Valery Zh. Dubrovsky [a], Ekaterina M. Ivanova [b], Natalia V. Chuprakova [c]
[a] Ural State University of Economics, Ekaterinburg, Russian Federation
[b, c] Technological Institute of National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Lesnoy, Russian Federation
[b] https://orcid.org/0000–0003–0690–0598, e-mail: ivanovaemlesnoy@mail.ru
[c] https://orcid.org/0000–0002–1483–0545

ECONOMIC ASSESSMENT OF GROWTH FACTORS OF LABOUR PRODUCTIVITY AT CORE ENTERPRISES OF THE DEFENCE INDUSTRY: IMPACT ON SINGLE-INDUSTRY TOWNS

The insufficient growth of labour productivity at the enterprises of the Russian defence industry compared to the world level results in the need to identify the causes of the current situation. In recent years, the military rearmament led to the use of new technologies in production, personnel reduction, and, ultimately, to the increase in labour productivity. Nevertheless, the growth of the target value due to a decrease in the number of employees has mixed effects on the development of the socio-economic environment of single-industry towns. As an information base for the study, we used the statistical data of six core enterprises of ROSATOM State Corporation for the period from 2008 to 2017. The paper relies on Russian and foreign research focused on measuring the impact of various factors on labour productivity. We applied correlation-regression analysis and index method of factor analysis. As a result, we built a multiple linear model of the dependence of labour productivity on the average headcount, capital-labour ratio of active business assets, the ratio of the active part of assets in their total value, and investments. Further, we examined the statistically significant difference of the multiple linear regression model and its parameters and confirmed the applicability of the postulated model for predicting indicators values. The index analysis of labour productivity as well as indices of capital-labour ratio and capital productivity revealed a discrepancy between the growth of an indicator and the increase in the utilisation efficiency of fixed assets in dynamics. Additionally, it indicated the need to compare labour productivity factors with performance indicators when predicting the development of enterprises. The conducted research and constructed model can be used for developing strategic plans for the defence industry enterprises, as well as for considering how the changes in labour productivity and personnel of the core enterprises of the defence industry influence the economy of single-industry towns.

Keywords: labour productivity, capital-labour ratio, fixed assets, active part of fixed assets, defence industry enterprises, Rosatom State Corporation, investments, non-core assets, technical equipment, index method, correlation-regression analysis, single-industry towns, core enterprises

For citation: Dubrovsky, V. Zh., Ivanova, E. M. & Chuprakova, N. V. (2020). Economic Assessment of Growth Factors of Labour Productivity at Core Enterprises of the Defence Industry: Impact on Single-Industry Towns. Ekonomika regiona [Economy of Region], 16(3), xx-xx, https://doi.org/ ekon.reg.10.17059/2020–3-x

Introduction

The growth of labour productivity remains one of the primary objectives of Russia's economic development. Recently, defence industry enterprises have displayed positive dynamics of this efficiency indicator due to various factors, including improvements in the technical equipment of production, organisational decisions on the disposal of non-core assets from the structure of enterprises, and strengthening of intra-corporate ties. Nevertheless, this dynamic is not so high at the Russian enterprises, including in the defence industry, compared to the world's leading corporations [1, p. 89; 2, p. 132; 3, p. 73; 4, p. 1230]. Generally, the priority of increasing labour productivity at defence industry enterprises assumes strategic importance to the state in modern economy.

Suffice it to mention the Executive Order of the President of the Russian Federation Vladimir Putin No. 204 of May 7, 2018 "On National Goals and Strategic Objectives of the Russian Federation through to 2024", which states the primary goal of increasing labour productivity at medium and large enterprises of basic non-resource industries by 5 % by 2024. Additionally, the measures provided in the national project "Labour Productivity and Employment Support" launched in 2019 and approved by the Presidential Council for Strategic Development and Priority Projects (Minutes No. 12 of September 24, 2018) aim at creating specific conditions for achieving goals, indicators, and results in the field of improving labour productivity.

