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Model for labour productivity management in the economy of Russia

Abstract. Improving labour productivity is one of the key challenges faced by the Russian economy. Since 2018, Russia has been implementing the national project “Labour Productivity and Employment Support”. There are reasons to believe that the task of ensuring the required dynamics of productivity growth within the project needs further theoretical grounding. The scientific problem is that the change in the uncertainty of the project environment significantly affects the productivity growth. The optimal amounts of funding allocated at each of the project stages depend on the random factors, which makes it crucially important to take into account their intensity when planning the dynamics of productivity. The paper develops a stochastic mathematical economic model for managing the growth of labour productivity and substantiates its uses as a tool to solve the scientific problem. The author sets the scientific task to determine the intensity values of random factors, which make it possible to reach the project targets with the planned amount of funding. The methodological basis of the study rests on the concepts of economic growth, optimal control, and stochastic dynamic systems. The article assesses risks of irrational spending, presents scenarios of changing the project environment, and gives recommendations for adjusting the funding. The theoretical and practical significance of the study lies in the justification of the need for additional control over the expenditure of financial resources in order to avoid their irrational use under growing uncertainty. The research shows that reducing uncertainty through institutional changes will increase the intensity of funding without compromising the dynamic characteristics of the project. The author justifies the limitations and ways of using the developed model.

Keywords: economic growth; labour productivity; mathematical economic model; scenario modelling; national project; funding; random factors; dynamics.

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Introduction

Labour productivity is recognised as one of the most pressing problems of the Russian economy. Intensive economic growth involves scaling up the output by employing more efficient factors of production, facilities, technology and professional workers through technological advance. Improvement of labour productivity is the most important driver of economic growth and can be generally expressed as the ratio of GDP to labour costs.

The analysis of publicly available official statistics on labour productivity provided by the Russian Federal State Statistics Service (Rosstat), the Organisation for Economic Cooperation and Development (OECD), and International Labour Organisation (ILO) demonstrated that in 2005–2015 Russian economy retained a more than twofold lower level of labour productivity compared to the European Union, G7, and OECD countries. This gap showed little if any signs of closing over time¹.

¹ Labour productivity in the Russian Federation. Analytical Centre for the Government of the Russian Federation. Social Bulletin, no. 9, June 2017, p. 3. (in Russ.)

According to the OECD data, labour productivity in Russia expressed as GDP per person employed in current prices at purchasing power parity (PPP) reached 54,975.02 US dollars in 2018, i.e. about 42.4% of the value shown by the USA where this indicator was the highest in 2018¹.

Speaking of the general state of labour productivity problem in the global economy, it should be noted that a negative trend in the growth rates of the indicator is typical of most countries: "... the global crisis has deepened the problem of productivity deceleration. In the 1970s, productivity in five leading OECD economies (the USA, Japan, the UK, France, Germany) was estimated to be growing by about 2.5 % per year, while in the past 10 years it only grew by about 0.5 %" [Medvedev, 2018, p. 9]. At the same time, labour productivity index in Russia calculated in US dollars in constant 2010 prices at PPP in 2018 reached 100.5 %, higher than in a number of countries².

Therefore, the Russian economy retains a significant potential for labour productivity growth. A relevant problem of applied research is to substantiate the parameters of measures aimed at labour productivity improvement in order to ensure the necessary growth of this macroeconomic indicator.

Russian authorities have repeatedly delivered statements and made corresponding decisions concerning the need to increase labour productivity. In his speech at an expanded meeting of the State Council on February 8, 2008, Vladimir Putin referred to extreme inefficiency as the main problem of the Russian economy. The President of the Russian Federation noted that "... labour productivity in Russia remains unacceptably low. With the same labour costs as in the most developed countries Russia's return is several times lower. This situation is all the more dangerous when global competition is increasing and the cost of qualified labour and energy resources is also on the rise"³.

In December 2018 at the session of the Presidium of the Presidential Council for Strategic Development and National Projects, the passport of the national project (programme) titled "Labour Productivity and Employment Support"⁴ (hereinafter referred to as "the project") was approved. The document indicates the percentage of labour productivity growth at the medium and large enterprises of basic non-energy sectors year on year as the main target.

In this article the process of monitoring the progress of the project over time under the influence of random factors serves as the object of research. The subject of research includes the mathematical economic model and the method for analysing the labour productivity growth management process implemented as part of the national project.

The working hypothesis of the study can be expressed as follows: the optimal funding amount allocated at each of the project stages substantially depends on the uncertainty of the environment – i. e. the presence of random factors intensity of which is unaccounted for at the time of setting the performance rates for the national project.

The purpose of the study is to quantify the intensity of random factors that would allow the project targets to be achieved with the scheduled amount of funding, as well as to provide rationale for and directions of changes in the amount of funding of the project stages depending on their

¹ Organisation for Economic Co-operation and Development (OECD). Level of GDP per capita and productivity/ GDP per person employed/ USD current prices, current PPPs. Available at: <https://stats.oecd.org>.

² The value is calculated by the author in relation to 2017 based on the OECD data: Level of GDP per capita and productivity/ GDP per person employed/USD constant price, 2010 PPPs. Available at: <https://stats.oecd.org>.

³ On Russia's development strategy through to 2020". The speech of Vladimir Putin, the President of the Russian Federation, at an expanded meeting of the State Council on February 8, 2008. Available at: <http://kremlin.ru/events/president/transcripts/24825>. (in Russ.)

⁴ The passport of the national project (programme) "Labour Productivity and Employment Support". Available at: <http://government.ru/news/29354>. (in Russ.)

implementation environment, i.e. an increase or a decrease in the intensity of random factors.

From the purpose of the study, the following main objectives can be derived:

- to develop a dynamic stochastic mathematical economic model of the process of managing labour productivity growth under the national project;
- to devise a method for analysing the potential labour productivity dynamics under uncertainty and to use it to determine the optimal funding amount under a higher or lower intensity of random factors.

Literature review

Economics has long been dealing with the problems of economic growth and labour productivity. The review of the previous publications presented below cannot be regarded as complete and intends to identify the main up-to-date areas of research into labour productivity with reference to the research topic at hand.

