture of the Russian Federation. The growth of wages with a decrease in productivity will inevitably lead to an excessive increase in costs and a decrease in profitability. However, the growth of labour productivity should also be accompanied by a corresponding increase in wages in order to be of interest to workers in the production process.

Many researchers note that the solution of the problem of a radical increase in wages is inextricably connected with the justification of its correlation with the rate of productivity growth. The conclusion that higher wage growth rates, labour costs per unit of product increase and the competitiveness of the economy declines is true only if the ratio of income to factors of production remains constant. Today in Russia the share of wages in GDP is lower than in developed countries (Aganbegyan, 2017). Thus, the share of wages of employees in GDP according to international statistics in Switzerland was 59.4%, in the US – 52.7%, in Germany – 51.0% (according to data for 2014), in Russia this figure in 2014 was 47.2%, in 2017 – 47.7% (Official Website of the Federal State Statistics Service). In these conditions it is possible to consider economically justified such a policy which is aimed at ensuring a faster rate of wage growth over labour productivity. This advance should be short-term before reaching the optimal ratio of wages and GDP. But the mechanism of wage organization should depend on the efficiency of enterprises.

Table 4. Labour productivity and real wages in agriculture of the Russian Federation (2003-2017)

Years	Rate of changes, % to the previous year		Ratio of the rate of change in labour productivity and real wages, times
	Labour productivity	Real wage	
2003	105.6	111.3	0.949
2004	102.9	115.3	0.892
2005	101.8	109.0	0.934
2006	104.3	115.0	0.907
2007	105.0	120.2	0.874
2008	110.0	121.8	0.903
2009	104.6	104.3	1.003
2010	88.3	102.0	0.866
2011	115.1	110.1	1.045
2012	100.2	106.4	0.942
2013	106.2	104.5	1.016
2014	103.3	101.2	1.021
2015	104.5	98.5	1.061
2016	103.5	104.7	0.989
2017	103.8	105.5	0.984

In order to study the impact of factors on the efficiency of agricultural production we analyzed the operating rate of agricultural enterprises in the regions of the Russian Federation.

The data groupings (Table 5) show that increasing productivity from 121.7 thousand roubles in the first group to 1099.7 thousand roubles in the fourth group the average monthly salary ranges from 19987.0 for the first group to 19265.6 roubles in the fourth group. The change in performance ratio as a whole repeats the change in the grouping indicator: capital productivity increases (from 26.8 roubles in the first group to 75.2 roubles in the fourth group per 100 roubles of fixed assets value), grain yield (from 19.8 C from 1 ha to 34.9 C from 1 ha in the first and fourth groups, respectively), average annual milk yield per cow (from 3478 kg in the first group to 5983 kg in the fourth group), labour productivity in real terms (grain and milk per employee). The growth of labour productivity in the transition from group to group is provided by the level of capital and energy labour. These indicators also increase. Indicators of the specific weight of crop/livestock products in agricultural products vary by group as well as the rate of feed consumption per 1 kg of milk. From group to group the rates of doses of mineral fertilizers under crops and feed consumption per 1 cow increases which indicates the influence of conditions of crop growing (Yarullin et al., 2018), the animals keeping at the output and further increase production efficiency, reduce production costs.

The conclusion that the indicator of labour productivity is one of the important indicators of production efficiency is confirmed as a whole. The trend in this indicator generally reflects changes in other indicators of production. However, the increase in the level of labour productivity is not accompanied by a corresponding increase in the level of wages, i.e. labour is exploited (data from the analysis of the dynamics of the level of wages and groups).

The essence of the direction of indicators relationship as already has been noted is presented the analytical group.

These groups of regions, according to the level of labour productivity in 2017, show that there are indicators changing the level of labour productivity. For the convenience of the analysis the results of statistical processing were divided into separate fragments.

The correlation matrix (Table 6) contains partial correlation coefficients. The coefficients of the second column of the matrix characterize the degree of tightness of the relationship between the effective and factor characteristics. The highest relationship is observed between labour productivity and its capital intensity (= 0.746) and energy intensity (= 0.725). We can see the lowest relationship with the average monthly wage (= 0.031). A direct relationship of labour productivity in agriculture can be traced all the factors except for average monthly wage.

Correlation coefficients between the factors indicate the absence of multicollinearity between the factors. The results of the correlation and regression analysis showed that the regression coefficients for variables are statistically insignificant at the 0.05 significance level. After the elimination of these factors new results are obtained as reflected in Table 7.