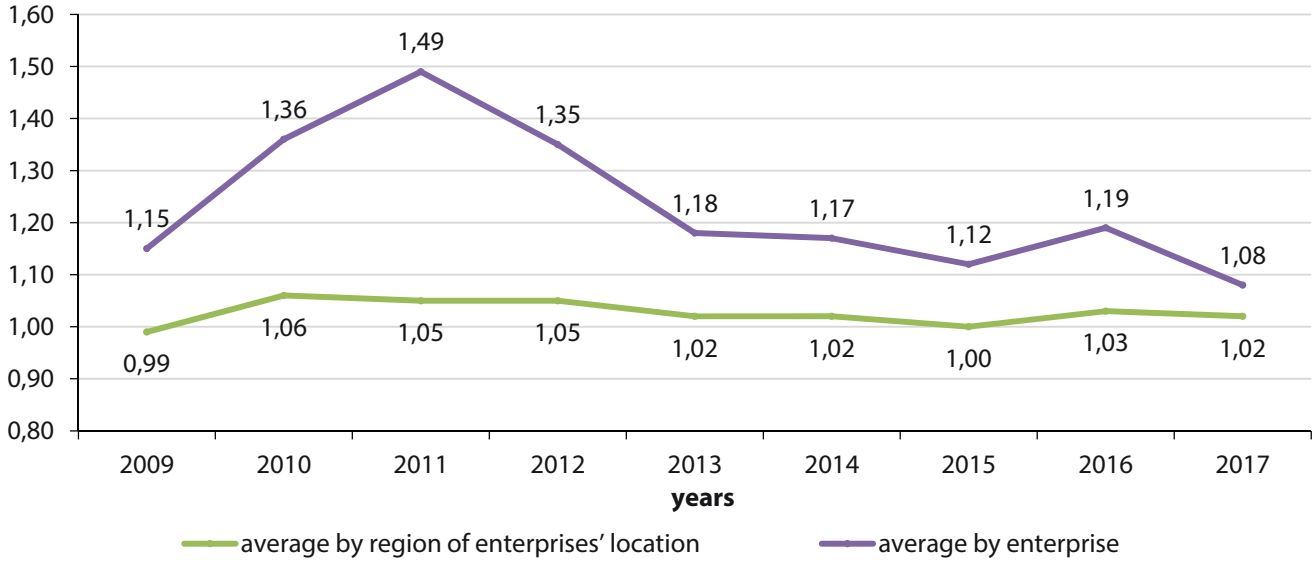

Fig. 1. *Average labour productivity index of defence industry enterprises and regions of its operation*

Historically, defence industry enterprises are located in various regions of the country in order to ensure the national defence capability. However, quite often they are structurally part of state corporations under federal control. Over the past decade, government investments in the development of defence industry enterprises, in particular, in the form of research and development funding and technical re-equipment of production facilities, have been quite sizeable. For example, the funding for the previous State Armaments Programme (2011–2020) amounted to 15 trillion roubles [5, p. 103; 6, p. 49], which was one of the reasons behind the increase in labour productivity (Figure 1).

While, obviously, the military production significantly contributes to the development of regions, socio-economic dynamics of single-industry towns at the time of an increase in labour productivity at core enterprises due to personnel reduction remains a problematic issue.

The insufficient efficiency of military production relative to the world level is confirmed by a comparison of labour productivity of Russian military enterprises with the world's leaders in the defence industry (Figure 2).

Therefore, due to comparatively low labour productivity, it is relevant to study the reasons behind its growth, and, in particular, to identify the conditions and factors affecting the efficiency of the Russian defence industry enterprises.

The research tests the hypothesis that the change in labour productivity directly depends on the dynamics of the average headcount, capital-labour ratio of active fixed assets, the ratio of the

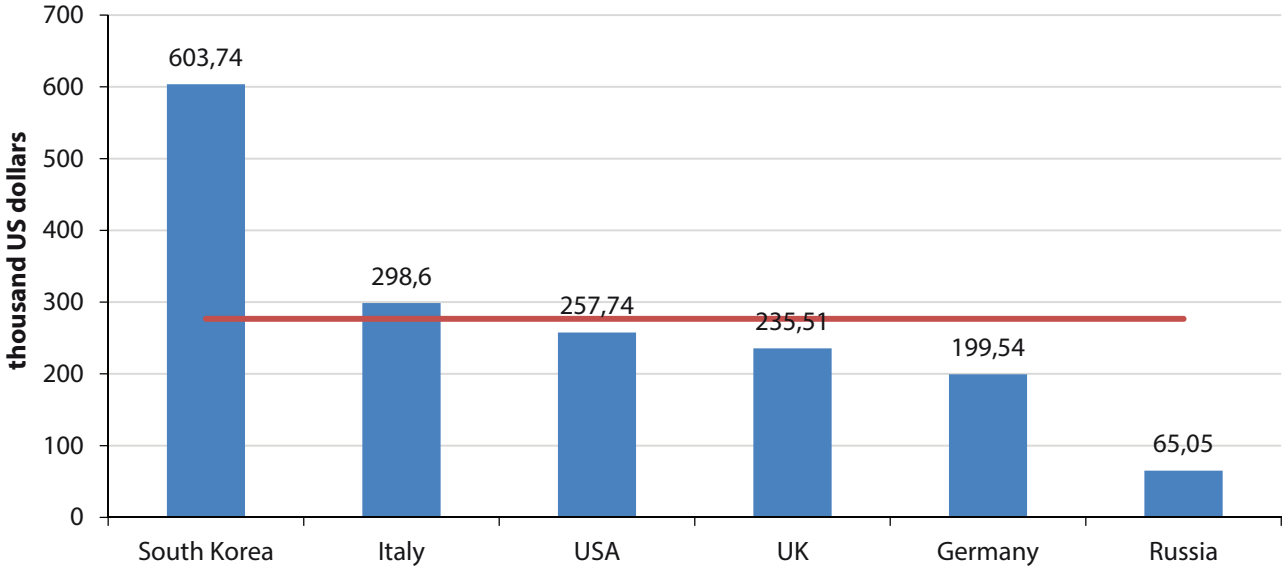

Fig. 2. *Average labour productivity of military industry enterprises in the industrialised countries in 2015 (calculated based on the SIPRI data)(See to: Stockholm International Peace Research Institute (SIPRI). Retrieved from: https://www.sipri.org/databases/armsindustry (Date of access: 27.02.2019))*

Translation

active part of fixed assets in their total value, and investments in the development of the material and technical base of production.

Increasing labour productivity: Conditions and factors

The problem of insufficient growth and the level of labour productivity is inherent in all Russian enterprises, and military production is no exception. As a rule, defence industry enterprises are large production facilities that possess the advantages of high-tech automated production, and have resource capabilities to develop and introduce new equipment and technologies [7, p. 319; 8, p. 30; 9, p. 270].

The availability of design bureaus, R&D divisions, new product development departments at defence industry enterprises, on the one hand, increases the proportion of fixed costs in the structure of production costs, while on the other hand, allows using new technologies in the production, indirectly influencing labour intensity of production, and, hence, labour productivity [10, p. 40; 11, p. 345; 12, p. 245]. In turn, integration of defence industry enterprises into the structures of state corporations creates special conditions for military production. Consolidation of enterprises filling state defence orders into corporate structures in the 1990s resulted in the growth of labour productivity, achievement of greater financial stability, and the possibility of renewing the fixed assets in the next decade.