The groundwork for economic growth theory was laid by Harrod [1939] and Domar [1946] who described a one-factor growth rate model. Starting with the well-known works by Solow [1956; 1957] and Swan [1956] who proposed a model of endogenous growth, modern economic thought continues to evolve in the direction where it substantiates the sources and models of economic growth, referring to technological progress and labour as basic exogenous factors [Romer, 1986]. The role of knowledge, human capital, and “learning by doing” in the process of economic growth was studied by Arrow [1962] and Uzawa [1965]. The mechanisms of “creative destruction” are described in “Schumpeterian models” of growth [Aghion, Howitt, 1992; Grossman, Helpman, 1991]. Stochastic models of economic growth are discussed in the monograph by Kurzenev, Matveenko [2018].

The relevance of labour productivity improvement as one of the sources of economic growth has latterly dramatically increased. Socioeconomic prerequisites and theoretical justifications for labour productivity are presented by Voskoboynikov, Gimpelson [2015]; Mikheeva [2015]; Zaytsev [2016]; Mironova [2017]; Goffe, Monusova [2017]; Tsvetkov et al. [2017]. The problem of increasing productivity in the context of national economic policy and strategic planning is discussed by Aganbegyan [2017]; Medvedev [2018]; Frenkel et al. [2018].

In his paper, Zaytsev [2016] concluded that the reasons behind Russia’s noticeable lagging behind developed countries in terms of labour productivity are 58–65 % low technology level and 33–39 % insufficient capital-labour ratio. Frenkel et al. [2018, p. 26] believe that the goal of raising Russia’s labour productivity to at least 5 % growth per year is at risk. Analysing the reasons behind low labour productivity in Russia, Mironova [2017] refers to such factors as insufficient investment to the real sector of economy, inefficiency of institutions and forms of government, and weak competition. Mikheeva [2015] believes the rate of growth in the number of highly productive jobs to be loosely correlated with the rates of actual personal income and labour productivity in the Russian economy.

Lannelongue, Gonzalez-Benito, Quiroz [2017, pp. 162-163] provide references to various approaches towards determining productivity: labour productivity is the ratio of total output to operating inputs, which corresponds to labour efficiency in producing goods or services [Samuelson, Nordhaus, 1989]; labour productivity is the logarithm of the ratio of revenue to the total number of employees [Ichniowski, 1990; Pritchard, 1992; Huselid, 1995; Koch, McGrath, 1996].

Huselid [1995] demonstrates that the second calculation method provides a single index that can be used to compare labour productivity in different organisations and assess the monetary value of return on investment for the high-performance operating methods. Fan et al. [2018] measure labour productivity as a value of operating income per employee. To calculate

productivity, the authors propose finding the ratio of revenue to the total cost and employees. This approach allowed the authors to determine the relationship between the decline in labour productivity and decline in sales.

Bhattacharya, Narayan [2015] study the relationship between output, labour productivity, and actual wages in the manufacturing sector of India. In their model, labour productivity is a control variable that depends on labour regulations, infrastructure, and access to external finance. The authors define labour productivity as the real gross value added per employee where employment is the total number of employees in the industry.

Tarancón et al. [2018] discuss the relation between labour productivity and operational excellence for the 24 EU countries over 17 years. Labour productivity is estimated as the average of productivities of each country and calculated as the ratio of GDP in constant 2010 prices to the hours worked in the country.

McCullough [2017] examines productivity gaps between four African economies. Productivity gaps are calculated from labour costs (hours worked per year) and productivity (sector output per unit of labour costs). The author's conclusion which is of particular interest reads that productivity gaps may be caused by statistical and methodological errors in calculations. There are two main methodological errors biasing the results of calculations: the assumption that workers in each sector work the same number of hours and are of the same level of human capital [Gollin, Lagakos, Waugh, 2014].

One of the approaches used to study the problems of labour productivity is mathematical modelling in economics. Mathematical economic models and methods used to analyse the dynamics of labour productivity including approaches to its assessment are presented by Senikova, Vorokova [2017]; Lyadova [2017]; Kutukova [2017]; Burtseva [2017].

Construction and analysis of labour productivity models built on the basis of the actual economic programmes and projects implemented in the country leads to the need to solve optimal control problems. A lot of research conducted by both Russian and foreign authors address the problems of the development of the theory of optimal control. Inclusion of random factors, uncertainty, and risk into the labour productivity improvement models compels modern researchers to turn to stochastic (probabilistic) programming, the foundations of which were laid in the 1950s.

As it can be seen, classic and modern publications cover a wide range of problems and methods related to establishing the role of labour productivity in reaching the goal of economic growth. One of the relevant approaches to study the growth rate of this economic indicator is mathematical (including stochastic) modelling in economics and the methodology of optimal control.

Mathematical economic model for managing labour productivity in the economy

The measure of labour productivity in the economy (E , million roubles / person) can be calculated as the quotient of GDP (Y , billion roubles) and the average annual number of labour force in a country (L , thousand people):

$$E(t) = \frac{Y(t)}{L(t)}, \quad (1)$$

where t is the measuring unit for a period of time, year¹.

A controlled increase in labour productivity in the national economy can be represented by a dynamic model that describes the process of implementing a national project (programme) with chronologically defined targets and the amount of funding for their achievement (Table 1).

¹ Hereinafter, the argument t will be omitted and used only to indicate the duration of the time period.

Table 1. Target and calculated values of labour productivity in accordance with the passport of the national project “Labour Productivity and Employment Support”

Таблица 1. Целевые и расчетные значения производительности труда в соответствии с паспортом национального проекта «Повышение производительности труда и поддержка занятости»

Year	Target labour productivity growth rate, %	Funding from all sources, billion roubles	Calculated values of labour productivity, million roubles / person
1	2	3	4
2018	1.4	1.471	1.363
2019	1.4	7.254	1.382
2020	2.0	7.991	1.410
2021	3.1	7.996	1.454
2022	3.6	8.776	1.506
2023	4.1	9.136	1.568
2024	5.0	9.504	1.646
Total:	20.6	52.127	–

Note. Compiled using the data from the passport of the national project and calculations.