The multiple correlation coefficient R = 0.888 shows that the close relationship between agricultural productivity and the factors included in the model is strong. The multiple coefficient of determination (R-square) D = 0.788 i.e. 78.8% of the variation in labour productivity is explained by the

Table 5. Distribution of regions of the Russian Federation according to the level of labour productivity in agriculture (2003-2017)

Indicators	Groups of regions of the Russian Federation producing agricultural products in average for one employee, thousand roubles				Total and in average in the RF
	to 200	200 – 500	500 – 800	more than 800	
Number of regions in a group	15	21	21	14	71
Produce per 1 average annual worker	121.7	386.0	622.5	1099.7	540.8
The average size of agricultural products in the region, million roubles	6545.1	29654.0	55925.4	75210.2	41525.2
The average monthly wage per employee, roubles	19987.0	19095.9	20895.3	19265.6	19849.8
Capital productivity (production per 100 roubles of fixed assets), roubles	26.8	57.6	64.7	75.2	56.7
Capital to labour ratio, thousand roubles per 1 employee	522.3	710.3	1051.2	1485.7	924.3
Energy, hp per 1 employee	4.5	15.2	19.0	25.0	16.0
The share of crop production in agricultural production, %	52.2	50.8	36.6	43.4	45.4
Share of livestock production in agricultural production, %	47.8	49.2	63.4	56.6	54.6
Grain yield, C from 1 ha	19.8	22.5	25.0	34.9	25.1
Average annual milk yield per cow, kg	3478	4898	5835	5983	5089
Produced grain per 1 employee, C / person	31.8	123.5	143.4	280.7	141.0
Produced milk per 1 employee, C / person	5.0	26.6	45.4	44.5	31.1
Introduced mineral fertilizers for grain crops in terms of 100% nutrients, C per 1 ha	0.2	0.2	0.5	0.6	0.4
Feed consumption per 1 milk, C.	1.3	1.4	1.0	1.1	1.2
Feed consumption per 1 cow, C. units	39.1	58.6	63.6	64.7	57.2

Note: 1 Euro = 65.75 Rubles

Table 6. Correlation matrix

	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7
Y	1.000							
X_1	-0.031	1.000						
X_2	0.496	-0.255	1.000					
X_3	0.466	-0.016	0.260	1.000				
X_4	0.649	-0.185	0.580	0.213	1.000			
X_5	0.414	0.079	-0.082	0.548	0.071	1.000		
X_6	0.746	0.049	0.310	0.269	0.419	0.402	1.000	
X_7	0.725	0.003	0.219	0.403	0.699	0.565	0.521	1.000

Table 7. Regression Statistics

Multiple R	0.888
R – square	0.788
Normalized R-square	0.775
Standard error	171.397
Observations	71

variation of the studied factors. The model is significant via F – test that all the regression coefficients are also significant on t – test.

The following regression equation of dependence is finally obtained:

$$\check{Y} = 7.269X_2 + 0.028X_3 + 0.330X_6 + 15.488X_7 - 338.032 \quad (12)$$

Thus, with an increase in the yield of grain crops per 1 C per ha, labour productivity in agriculture increases by 7.269 thousand roubles per employee provided that other factors remain constant. With increasing milk yield per cow of 1 centner productivity increases by 0.028 thousand rubles per one employee provided that other factors remain constant. While the higher capital-labour ratio and power respectively for 1 thousand roubles and on 1 hp based on the agricultural worker labour productivity increases by 0.330 and 15.488 thousand roubles per employee.

Different units make regression coefficients incomparable. The question arises as to the relative strength of the impact on the performance of each of the net regression factors. We express them in a standardized form in beta coefficients and elasticity coefficients.

Table 8. Characteristics of the influence degree of the studied factors on the level of labour productivity of agricultural enterprises employees in the regions of the Russian Federation for 2017

Factors	b – coefficient	Coefficient of elasticity
Grain yield, centner from 1 ha X_2	0.243	0.338
Average annual milk yield per cow, kg X_3	0.127	0.263
Capital labour, thousand rubles per 1 employee X_6	0.429	0.564
Energy intensity of labour, hp per 1 employee X_7	0.397	0.457

Note: 1 Euro = 65.75 Rubles

Comparison of β-coefficients and elasticity coefficients shows that the greatest influence on the variation of labour productivity in agriculture is exerted by the capital – labour ratio, the second is by the energy – labour ratio, and the third is by the grain yield, then by the average annual milk yield per cow (Table 8).

The analysis of the dependence of labour productivity level on the factors led to the conclusion that the course chosen in modern conditions for technical equipment, the introduction of digital technologies in crop and livestock production, elements of precision agriculture maintaining the identified patterns will lead to increased productivity in agriculture (Gabitov et al., 2014; De Pinto et al., 2016; Mudarisov, 2017; Gabitov et al., 2018). On the basis of the correlation and regression model taking into account the confidence intervals of regression coefficients, various variants of the forecast values of labour productivity in agriculture of the Russian Federation are calculated (Table 9).