Currently, labour productivity is considered the key indicator for assessing the efficiency of defence industry enterprises both in Russia and abroad, providing an opportunity to manage the efficiency of military production [5, p. 103; 13, p. 48].

In microeconomic analysis, it is customary to use indicators of production output and labour intensity of products to quantitatively measure labour productivity. The production output as an economic category is a relative indicator of the efficiency of using labour resources of an enterprise, which determines the volume of production per unit of labour input (Formula 1).

$$W = Q / T, \quad (1)$$

where W denotes the production output; Q is the volume of production (natural, conditionally natural and monetary units of measurement); T is the number of personnel (average headcount, number of production workers).

Karl Marx interpreted the positive dynamics of labour productivity as any general change in the labour process that reduces the labour time socially necessary to produce a given commodity, so that less labour acquires the ability to produce more use-value[1].

The dynamic nature of labour productivity is determined by simultaneous influence of various factors. Most researchers group the factors behind the growth of this indicator as follows:

— material and technical factors that encompass the use of new machines and equipment, new technologies of military production, new types of materials. At defence industry enterprises, these factors are considered as the main driving force capable of increasing labour productivity, especially with introduction of promising automation technologies and technical solutions;

— socio-economic factors that include personnel qualification, possession of unique competencies, the system of values, leadership style, the degree of manual labour, personnel's interest in efficient activity [14, p. 74; 15, p. 19];

— organisational factors that comprise the use of a variety of techniques, ranging from the upper level of management, for example, defining the degree of production specialisation, to the operational management issues, for instance, workplace management [16, p. 56].

Considering the specificity of the factor analysis of labour productivity at defence industry enterprises, it is also advisable to divide the factors into two groups: extensive, which increase the output due to a larger amount of consumed resources (time, materials, labour), and intensive, which reduce the time for the manufacture of products. The strategic programmes for developing defence industry enterprises mostly aim at increasing labour productivity through intensive factors, such as production automation, and the use of new technologies [17, p. 52].

Undoubtedly, military production has some features that enhance or weaken the impact of the said factors. The conditions for improving production efficiency at defence industry enterprises include:

1) high technical equipment;

[1] See: http://www.esperanto.mv.ru/Marksismo/Kapital1/kapital1–05.html#c5.2 (Date of access: 27.07.2019).

2) distribution of highly qualified labour resources between the defence industry enterprises regardless of their territorial location;

3) federal funding to some defence industry enterprises located in the regions;

4) a high level of automation of mass production assemblies [18, p. 138; 19, p. 12].

The low labour productivity in this sphere is due to a list of objective reasons. They include the presence of single unique military production sites, mainly characteristic of enterprises producing nuclear weapons; the impossibility to manufacture military and civilian products on the same production lines; special territorial location of production facilities (irrational in terms of economic efficiency, but justified by national security) and regime barriers [3, p. 72; 20, p. 44; 21, p. 430]. In the past decade, state corporations decided to increase the influence of organisational factors on labour productivity. In particular, some of them pursued a policy of disposing of non-core assets, which led to the reduction of costs and thereby increased the efficiency of military production. For example, according to the ROSATOM State Corporation annual reports, one of the consequences of the disposal of non-core assets is a decrease in both the number of personnel at defence enterprises, and costs of facility maintenance that are the basis of non-core assets [22, p. 8; 23, p. 39; 24, p. 104].

Methods and tools for examining the influence of economic and material and technical factors on labour productivity

To uncover the reasons for the change in labour productivity at defence industry enterprises, it is necessary to establish causal relationships between changes in factors that influenced the resulting indicator (output indicator) and the dynamics of the indicator itself. The studies of both Russian and foreign researchers reveal various methods for measuring the impact of factors on labour productivity [25, p. 45; 22, p. 3; 14, p. 73].

Generally, in relation to any group of factors, the methods for examining the causes of changes in labour productivity at the defence industry enterprises can be classified as follows:

1. Calculation of indicators:

— absolute values (natural, conditionally natural and monetary units of measurement);

— relative values (efficiency, coordination, target values, intensity, dynamics, structure).

2. Factor analysis methods:

— method of absolute differences;

— method of relative differences;

— method of chain substitutions;

— index method;

— equity method;

— integral method.

3. Methods and techniques for examining economic data:

— method of comparison (comparing actual data with the plan, the approved standards, the data from previous years, the average industry data);

— grouping method (with substantiation of the criterion for grouping indicators).

4. Selectively applied methods:

— SWOT analysis;

— economic mathematical methods (decision-making methods, statistical and econometric methods, matrix models);

— expert assessments;

— sociological studies (using correlation-regression analysis, in particular, pair and multiple correlation).

The choice to use one or another tool largely depends on the purpose of the study, taking into account its time, labour and financial costs.

Identification of the conditions for increasing labour productivity transforms relies on retrospective examination of the factors. Therefore, the most frequently used methods for defence industry enterprises are the methods of comparison and grouping, the input-output method, as well as the factor analysis methods: methods of absolute and relative differences, index method, method of chain substitutions. The advantages of these methods are their efficiency, affordability in terms of time and labour costs. Despite their relative simplicity, all methods employed in factor analysis (except for the integral method) suffer from one significant drawback. The effect produced by each

factor is calculated by eliminating the impact of all other factors. This approach contradicts the nature of economic processes, which occur under the simultaneous influence of several factors.