It should be noted that the passport of “Labour Productivity and Employment Support” national project lists 93 tasks. Most of them relate to systemic measures and targeted support to increase labour productivity while 28 tasks are systemic measures to improve labour market efficiency. Therefore, financial target for the project, among other matters, provides for a portion of funds to be allocated to the construction and development of employment centres and fulfilling other tasks indirectly related to labour productivity improvement. At the current stage of the project, this condition can hardly be addressed due to the lack of actual results that would demonstrate the interrelation between the tasks.

Column 4 (see Table 1) lists the values of labour productivity in physical terms calculated in constant 2018 prices based on the growth targets. As a reference value, we used labour productivity for 2018 calculated with formula (1) based on the data from Rosstat.

With the proposed mathematical model, the management of labour productivity growth in the country's economy (execution of the national project) can be interpreted as a continuous process of identifying and eliminating dynamic deviations δ of actual labour productivity E_f from its target value E for a given period

$$\delta = E - E_f, \quad (2)$$

where $E = \int_{t_0}^t \dot{E} dt$; $\dot{E}$ is the target rise in labour productivity.

Implementation of the national project comes along with the influence of unaccounted for, random factors having additional effect on labour productivity development in the country and may include, without limitation, instrument errors in measuring and interpreting the actual results of labour productivity and employment support measures.

All random factors and potential causes of variations in the anticipated outcome can be divided into two groups:

- “internal” factors variability (stochasticity) of which may be due to inaccuracy in handling the project tasks;
- “external” ones caused by changes in socioeconomic factors not acknowledged in the project.

Internal random factors and potential causes of variations in the anticipated outcome include¹:

- potential changes in the number of enterprises participating in the project;
- variable effectiveness of measures and actions related to non-financial stimulation of the advanced managerial, organisational, and technological solutions applied;
- changes in prerequisites for the provision of state support to the enterprises participating in the programme, including changes of the criteria and conditions for tax preferences;
- variable application of the annual administrative barrier reducing mechanisms;
- instrument errors in the quantitative and qualitative estimation of costs incurred by the businesses and sectors in connection with the administrative barriers;
- the number of rules and regulations that need to be revised in a bid to increase labour productivity, as well as the course of their adaptation;
- variable outcome of managerial training programme and variable effectiveness of the corresponding federal educational standards;
- variable number of employees at the enterprises trained to apply productivity improvement tools and variable quality of their training;
- variable number of in-house trained instructors and their variable performance;
- variable methodology and results of comprehensive production system certification at the enterprises in terms of labour productivity;
- fluctuations in the quantity and qualitative characteristics of key product samples developed as part of the process of lean production implementation, and other factors indicated as tasks in the project passport.

By external factors we understand volatility of socioeconomic factors in global and national economies; changes in the country's demographic indicators; institutional transformations caused by execution of other national projects and programmes, etc.

In this model, the effect of random factors is described by white noise² ξ with the expected value $m_\xi = 0$ and intensity (standard deviation) σ in labour productivity units (million roubles / person). Zero expected value indicates that there is no systematic component in random factors, which is equivalent to the assumption of consistency of and economic rationale behind key areas of labour productivity improvement listed in the national project passport. The premise of constant white noise intensity allows us to simulate the system's "transitions" into successively changing states characterised by various constant intensities of random factors. For example, transition from high intensity of random factors to a low one can be ascribed to effective project implementation (increased certainty of internal factors) on the one hand, or to the formation of more favourable external conditions (reduction of risks due to macroeconomic, political and other factors), on the other.

Change in the actual level of labour productivity is described by the equation

$$\dot{E}_f = G(\delta + \xi), \quad (3)$$

where G is the intensity of labour productivity management in the economy in accordance with the national project parameters.

Formally, G is measured in years⁻¹, which corresponds to the frequency of events per unit of time. However, the model is based on the assumption that the intensity of labour produc-

¹ The language of the tasks is borrowed from the passport of the national project.

² The term "white noise" indicates that process correlation at two different points in time does not depend on distribution of noise values. A property of this process which is important to modelling implies that the constant is equal to zero, which greatly simplifies the derivation of the final equation for the intensity of the project implementation management process.

tivity management is governed by the amount of funding available at each stage of the project implementation, and the actual change in labour productivity is caused by the utilisation of these funds¹.

The actual measured outcome of labour productivity management is described by an integral equation

$$E_f = \int_{t_0}^t \dot{E}_f dt = \int_{t_0}^t G(\delta + \xi) dt. \quad (4)$$

The presence of integral negative feedback E_f reduces the description of productivity improvement management to the dynamic control of project outcome and making operational decisions to eliminate deviations (Fig. 1).

Fig. 1. Project implementation process diagram

Рис. 1. Схема процесса управления реализацией проекта

The task is to determine the optimal² amount of funding G_0 that would minimise the probability of dynamic deviation δ . In economic and managerial terms, it means to justify the project's funding dynamics that would ensure the most accurate operational achievement of performance targets in relation to their set values. The task which is also of interest is establishing the limit intensity of random factors at which the funding dynamics set out in the project passport can be conditionally considered as optimal.

By differentiating equation (2) once with respect to time and by applying (3) we obtain:

$$\dot{\delta} = \dot{E} - G(\delta + \xi). \quad (5)$$

Using the probabilistic method of moments, we obtain differential equations for the expected value m_δ and variance θ_δ of dynamic deviation δ , assuming the $\dot{E}$ and G variables are non-random:

$$\dot{m}_\delta = \dot{E} - Gm_\delta; \quad (6)$$

$$\dot{\theta}_\delta = 2G\theta_\delta - G^2q, \quad (7)$$

where $q = \sigma^2$ is the variance of the random variable ξ ; m_δ and θ_δ are determined for the time interval of the next project implementation period (year).

¹ Such interpretation requires the use of a normalisation coefficient with the measurement unit of billion roubles · year, which is equivalent to adopting the total project funding amount of billion roubles as a unit of measure.

² Hereinafter, the term “optimality” as applied to the amount of funding for the national project will be used exclusively in the mathematical sense to indicate the value of the G variable under which the minimum of the below criterion is guaranteed, which corresponds to the minimum values of the project error probability.