The difference in the forecast values of the labour productivity level is significant that along with significant regional differences in the conditions of the organization of agricultural production indicates the potential for improving the efficiency of production with its scientifically based placement, sufficient information and analytical support.

The research results proved labour productivity to be one of the main indicators of the efficiency of agricultural production. On the whole, the received results and the conclusions drawn from them correspond to the results of other researchers. Labour productivity should be analyzed in long-term dynamics on the basis of a broad and diverse information base (Lavrovskii, 2015). We consider the time series method to be applicable to make predictions on the further development of the phenomenon, an economic indicator and the industry in general. Forecast calculations of labour productivity in Russia are studied in other works as well (Melin et al., 2018). We also support the idea that Russian companies need to analyze labour productivity based on comparison with the largest economies of the world (Mkhitarian et al., 2016). This

Table 9. Point forecasts of labour productivity by regression model

Options forecasts	Possible values of the regression coefficients				Expected value of labour productivity	
	X_2	X_3	X_6	X_7	Y, thousand roubles per person	in % to average
Pessimistic	3.637	0.0003	0.225	10.031	24.771	4.6
Probable (average)	7.269	0.028	0.330	15.488	539.472	100.0
Optimistic	10.902	0.056	0.436	20.945	1106.648	205.1

Note: 1 Euro = 65.75 Rubles

paper analyzes indicators of labour productivity, including by the type of economic activities in the Russian Federation. The broad scope of the analysis is explained by diversity and importance of economic activities for the country. There is a significant difference in labour productivity according to the type of economic activities. Thus, its greatest growth is observed in trade. Labour productivity growth is less in production (Brezis & Gilad, 2018). We get similar results. Labour productivity growth in production activities is achieved more difficult and requires a significant return on resources.

Some results on the analysis of production dynamics and resource reproduction in agriculture for the earlier period (1990-2002) can be found in the works of Zinchenko, 2017. This proves the time series analysis to be essential in finding new development directions and strategies. Under present development conditions of the technical capacity in agriculture labour productivity growth largely depends on the level of knowledge and skills of the workforce, their level of education and the ability to deal with current problems quickly on the basis of knowledge and competencies. Scientists also emphasize the need to increase the contribution of the "knowledge economy" to GDP (Aganbegyan, 2017; Ayvazyan & Afanasyev, 2015).

Methods to study interrelations between phenomena and indicators characterizing them are widely used in researches. This study presents an analysis of the labour productivity level depending on the factors affecting it. In turn, labour productivity itself acts as a factor affecting various indicators. Thus, there are models of the labour productivity impact on the level of wages and living standards of the population (Emran & Shilpi, 2018). In our works, we also underline the mutual influence of labour productivity and wages upon each other (Salimova & Rafikova, 2007). Thus, the relevance of the subject and the received results find support and further development both in the domestic and world science. Many scientists in the field of Economics claim the need to study and increase labour productivity.

Conclusions

The statistical study of the labour productivity level in agriculture has led to a number of conclusions. During the period from 2003 to 2014 labour productivity in the country's economy increased (with the exception of the post-crisis 2009). In 2015 the overall labour productivity in the economy decreased by 1.9%, in 2016 – by 0.3%. However, in 2015 and 2016 the growth of this indicator was observed in agriculture with the highest relative value.

The increase in the value of agricultural products in the Russian Federation was due to the growth of labour productivity (its average level). The number of employees decreased almost from year to year which is shown by the indices of the value of agricultural products due to changes in this indicator. Structural regional changes also contributed to the growth of the average labour productivity in the industry as a whole. It can be concluded that the share of workers in the regions who have reached the highest level of productivity and higher efficiency of agricultural production is increasing in agricultural enterprises.

Productivity growth must be seen in close connection with changes in wages. During the period 2003-2017 the growth rate of labour productivity lagged behind the growth rate of real wages in agriculture of the Russian Federation in the vast majority of years. However, in Russia the share of wages in GDP is lower than in developed countries. In these conditions we can consider such a policy as economically justified which is aimed at ensuring higher rates of wage growth over labour productivity. This advance should be short-term before reaching the optimal ratio of wages and GDP. But the mechanism of wage organization should depend on the efficiency of enterprises.

The grouping of Russian regions by the level of labour productivity confirms the conclusion that the labour productivity indicator is one of the important indicators of production efficiency in general. The trend in this indicator generally reflects changes in other indicators of production. The correlation and regression analysis of the dependence of the labour productivity level on the factors allowed to come to the conclusion that the course chosen in modern conditions for technical equipment, the introduction of digital technologies in crop and livestock production, elements of precision agriculture maintaining the identified patterns will lead to increased productivity in agriculture.

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