Nevertheless, the index method is one of the most frequently applied methods for identifying dynamic dependencies of labour productivity at defence industry enterprises. In this particular case, the index is the ratio of the analysed value and the value taken as the base. The benefits of employing this method include the operational efficiency of the analysis, the possibility to compare indices in a significant time interval, and reflection of the relationship between the corresponding absolute values [26, p. 71].

For example, comparison of indices of labour productivity and capital-labour ratio is useful for assessing how technical equipment factors influence labour productivity of defence industry enterprises. In this case, the index of capital-labour ratio is the ratio of the value of fixed assets or their active part to the average headcount. Additionally, a certain ratio between the indices of labour productivity and capital-labour ratio allows assessing capital productivity[2]. The equality of the indices of labour productivity and capital-labour ratio indicates the constancy of capital productivity, that is, the replacing fixed assets have the same productivity as the replaced ones (Formula 2).

$$I_{lp} = I_{clr}, \tag{2}$$

where I_{lp} denotes the index of labour productivity; I_{clr} is the index of capital-labour ratio.

Lower indices of capital-labour ratio compared to the indices of labour productivity at the defence industry enterprises may indicate a lower productivity of new fixed assets compared to the previously used ones, a change in the structure of the active part of fixed assets, as well as changes in the organisation of production, which uses new fixed assets (Formula 2a).

$$I_{lp} < I_{clr}. \tag{2a}$$

Should the new fixed assets have higher productivity than those previously used, the index of labour productivity index will be higher than the index of capital-labour ratio (Formula 2b):

$$I_{lp} > I_{clr}. \tag{2b}$$

This ratio allows determining the impact of technical equipment factors on the level and dynamics of labour productivity at defence industry enterprises.

In addition to the methods traditionally used at defence industry enterprises, it is advisable to use selectively applied methods (economic mathematical methods, expert assessments using regression-correlation analysis) to understand the degree of influence of certain factors and make objective forecasts for the enterprises' development. The purpose of using more labour-intensive methods is to specify the influence of individual factors and identify the dependence of labour productivity on several factors affecting it simultaneously.

To model the dependence of labour productivity on economic and material and technical factors at the defence industry enterprises, we collected information on the performance of military production of the ROSATOM State Corporation for the period 2008–2017. To study the simultaneous influence of the listed factors on labour productivity, as well as to identify the relationship between the target indicator and the efficiency of using fixed assets, we applied correlation-regression analysis and the index method.

Modelling of the impact of the factors of technical development and headcount on labour productivity at the enterprises of ROSATOM State Corporation

The assessment of influence of economic factors, and material and technical equipment factors is based on the assumption that labour productivity depends on the average headcount, capital-labour ratio of active fixed assets, the ratio of the active part of fixed assets in their total value, and the investments in production. The method of multiple correlation is applied quite often to examine the impact of factors on labour productivity, while the set of factors varies depending on the purpose of the study [26, p. 73; 22, p. 3]. A narrow choice of indicators in the present research is due to the expediency of studying the effect produced on labour productivity by the condition and structure of fixed assets

[2] In this paper, by capital productivity we understand fixed assets turnover.

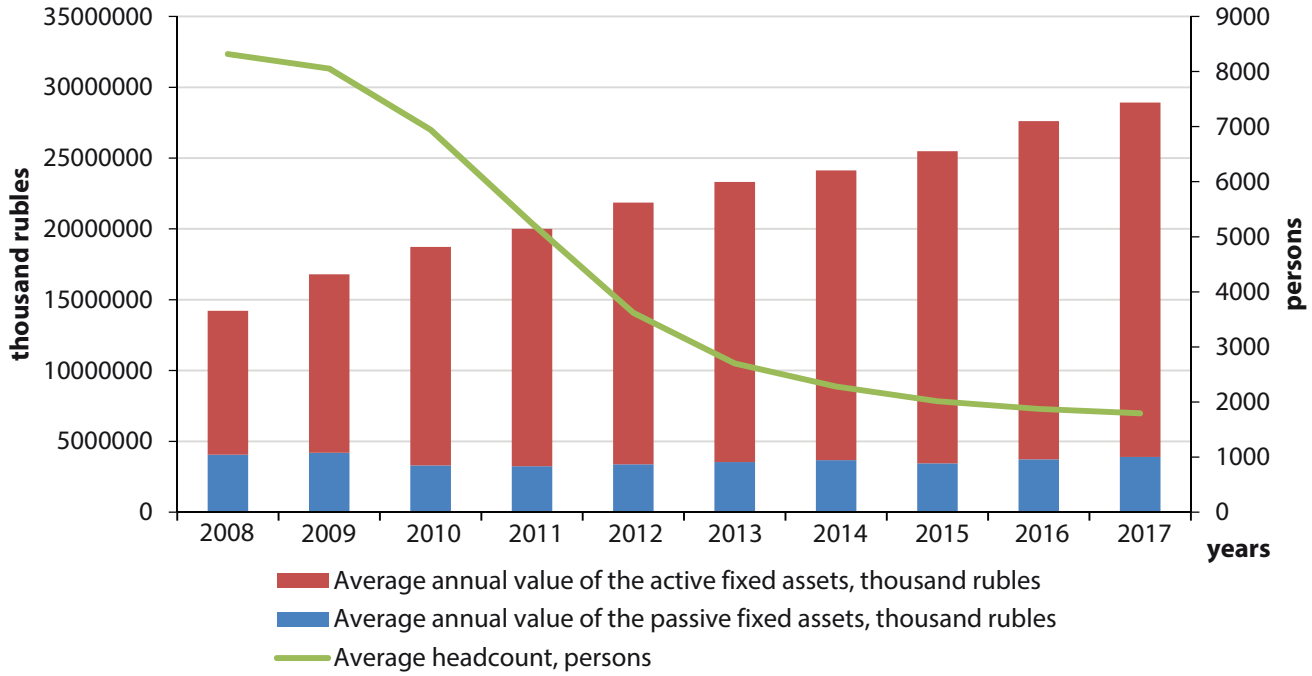

Fig. 3. *Changes in average headcount and the structure of fixed assets at the enterprises of ROSATOM State Corporation*

at defence industry enterprises, and a decrease in the number of personnel associated largely with the disposal of non-core assets (Figure 3).