From formulas (6) and (7) we get the expressions for the expected value m_δ^0 and variance θ_δ^0 of dynamic deviation δ in the steady state $\dot{m}_\delta = 0, \dot{\theta}_\delta = 0$, i. e. after deviation at the end of the reference period has formed:

$$m_\delta^0 = \frac{\dot{E}}{G}; \quad (8)$$

$$\theta_\delta^0 = \frac{1}{2} G q. \quad (9)$$

According to expressions (8) and (9), an increase in funding amount for another project stage G causes the management bias – expected value m_δ^0 to decrease and random error component – variance θ_δ^0 to increase. Graphs in Fig. 2 compiled by the author illustrate the dependence of probability moments δ on the G value, provided that $\dot{E} = 0.05$ million roubles / person per year; $q = 0.025$ million roubles / person.

Fig. 2. Impact of funding amount on stochastic deviation indicators¹

Рис. 2. Зависимость вероятностных моментов отклонения от суммы финансирования

As it can be seen, higher funding decreases the expected value and increases the deviation variance δ . Therefore, for each group of values of $\dot{E}$ and q variables, the optimal value of G variable can be found by the minimum criterion of a certain m_δ^0 and θ_δ^0 dependent function. As such a function, we will use the absolute value of the probabilistic characteristics difference $\gamma = |\theta_\delta^0 - m_\delta^0|$ the minimum of which corresponds to the optimal combination of systematic and random components of deviation δ .

Condition

$$\gamma = 0 \quad (10)$$

characterises the ratio of variables when a further increase in a project stage funding to reduce the systematic component of the management error becomes pointless due to higher error variance.

By applying formulas (8), (9), and (10), we obtain a square equation

$$\frac{1}{2} G^2 q - \dot{E} = 0,$$

the solution of which gives a formula for the optimal intensity of project implementation management [Mikhnenko, 2017b]:

¹ The range of X-axis values corresponds to the conditional annual amount of funding.

$$G_0 = \frac{\sqrt{2\dot{E}}}{\sigma}. \quad (11)$$

Economic rationale behind equation (11) is as follows: an optimum amount of funding in terms of its dynamic accuracy depends on the target rates of labour productivity growth $\dot{E}$ and standard deviation σ of the random component ξ . A higher target rate of productivity growth causes an increase in funding; however, a more intensive random component means that it should be reduced in order to avoid wasting money on unsystematic solutions (including “pendulum” ones).

According to formula (11), the intensity of random effects corresponding to the optimal amount of funding is given by the expression

$$\sigma_0(t) = \frac{\sqrt{2\dot{E}(t)}}{G_0(t)}. \quad (12)$$

To identify the dynamic characteristics of managing labour productivity growth, we will use a piecewise linear approximation per month:

$$E(t') = E(t' - 1) + \frac{nE(t' - 1)}{12}, \quad (13)$$

where n is the planned annual increase in labour productivity (as a decimal quantity); t' is the current month; $t' - 1$ is the previous month.

Method for analysing potential labour intensity dynamics under uncertainty

Assume that the amounts of funding set in the national project passport are optimal in terms of (10), then, in accordance with expression (12), the “predicted”¹ monthly intensities of random factors will correspond to the conditions that ensure smooth achievement of the target rates of productivity growth:

$$\sigma_0(t) = \frac{\sqrt{2\dot{E}(t')}}{G_0(t')}, \quad (14)$$

where $\dot{E}(t') = E(t') - E(t' - 1)$; $G_0(t') = \frac{1}{12}G(t)$, $G(t)$ is the target value of the annual funding for a given project stage.

Table 2 lists “predicted” optimal intensities of random factors (standard deviation) for each year of the project implementation in accordance with target rates of labour productivity growth.

Table 2. Planned productivity growth rates and random factor intensity

Таблица 2. Плановые темпы прироста производительности и интенсивность случайных факторов

Indicator	2018	2019	2020	2021	2022	2023	2024
Labour productivity growth rate, %	1.4	1.4	2.0	3.1	3.6	4.1	5.0
Random factor intensity (standard deviation), million roubles / person	0.433	0.088	0.097	0.121	0.121	0.126	0.137

Note. Compiled using the data from the passport of the national project and calculations.

The values of 2017 input variables were used as initial data for the calculations (based on the data from Rosstat): $Y_{2017} = 92101.35$ billion roubles; $L_{2017} = 76285.411$ thousand people; from where $E_{2017} = 1.207$ million roubles / person. Random factor intensity measuring unit (million

¹ Quotes in the word “predicted” indicate that the calculated values of random factor intensities can be viewed as anticipated but there is no reason to believe that such values were actually predicted during the project preparation.

roubles / person) can be used to interpret possible random changes in the annual labour productivity values from the target values.

Fig. 3 shows the dynamics of the target and actual labour productivity in the presence of random factors with “predicted” intensity over the project implementation years.

Fig. 3. Dynamics of target and actual labour productivity in the presence of random factors¹

Рис. 3. Динамика целевой и фактической производительности труда при наличии случайных факторов

Calculations show that, if the assumptions about the optimal project funding in terms of (10) are valid, the “predicted” intensities of random factors in 2019–2024 set very stringent requirements for the stability of socioeconomic factors, as well as for the quality of the project objectives achievement and monitoring procedures. The “permissible” spread in the actual results from this period should be in the range of 88–137 thousand roubles / person, which is equivalent to 7.12–9.25 % of labour productivity targets. In contrast to this period, the 2018 objectives “allowed” a wide spread of results, i.e. in the range of 433 thousand roubles / person (35.37 %).

Mathematical modelling demonstrates that a change in the amount of project funding G (with the same “predicted” intensity of random factors σ_0) will lead to a theoretically justified (see Fig. 2) change in probabilistic characteristics of deviation (management errors) δ (Fig. 4).

Fig. 4. Impact of funding correction on stochastic indicators of the management error²

Рис. 4. Зависимость вероятностных характеристик ошибки управления от величины изменения суммы финансирования

¹ The actual labour productivity graph represents the mean value of fifty realisations of random variable ξ ; Figs. 3–8 are constructed using the data from mathematical modelling.

² The graphs are plotted using 50 realisations of random variable ξ . The absence zero absolute value of the difference γ on the graph is due to the discreteness of the funding amount changing scale as compared to its target value (in 25 % increments). The absolute value of the difference $\gamma = 0$ when the funding amount changes by about -12.5 %.

A change in the funding amount between 0 % and –25 % can be considered acceptable and is equivalent to the change in the total amount of project funding from 52.127 to 39.095 billion roubles¹. The range of the absolute value of the difference variation γ in this case will not exceed 0.003–0.004 million roubles / person.

A further decrease in funding amount (by more than 25 %) will increase the systematic component of the management error (Fig. 5).

Fig. 5. Decrease in the accuracy of the project implementation (increase in the expected value of the error) due to a 50% reduction in the total amount of funding

Рис. 5. Снижение точности реализации проекта (рост математического ожидания ошибки) вследствие уменьшения общей суммы финансирования на 50 %

An increase in funding in excess of the planned value will entail a higher variance of the management error δ (Fig. 6).

Fig. 6. The rise of the outcome variance due to the 50% increase in the total amount of funding

Рис. 6. Увеличение дисперсии результатов вследствие прироста общей суммы финансирования на 50 %

Therefore, with the “predicted” intensity of random factors, the scheduled project funding amounts can be deemed to be close to optimal².

With the planned funding amounts unchanged (deemed to be optimal), an increase in the intensity of random factors will lead to a systematic deviation of the actual results from the target values, which indicates the need to reduce the amount of funding to a more “conservative” value. For example, an increase of σ_{2020} to 0.25 million roubles / person would require the funding to be reduced to 3.088 billion roubles (61.36 % lower than the planned value) in order to avoid inefficient (accidental) utilisation of financial resources. With a decrease in standard deviation of random factors σ_{2020} to 0.05 million roubles / person, the optimal amount of funding for this project stage will be 15.438 billion roubles (93.2 % higher than the set value).

¹ With the target value of 52.127 billion roubles.

² Permissible 25% reduction (13.032 billion roubles) in the total funding amount can be considered as a target “safety margin”.

When analysing the presented mathematical modelling data, it should be understood that the estimated optimal funding amounts disregard both actual and predicted economic costs involved in achieving the project objectives. The calculations aim to demonstrate that accurate achievement of project objectives stochastically depends on the amount of funding and on the anticipated uncertainty of the socioeconomic and institutional environment. With the mathematical model, the potential effectiveness of the project can be assessed together with the possible scenarios of internal and external factor dynamics.

Consider possible scenarios of changes in the project environment (Table 3).

Table 3. Scenarios of project environment changes (intensity of random factors)

Таблица 3. Сценарии изменения условий реализации проекта (интенсивности случайных факторов)

Scenarios	2018	2019	2020	2021	2022	2023	2024
1. Rise in the project environment uncertainty, million roubles / person	0.433	0.088	0.100	0.150	0.200	0.250	0.300
2. Decrease in the project environment uncertainty, million roubles / person	0.433	0.088	0.085	0.080	0.075	0.070	0.065

Note. Compiled using the data from scenario modelling.

Scenario 1. Rise in the project environment uncertainty. Suppose that starting from 2020, the intensity of random factors will show linear growth.

Due to the lack of statistical data on the project outcome as it was not launched until recently, no valid forecast can be made on the potential of and reasons for such growth. Nevertheless, an analysis of the general economic and social trends in a number of project objectives suggests that an increase in the intensity of random factors may be caused by:

- variable results of management training programmes due to the long period of time needed to prepare, harmonize, and adapt the set of new Federal State Educational Standards (FSSES);
- variable number of in-house trained instructors and their variable performance associated, among other things, with the influence of the first factor;
- variable amount of employees at the enterprises trained to apply productivity improvement tools and variable quality of their training associated, on the one hand, with the influence of the first and second factors, and with other, primarily institutional, reasons that prevent staff from seeing high labour productivity as a traditional element of corporate and national culture, on the other;
- errors in collecting data on the outcome of new performance management technologies, in their interpretation and distribution.

The reasons behind these factors include the uneven distribution of labour productivity experts among the industries and regions and the resulting uneven awareness. As noted by the CEO of the Federal Competence Centre for Labour Productivity, “today there are about 1,600-1,800 experts in Russia who understand how to optimise production. The problem is that most of them (1,400 people) are concentrated in large corporations and organisations, and their knowledge is not publicly available”¹.

Apparently, for its successful implementation the project needs uncertainty monitoring mechanisms, which implies having a fundamental possibility to obtain objective assessments of the status and changes in these and other factors. It should be admitted that the task of such assessment (ideally using consistent quantitative measures) is all but trivial. Nevertheless, there are reasons to believe that the acceptable accuracy and objectivity in determining the degree

¹ Production management portal. Russian national award “Labour productivity – 2018”. Available at: http://www.up-pro.ru/imgs/specprojects/lidery-promyshlennosti/2018/Productivity_2018.pdf. (in Russ.)

of variability in these and other factors can be achieved using contextual analysis¹ and expert evaluation² in combination with the fuzzy-set approach to modelling the input (observation data) variables and interpreting the output (expert assessments) ones. In our opinion, dynamic diagnostic of the coordination and cultural profile [Mikhnenko, 2017a] and other techniques can be used as a tool for corporate culture (expected culture of efficient labour) analysis.

The optimal funding dynamics for the project stages assuming the uncertainty to rise and the target indicators to remain unchanged is shown in Fig. 7.

With the rising uncertainty and the target indicators unchanged, the optimal funding dynamics for the project stages will appear as shown in Fig. 7

Fig. 7. Dynamics of planned and optimal funding under the rising intensity of random factors

Рис. 7. Динамика планового и оптимального финансирования в условиях роста интенсивности случайных факторов

As noted above, the fact that the estimated amounts of funding are “optimal” does not imply that the project tasks can be completed under planned budget. The trend towards a decrease in the optimal amount of funding signals in this case the need to tighten control over spending in order to avoid an increase in the random component of outcome under growing uncertainty.