Based on the performance data (value of the enterprises' fixed assets, ratio of the active part of fixed assets, average headcount, volume of investments, achieved level of labour productivity) of six enterprises of ROSATOM State Corporation during 2008–2017[3], a linear model of multiple regression is built.

For the correlation analysis, we selected the following variables:

y — labour productivity (output indicator);

x_1 — capital-labour ratio of active fixed assets;

x_2 — ratio of the active part of fixed assets in their total value;

x_3 — average headcount;

x_4 — volume of investments.

To determine the strength of the relationship between labour productivity and each factor, we calculated the pair correlation coefficients:

$$r_{yx1} = 0{,}99390,$$
$$r_{yx2} = 0{,}80561,$$
$$r_{yx3} = -0{,}94402,$$
$$r_{yx4} = 0{,}25507.$$

These coefficients reveal that the relationship between the independent variables (capital-labour ratio of active fixed assets and the annual average headcount) and the output indicator is very strong. Moreover, the relationship between the ratio of the active part of fixed assets in their total value and labour productivity is strong, whereas the relationship between the volume of investments and the output indicator is weak.

According to the calculated regression coefficients, the equation of the model is:

$$y = 0{,}9886 + 0{,}00031x_1 + 0{,}6912x_2 - 0{,}00014x_3 + 0{,}00014x_4.$$

The model is built after removing observation No. 8, which is a statistical outlier. Regression statistics for the model are given in Table 1.

The multiple correlation coefficient, which describes the linear dependence between the dependent variable and independent variables, is close to one, indicating a high relationship between the factors.

[3] Annual reports of the ROSATOM State Corporation for 2008–2017.

Table 1

Regression statistics of parameters of the four-factor model

Parameter	Value
Multiple *R*	0,999395517
R squared	0,9987914
Adjusted *R* squared	0,9975828
Standard error	0,091510622
Observations	9

Table 2

Predicted values and standard residuals of the output indicator of the four-factor model

Observation	Predicted *Y*	Residuals	Standard residuals
1	0,920645193	0,050904807	0,786687563
2	1,176938866	–0,064989526	–1,004354101
3	1,564412469	–0,052740145	–0,815051047
4	2,12800408	0,11738311	1,814049365
5	3,031950065	–0,003751985	–0,057983519
6	3,617774334	–0,036134434	–0,558424868
7	4,222650851	–0,030173751	–0,466307918
8	5,625549072	–0,052301952	–0,808279167
9	5,933962524	0,071803876	1,10966369

The value of the coefficient of determination R^2 shows that 99.9 % of the total variation of the outcome variable is explained by the variability of the factors included in the model. The calculations also confirm the statistical significance of the model's coefficients.

Based on the derived regression equation, we compare the actual values of the output indicator with its predicted values (Table 2), demonstrating the absence of statistical outliers (the absolute value of standard residuals is less than two).

The coefficient of elasticity shows the percent change of the output indicator under the change of the independent variable by one percent. The coefficients appear as follows:

$$E_{yx1} = 0{,}61152,$$
$$E_{yx2} = 0{,}1812,$$
$$E_{yx3} = -0{,}20368,$$
$$E_{yx4} = 0{,}09569.$$

— an increase in the capital-labour ratio of active fixed assets by 1 % leads to an increase in labour productivity by an average of 0.61 % (with the remaining factors unchanged);

— an increase in the ratio of the active part of fixed assets in their total value by 1 % increases labour productivity by an average of 0.18 % (with the remaining factors unchanged);

— an increase in the average headcount by 1 % leads to a decrease in labour productivity by an average of 0.2 % (with the remaining factors unchanged);

— an increase in investment by 1 % increases labour productivity by an average of 0.1 % (with the remaining factors unchanged).

Since the relationship between investment and labour productivity is weak, we constructed another multiple linear regression model excluding this factor. According to the calculated regression coefficients, the equation of the model takes the form:

$$y = -0{,}15697 + 0{,}00032x_1 + 2{,}11079x_2 - 0{,}00010x_3.$$

Regression statistics for this model are given in Table 3.

For the constructed model, the value of the coefficient of determination R^2 shows that 99.9 % of the total variation of the outcome variable is explained by the variability of the factors included in the model. The calculations also confirm the statistical significance of the model's coefficients.

Translation

Table 3

Regression statistics of parameters of the three-factor model

Parameter	Value
Multiple *R*	0,99874125
R squared	0,997484085
Adjusted *R* squared	0,995974535
Standard error	0,118092736
Observations	9

Table 4

Predicted values and standard residuals of the output indicator of the three-factor model

Observation	Forecasted *Y*	Residuals	Standard residuals
1	0,932575158	0,038974842	0,417466062
2	1,143365103	–0,031415763	–0,336499493
3	1,617111072	–0,105438748	–1,129372079
4	2,123077759	0,122309431	1,310076799
5	2,90750343	0,12069465	1,29278061
6	3,712050433	–0,130410533	–1,396849051
7	4,274367029	–0,081889929	–0,877136737
8	5,557125912	0,016121208	0,17267696
9	5,954711561	0,051054839	0,54685693

Based on the derived regression equation, we compared the actual values of the output indicator with its predicted values (Table 4), indicating the absence of statistical outliers (the absolute value of standard residuals is less than two).

The coefficients of elasticity are as follows:

$$E_{yx1} = 0{,}63744,$$
$$E_{yx2} = 0{,}55335,$$
$$E_{yx3} = -0{,}14074.$$

— an increase in the capital-labour ratio of active fixed assets by 1 % can increase labour productivity by an average of 0.64 % (with the remaining factors unchanged);

— an increase in the ratio of the active part of fixed assets in their total value by 1 % increases labour productivity by an average of 0.55 % (with the remaining factors unchanged);

— an increase in the average headcount by 1 % decreases labour productivity by an average of 0.14 % (with the remaining factors unchanged).

By comparing the 'long' and 'short' regressions, we determined which of them is preferable for the analysis. The *F* statistic is:

$$F_{obs.} = \frac{0{,}06973 - 0{,}0335}{0{,}0335 / 5} = 5{,}41.$$

According to the table of critical values of the *F*-distribution (with the level of significance $\alpha = 0{,}05$) we found:

$$F_{crit} = 6{,}61.$$

Since $F_{obs.} < F_{crit.}$, 'short' regression can be used for further analysis.

The obtained multiple linear regression model illustrates the correlation between the above factors and the level of labour productivity at the enterprises of ROSATOM State Corporation. Furthermore, it can act as an effective tool for predicting the growth of this indicator. Simultaneously, if we assume that the short- or medium-term goal of ROSATOM State Corporation is to boost labour productivity, we can make a point forecast. Given the capital-labour ratio of active fixed assets equals 15,000 thousand roubles per person, the ratio of the active part of fixed assets is 0.8, the annual average headcount amounts to 1,500 persons, the level of labour productivity is likely to be 6.178 million roubles per person.

Translation

A decrease in the average headcount leads to the increase in labour productivity only if the financial performance (revenue) of the enterprise is maintained or improved. Therefore, labour costs reduction should influence the outcome in parallel with the intensive factors of labour productivity, that is, the replacing fixed assets should have greater productivity than the replaced ones and the load of production capacities should approach the optimal one.

The application of the three-factor model to forecast the dynamics of labour productivity at defence industry enterprises allows operating the fixed assets, their structure, as well as the headcount in conditions of considerable changes at defence industry enterprises (increasing the share of civilian products to achieve the target level of labour productivity). To find objective and justified values, it is necessary to involve the multiplicity of factors affecting the level of labour productivity in the model. However, in practice, modelling of the outcome while involving all factors is hardly feasible.

The impact of the factor "capital-labour ratio of active fixed assets" on labour productivity at defence industry enterprises has its specificity. The renewal of the active part of fixed assets, introduction of new production lines with greater productivity and a higher degree of automation have been characteristic of Russian defence industry enterprises over the past decade. Nonetheless, it should be borne in mind that the impact of the factor "capital-labour ratio of active fixed assets" is limited. When machines and equipment (the active part of fixed assets) reach the maximum possible level of productivity, the factor of capital-labour ratio no longer significantly affects the growth of labour productivity and can positively contribute to the growth only when the used equipment is replaced by another with higher productivity.

At first glance, using the factor "ratio of the active part of fixed assets in their total value" in the model seems excessive and unjustified. Yet, the change in the ratio of the active part of fixed assets at enterprises relates not only to the growth of the active part of fixed assets and equipment upgrade. The increase in the ratio and, consequently, the factor's impact strength also results from the relatively stable value of the passive part of fixed assets caused by two simultaneous processes: withdrawal of excessive production capacity, social infrastructure facilities and service units, and creation of new military production. This factor particularly affects state corporations that carry the legacy of the Soviet enterprises with many auxiliary production and social service units [27, p. 37; 23, p. 40].

To perform a more complete assessment of the dependence of labour productivity on capital-labour factors, it is advisable to apply the index method. Comparison of the indices of labour productivity, capital-labour ratio and capital productivity demonstrates the growth of all of them during the period under consideration. However, the value of the index of labour productivity exceeds the value of the index of capital-labour ratio in the second and third intervals. This fact indicates the efficient use of fixed assets and an increase in labour productivity both due to a decrease in the number of employees and a more efficient use of fixed assets in this period (Figure 4).