Therefore, the practical significance of the results obtained using the model consists in identifying the ranges $\lambda(t) = G(t) - G_0(t)$, i. e. the difference between the planned $G(t)$ and optimal $G_0(t)$ amounts of funding allocated at each of the project stages. The $\lambda(t)$ values range corresponds to the degree of risk of funds’ misallocation.

Under the first scenario, values $\lambda_{2023} = 4.522$ billion roubles (50.5 %) and $\lambda_{2024} = 5.171$ billion roubles (45.6 %) indicate an extremely high risk of funds’ misallocation at the final stages of the project.

In this scenario, the risk of funds’ misallocation is due to a possible lack or insufficient economic efficiency of the outcome that should have been reached at the previous stages of the project. For example, the lack of anticipated outcome from the managerial training programmes or their poor efficiency would lead to poor qualification of in-house trainers at the enterprises and poor efficiency of their work and, as a result, to a decrease in the number of employees who have mastered productivity increasing tools. In this case, funding of the subsequent project stages, such as implementation of lean principles and development of key product samples, may be unjustified in terms of its effectiveness.

Scenario 2. Decrease in the project environment uncertainty (see Table 3). Suppose that from 2020, a trend towards a lower intensity of random factors will become apparent. Considering the comments made regarding the potential reasons behind the first scenario, the trend towards a decrease in the project environment uncertainty would depend, first of all, on the

¹ As applied to the FSSES analysis.

² When determining the competence of trained instructors and employees.

successful implementation of institutional changes aimed at shaping the public views on high labour productivity as a traditional element of corporate and national culture.

According to the simulation data, lower intensity of random factors will increase the values of $\lambda(t)$ ranges, which in this case will indicate a possibility of a more accurate project execution in terms of (10). As follows from the graphs showing the impact of funding amount on the probabilistic characteristics of the error, more funding will decrease the management bias and slightly increase the random component. For example, values $\lambda_{2023} = 7.344$ billion roubles (80.4 %) and $\lambda_{2024} = 10.493$ billion roubles (110.4 %) indicate a noticeable potential for higher control accuracy at the final stages of the project under the second scenario (Fig. 8).

Fig. 8. Dynamics of planned and optimal funding under the decreasing intensity of random factors

Рис. 8. Динамика планового и оптимального финансирования в условиях спада интенсивности случайных факторов

In the second scenario, the success of the aforementioned institutional reforms (that can also be initiated and implemented outside of the analysed national project) can create conditions for a higher labour productivity growth in the economy, which will require increased project funding and will make it possible to utilise the allocated funds rationally.

Generation and analysis of other project environment scenarios will reveal other variants and degrees of funds' misallocation risks. As noted above, execution of the project requires the introduction of mechanisms that can be used to monitor the uncertainty of conditions and make corresponding adjustments to the funding at the project stages.

Conclusion

Consistent increase in labour productivity is a key factor behind the sustainable intensive growth of the Russian economy. The article sets and solves the task of building a stochastic mathematical economic model to evaluate the effectiveness of operational management in the process of implementing the "Labour Productivity and Employment Support" national project that designates consistent labour productivity growth in Russia's economy as one of its main goals.

As the indicator measuring the effectiveness of the project implementation management the model adopts the γ value that characterises the ability of a practitioner to minimise the systematic and random components of deviation δ , i. e. the operational management error in labour productivity improvement compared to the set target values. The model assumes that lower accuracy of project implementation may be caused by random factors originating from variability of internal and external (in relation to the project) conditions.

It is shown that given the validity of the assumption that the total planned amount of funding is optimal in terms of dynamic accuracy of the project implementation at each of its stages,

the variation of funds from 0 to –25 % is allowable. However, different scenarios of changes in random factors require that practitioners use different approaches to adjust the spending at the project stages. Therefore, a recommendation is made to update the project by introducing the mechanism for monitoring the uncertainty of its implementation environment.

The growing uncertainty of the project implementation environment necessitates better expenditure control in order to avoid misallocation of funds where the results obtained at the previous project stages are absent or not cost-efficient enough. Reduction of uncertainty resulting from institutional changes aimed at shaping the public perception of labour productivity as a traditional element of common cultural values would increase the funding intensity for the national project stages without compromising the dynamic characteristics of its operational implementation.

From this perspective, the author considers the proposed mathematical economic model and its application method as the first link in the chain of studies that develop a system of reasonable recommendations for improving the effectiveness of measures aimed at increasing labour productivity in the economy.

References

- Aganbegyan A. G. (2017). Kakoy kompleksnyy plan do 2025 goda nuzhen Rossii? [What Package Plan up to 2025 does Russia need?]. *Ekonomicheskaya politika = Economic Policy*, vol. 12, no. 4, pp. 8–29. (in Russ.)
- Burtseva T. A. (2017). Ekonometricheskie modeli regional'noy proizvoditel'nosti truda [Econometric models of regional labour productivity]. *Voprosy statistiki = Issues of Statistics*, no. 3, pp. 30–36. (in Russ.)
- Voskoboinikov I. B., Gimpelson V. E. (2015). Rost proizvoditel'nosti truda, strukturnye sdvigi i neformal'naya zanyatost' v rossiyskoy ekonomike [Productivity Growth, Structural Change and Informality: The Case of Russia]. *Voprosy ekonomiki = Issues of Economics*, no. 11, pp. 30–61. (in Russ.)
- Goffe N., Monusova G. (2017). Proizvoditel'nost' truda: sotsial'no-ekonomicheskie predposylki rosta [Labour productivity: Social and economic prerequisites for growth]. *Mirovaya ekonomika i mezhdunarodnye otnosheniya = World Economy and International Relations*, no. 4, pp. 37–49. (in Russ.)
- Zaytsev A. A. (2016). Mezhsranovye razlichiya v proizvoditel'nosti truda: rol' kapitala, urovnya tekhnologii i prirodnoy renty [International differences in labour productivity: Role of capital, technological level and resource rent]. *Voprosy ekonomiki = Issues of Economics*, no. 9, pp. 67–93. (in Russ.)
- Kurzenev V. A., Matveenkov V. D. (2018). *Ekonomicheskyy rost* [Economic growth]. Saint Petersburg: Piter Publ., 608 p. (in Russ.)
- Kutukova E. S. (2017). O nekotorykh podkhodakh k otsenke proizvoditel'nosti truda v sovremennoy rossiyskoy ekonomike [About some approaches to valuation to performance rating in the modern Russian economy]. *Gosudarstvennyy audit. Pravo. Ekonomika = State Audit. Law. Economics*, no. 3-4, pp. 129–135. (in Russ.)
- Lyadova E. V. (2017). Analiz dinamiki proizvoditel'nosti truda v Rossii: makroekonomicheskiy aspekt [Analysis of the dynamics of labour productivity in Russia: The macroeconomic aspect]. *Vestnik Nizhegorodskogo universiteta im. N. I. Lobachevskogo. Seriya: Sotsial'nye nauki = Bulletin of Lobachevsky State University of Nizhni Novgorod. Series: Social Sciences*, no. 1 (45), pp. 46–53. (in Russ.)
- Medvedev D. A. (2018). Rossiya-2024: Strategiya sotsial'no-ekonomicheskogo razvitiya [Russia-2024: The strategy of social and economic development]. *Voprosy ekonomiki = Issues of Economics*, no. 10, pp. 5–28. (in Russ.)
- Mironova V. N. (2017). Proizvoditel'nost' truda kak faktor povysheniya konkurentosposobnosti ekonomiki Rossii [Labour productivity growth as a way to increase the competitiveness of the Russian economy]. *Ekonomika. Nalogi. Pravo = Economics, Taxes & Law*, vol. 10, no. 2, pp. 22–29. (in Russ.)
- Mikheeva N. N. (2015). Sravnitel'nyy analiz proizvoditel'nosti truda v rossiyskikh regionakh [Workforce productivity in Russian regions: Comparative analysis]. *Region: Ekonomika i Sotsiologiya = Region: Economics and Sociology*, no. 2 (86), pp. 86–112. (in Russ.)

- Mikhnenko P. A. (2017a). Dinamicheskaya matematicheskaya model' protsessa upravleniya organizatsionnymi izmeneniyami [Dynamic mathematical model of the organisational change management]. *Upravlencheskie nauki v sovremennom mire = Managerial Sciences in the Modern World*, vol. 1, pp. 119–128. (in Russ.)
- Mikhnenko P. A. (2017b). *Modeli i metody strategicheskogo analiza strukturno-kul'turnykh svoystv organizatsii: Monografiya* [Structural and cultural properties of organisations: Models and methods of strategic analysis]. Moscow: Synergy University Publ. 263 p. (in Russ.)
- Sennikova A. E., Vorokova N. Kh. (2017). Metody i modeli analiza proizvoditel'nosti truda [Methods and models of analysis of labour productivity]. *Konkurentosposobnost' v global'nom mire: ekonomika, nauka, tekhnologii = Competitiveness in a global world: Economics, science, technology*, no. 11 (58), pp. 1573–1574. (in Russ.)
- Frenkel A. A., Sergienko Ya. V., Tikhomirov B. I., Surkov A. A. (2018). Ekonomika Rossii v 2017–2019 godakh: predposylki dlya proryva poka ne sozdany [Russian economy in 2017–2019: The prerequisites for a breakthrough have not yet been created]. *Ekonomicheskaya politika = Economic Policy*, vol. 13, no. 5, pp. 24–49. DOI: <https://doi.org/10.18288/1994-5124-2018-5-24-49> (in Russ.)
- Tsvetkov V. A., Dudin M. N., Lyasnikov N. V., Zoidov K. Kh. (2017). Issledovanie problemy proizvoditel'nosti truda v kontekste klyuchevykh teoreticheskikh polozheniy neomarksistskoy paradigmy, teorii spravedlivosti i neyroekonomiki [The study of the problem of labour productivity in the context of the key theoretical positions of the neo-Marxist paradigm, the theory of justice and neuroeconomics]. *Segodnya i zavtra Rossiyskoy ekonomiki = Today and Tomorrow of the Russian Economy*, no. 81–82, pp. 27–54. (in Russ.)
- Aghion P., Howitt P. (1992). A model of growth through creative destruction. *Econometrica*, vol. 60, no. 2, pp. 323–351.
- Arrow K. (1962). The economic implications of learning by doing. *Review of Economic Studies*, vol. 29, no. 3 (Jun), pp. 155–173.
- Bhattacharya M., Narayan P. (2015). Output and labor productivity in organized manufacturing: A panel cointegration analysis for India. *International Journal of Production Economics*, vol. 170 (A), pp. 171–177.
- Domar E. (1946). Capital expansion, rate of growth and employment. *Econometrica*, vol. 14, no. 2, April, pp. 137–147.
- Fan D., Lo Ch. K. Y., Yeung A. C. L., Cheng T. C. E. (2018). The impact of corporate label change on long-term labor productivity. *Journal of Business Research*, vol. 86, pp. 96–108.
- Gollin D., Lagakos D., Waugh M.E. (2014). The agricultural productivity gap. *The Quarterly Journal of Economics*, vol. 129, no. 2, pp. 939–993.
- Grossman G. M., Helpman E. (1991). *Innovation and growth in the global economy*. Cambridge, MA: MIT Press. 359 p.
- Harrod R. F. (1939). An essay in dynamic theory. *Economic Journal*, vol. 49 (March), pp. 14–33.
- Huselid M. A. (1995). The impact of human resource management practices on turnover, productivity and corporate financial performance. *The Academy of Management Journal*, vol. 38(3), pp. 635–672.
- Ichniowski C. (1990). Human resource management systems and the performance of U.S. manufacturing businesses. *National Bureau of Economic Research Working Paper*, no. 3449.
- Koch M. J., McGrath R. G. (1996). Improving labor productivity: human resource management policies do matter. *Strategic Management Journal*, vol. 17, no. 5, pp. 335–354.
- Lannelongue G., Gonzalez-Benito J., Quiroz I. (2017). Environmental management and labour productivity: The moderating role of capital intensity. *Journal of Environmental Management*, vol. 190, no. 1, pp. 158–169. DOI: [10.1016/j.jenvman.2016.11.051](https://doi.org/10.1016/j.jenvman.2016.11.051)
- McCullough E. B. (2017). Labor productivity and employment gaps in Sub-Saharan Africa. *Food Policy*, vol. 67, pp. 133–152. DOI: [10.1016/j.foodpol.2016.09.013](https://doi.org/10.1016/j.foodpol.2016.09.013)
- Pritchard R. D. Organizational productivity. In: Dunnette M. D., Hough L. M. (eds.) (1992). *Handbook of Industrial and Organizational Psychology*. 2nd ed. Palo Alto, CA: Consulting Psychologists Press, vol. 3, pp. 443–471.
- Romer P. M. (1986). Increasing returns and long-run growth. *The Journal of Political Economy*, vol. 94, October, pp. 1002–1037.
- Samuelson P. A., Nordhaus W. D. (1989). *Economics*. 13th ed. N. Y.: McGraw-Hill. 1013 p.
- Solow R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics*, vol. 70, no. 1, pp. 65–94.