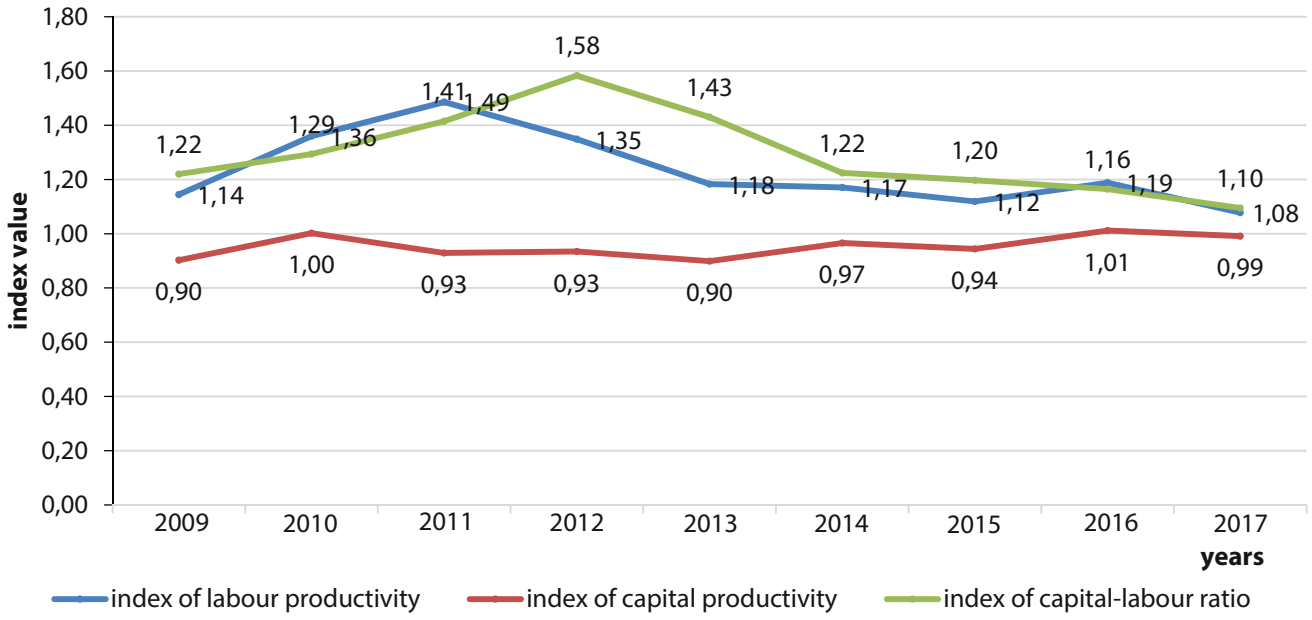

Fig. 4. *Dynamics of the indices of labour productivity, capital-labour ratio and capital productivity*

Translation

Figure 4 also illustrates that the dynamics of labour productivity does not always follow the dynamics of the capital-labour ratio and capital productivity. We can observe the consistency in the dynamics of the capital-labour ratio and labour productivity in six out of eight intervals (periods) from 2009 to 2016, while capital productivity and labour productivity change only five times in the same direction. Additionally, to a certain extent, we can argue that an increase in labour productivity and a decrease in capital productivity (for example, in the period from 2010 to 2011) resulted from the fact that the rate of personnel reduction was higher than the revenue growth generated by sales.

Conclusion

As a result of the conducted research, we constructed a regression model, which allows considering the impact of changes in the capital-labour ratio of active fixed assets, ratio of the active part of fixed assets in their total value, and the average headcount on labour productivity at defence enterprises. We took into account the policy of disposing of non-core assets pursued by state corporations in the past decade. In this regard, the main advantage of the model is the ability to assess and forecast the increase in the efficiency of military production under a decrease in the number of personnel based on the use of new fixed assets with higher productivity. Simultaneously, it is necessary to consider personnel reduction at the core enterprises when predicting the development of single-industry towns. For example, a six-fold decrease in the average headcount at the core enterprise of Novouralsk city in the considered period led to numerous socio-economic consequences. The population decreased by 13 %, the average registered unemployment rate was 2.6 %, whereas the average annual migration outflow amounted to 0.005 % of the total population, which significantly exceeds the average for the region[4]. Thus, the use of the index method in tandem with the construction of the model will allow enterprises to predict the growth of labour productivity under a decrease in the number of employees, renewal of fixed assets, disposal of non-core assets, quantitatively expressed by a change in the share of the active part of fixed assets. At the same time, the municipalities can take into account the number of personnel released from core enterprises when predicting the socio-economic development of territories and planning new jobs.

References

1. Hall, R. E. & Jones, C. I. (1999). Why do some countries produce so much more output per worker than others? *The Quarterly Journal of Economics, 114(1),* 83–116. Retrieved from: https://web.stanford.edu/~chadj/HallJonesQJE.pdf (Date of access: 10.03.2019 г.)

2. Golova, I. M. & Sukhovey, A. F. (2015). Innovation and technological development of industrial regions in the conditions of socioeconomic insecurity *Ekonomika regiona [Economy of Region], 1,* 131–144. DOI: 10.17059/2015–1-12.12. (In Russ.)

3. Eleneva, Yu. Y. & Voytova, V. N. (2013). Problem of Labor Productivity Management in Industrial Enterprises. *Rossiyskoe predprinimatelstvo [The Russian Journal of Entrepreneurship], 3,* 70–75. (In Russ.)

4. Bernard, A. B. & Jones, C. I. (1996). Comparing Apples to Oranges: Productivity Convergence and Measurement Across Industries and Countries. *American Economic Review, 86(5),* 1216–1238.

5. Ukhalina, I. A., Efimenko, N. A. & Agapova, S. P. (2017). Key Performance Indicators as Economic Security Tool of the Rosatom State Corporation Enterprises. *Globalnaya yadernaya bezopasnost [Global nuclear safety], 1,* 102–112. (In Russ.)

6. Sokolov, A. V. & Rimskaya, A. O. (2016). Methodological issues of modeling of the efficiency of labor in the Russian defense industry enterprises. *Mir ekonomiki i upravleniya [World of economics and management], 16(4),* 48–66. (In Russ.)

7. Solow, R. M. (1957). Technical Change and the Aggregate Production Function. *The Review of Economics and Statistics, 39(3),* 312–320.

8. Battisti, M., Del Gatto, M. & Parmeter, C. F. (2014). *Labor productivity growth: disentangling technology and capital accumulation.* Retrieved from: https://www.bus.miami.edu/_assets/files/repec/WP2014–02.pdf (Date of access: 05.03.2019).

9. Gambardella, A. & McGahan, A. M. (2010). Business-Model Innovation: General Purpose Technologies and their Implications for Industry Structure. *Long Range Planning, 43(2–3),* 262–271.

10. Reamer, A. (2014). *The Impacts of Technological Invention on Economic Growth. A Review of the Literature.* The George Washington Institute of Public Policy, 55.

11. Gorbunov, V. K. & Krylov, V. A. (2015). Region Effective Production Assets and Their Assessment By The Production Function Method. *Ekonomika regiona [Economy of Region], 3,* 334–347. DOI: 10.17059/2015–3-27. (In Russ.)

12. Abel, E. & Bernanke, B. (2010). *Macroeconomics (5th ed.) [Makroekonomika (5 izd.)].* Trans. from English. SPb.: Peter, 768. (In Russ.)

13. Parmenter, D. (2007). *Key Performance Indicators: Developing, Implementing and Using Winning KPI's.* New Jersey, USA: John Wiley & Sons, inc., 233.

14. Krasnopevtseva, I. V. (2017). Searching for the concept of formation of organizational and economic mechanism of performance management in engineering at the machine-building enterprises. *Vektor nauki Tolyattinskogo gosudarstvennogo universiteta. Seriya: Ekonomika i upravlenie [Science Vector of Togliatti State University. Series: Economics and Management], 2(29),* 72–78. DOI: 10.18323/2221–5689–2017–2-72–78. (In Russ.)

[4] Retrieved from: http://adm-ngo.ru/docunit/6238 (Date of access: 20.07.2020).

15. Chistnikova, I. V. & Antonova, M. V. (2015). Theoretical aspects of research of factors of increase of labor productivity at the enterprise. *European science, 4,* 18–20. (In Russ.)

16. Tremblay, V. & Tremblay, C. (2012). *New Perspectives on Industrial Organization: With Contributions from Behavioral Economics and Game Theory.* New York: Springer, 837.

17. Nechaev, A. S. (2009). The factors of growth of labor productivity at the enterprises of Russia. *Trud i sotsialnye otnosheniya [Labour and social relations], 9,* 52–58. (In Russ.)

18. Chistov, I. B. & Astakhov, V. G. (2018). Building an effective system fo managing production processes at the military-industrial complex enterprises based on lean production principles. *Voennyy akademicheskiy zhurnal [The Military Academic Journal], 3,* 136–141. (In Russ.)

19. Fujiwara, Y. & Aoyama, H. (2010). *A Stochastic Model of Labor Productivity and Employment.* RIETI Discussion Paper Series 10-E-001. January 2010. Retrieved from: http://www.rieti.go.jp/jp/publications/dp/10e001.pdf (Date of access: 02.03.2019)

20. Mukhopadhyaya, A. K. (2009). *Value Engineering Mastermind: From Concept to Value Engineering Certification.* New Delhi, 154.

21. Spiegel, U., Gonen, L. D. & Weber, M. (2014). Duration and optimal number of shifts in the labour market. *Applied Economics Letters, 21(6),* 429–432.

22. Gagarinskii, A. V., Kuznetcova, I. G., Kotmyshev, S. D. & Gagarinskaia, G. P. (2016). Labour productivity in the machine-building enterprises of Russia: Reserves and factors. *Naukovedenie, 1,* 1–12. DOI: 10.15862/72EVN11611. (In Russ.)

23. Ryabtsun, O. A. (2011). Institutional aspects of industrial enterprises NWC property complexes efficiency increase. *Sovremennaya nauka. Aktualnye problemy teorii i praktiki Seriya: Ekonomika i pravo [Modern science: actual problems of theory and practice. Series of Economics and law], 2,* 38–41. (In Russ.)

24. Movsesyan, V. E. (2018). Estimation of the effect of material and technical factors on the productivity of the work of the industrial enterprise. *Problemy razvitiya predpriyatiy: teoriya i praktika [Problems of enterprise development: theory and practice], 2,* 102–106. (In Russ.)

25. Fedchenko A. A. (2016). Methodological Approaches to Studying of Labor Productivity. *Ekonomika truda [Russian Journal of Labour Economics], 1,* 41–62. DOI: 10.18334/et.3.1.35153 (In Russ.)

26. Solov'ev, M. A. (2014). Correlation of wage growth and labor productivity in military-industrial complex of Russia through 2020. *Problemy prognozirovaniya [Studies on Russian Economic Development], 5,* 70–78. (In Russ.)

27. Rodin, I. I. (2015). Improvement of strategic manipulated federal property the example non-core assets of JSC "Center for nuclear industry noncore assets" State Corporation "Rosatom". *Ekonomika, statistika i informatika. Vestnik UMO [Economics, Statistics and Informatics. Bulletin of Educational Methodical Association], 6,* 33–39. (In Russ.)

About the authors

Valery Zh. Dubrovsky — Dr. Sci. (Econ.), Professor, Director of the Institute of Economics, Ural State University of Economics (62/45, 8 Marta/Narodnoy Voli St., Ekaterinburg, 620144, Russian Federation; e-mail: dubr@usue.ru).

Ekaterina M. Ivanova — Senior Lecturer, Economics and Management Department, Technological Institute of the National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), branch; https://orcid.org/0000–0003–0690–0598 (36, Communisticheskiy Av., Lesnoy, 624200, Russian Federation; e-mail: IvanovaEMLesnoy@mail.ru).

Natalia V. Chuprakova — Senior Lecturer, Higher Mathematics Department, Technological Institute of the National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), branch; https://orcid.org/0000–0002–1483–0545 (36, Communisticheskiy Av., Lesnoy, 624200, Russian Federation; e-mail: natashachuprakova@rambler.ru).