Solow R. M. (1957). Technical change and the aggregate production function. *The Review of Economics and Statistics*, vol. 39, no. 3, pp. 312–320.

Swan T. W. (1956). Economic growth and capital accumulation. *Economic Record*, vol. 32, Nov, pp. 334–361.

Tarancón M.-A., Gutiérrez-Pedrero M.-J., Callejas F. E., Martínez-Rodríguez I. (2018). Verifying the relation between labor productivity and productive efficiency by means of the properties of the input-output matrices. The European case. *International Journal of Production Economics*, vol. 195, pp. 54–65. DOI: 10.1016/j.ijpe.2017.10.004

Uzawa H. (1965). Optimum technical change in an aggregative model of economic growth. *International Economic Review*, vol. 6, no. 1. (Jan.), pp. 18–31.

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Модель управления производительностью труда в экономике России

Аннотация. Повышение производительности труда является одной из ключевых проблем российской экономики. С 2018 г. в России реализуется национальный проект «Повышение производительности труда и поддержка занятости». Есть основания полагать, что задача обеспечения требуемой динамики роста производительности в рамках проекта теоретически решена не полностью. Научная проблема состоит в том, что на динамику роста производительности существенное влияние оказывает изменение неопределенности условий реализации проекта. Оптимальные величины финансирования этапов проекта зависят от наличия случайных факторов, интенсивность которых должна учитываться при планировании динамики производительности. Статья посвящена разработке стохастической экономико-математической модели управления ростом производительности труда и обоснованию направлений ее использования как инструмента, позволяющего решить указанную научную проблему. Поставлена задача определения величин интенсивности случайных факторов, в условиях которых могут быть реализованы целевые показатели проекта при плановом финансировании. Методологической базой исследования являются концептуальные основы теорий экономического роста, оптимального управления и стохастических динамических систем. Произведен расчет оценок риска нерационального расходования финансовых средств. Описаны сценарии изменения условий реализации проекта и сформулированы предложения по корректировке динамики финансирования. Теоретическая и практическая значимость исследования заключается в обосновании необходимости дополнительного контроля расходования финансовых средств во избежание их нерационального использования в условиях роста неопределенности. Показано, что снижение неопределенности путем

институциональных изменений позволит увеличить интенсивность финансирования без ущерба для динамических характеристик проекта. Обоснованы ограничения и способы использования модели.

Ключевые слова: экономический рост; производительность труда; экономико-математическая модель; сценарное моделирование; национальный проект; финансирование; случайные факторы; динамика.

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Источники

- Аганбегян А. Г. (2017). Какой комплексный план до 2025 года нужен России? // *Экономическая политика*. Т. 12. № 4. С. 8–29.
- Бурцева Т. А. (2017). Эконометрические модели региональной производительности труда // *Вопросы статистики*. № 3. С. 30–36.
- Воскобойников И. Б., Гимпельсон В. Е. (2015). Рост производительности труда, структурные сдвиги и неформальная занятость в российской экономике // *Вопросы экономики*. № 11. С. 30–61.
- Гоффе Н., Монусова Г. (2017). Производительность труда: социально-экономические предпосылки роста // *Мировая экономика и международные отношения*. № 4. С. 37–49.
- Зайцев А. А. (2016). Межстрановые различия в производительности труда: роль капитала, уровня технологий и природной ренты // *Вопросы экономики*. № 9. С. 67–93.
- Курзенев В. А., Матвеев В. Д. (2018). *Экономический рост*. СПб.: Питер. 608 с.
- Кутукова Е. С. (2017). О некоторых подходах к оценке производительности труда в современной российской экономике // *Государственный аудит. Право. Экономика*. № 3-4. С. 129–135.
- Лядова Е. В. (2017). Анализ динамики производительности труда в России: макроэкономический аспект // *Вестник Нижегородского университета им. Н. И. Лобачевского. Серия: Социальные науки*. № 1 (45). С. 46–53.
- Медведев Д. А. (2018). Россия-2024: Стратегия социально-экономического развития // *Вопросы экономики*. № 10. С. 5–28.
- Миронова В. Н. (2017). Производительность труда как фактор повышения конкурентоспособности экономики России // *Экономика. Налоги. Право*. Т. 10. № 2. С. 22–29.
- Михеева Н. Н. (2015). Сравнительный анализ производительности труда в российских регионах // *Регион: Экономика и Социология*. № 2 (86). С. 86–112.
- Михненко П. А. (2017а). Динамическая математическая модель процесса управления организационными изменениями // *Управленческие науки в современном мире*. Т. 1. С. 119–128.
- Михненко П. А. (2017б). *Модели и методы стратегического анализа структурно-культурных свойств организации: монография*. М.: Университет «Синергия». 263 с.
- Сенникова А. Е., Ворокова Н. Х. (2017). Методы и модели анализа производительности труда // *Конкурентоспособность в глобальном мире: экономика, наука, технологии*. № 11 (58). С. 1573–1574.
- Френкель А. А., Сергиенко Я. В., Тихомиров Б. И., Сурков А. А. (2018). Экономика России в 2017–2019 годах: предпосылки для прорыва пока не созданы // *Экономическая политика*. Т. 13. № 5. С. 24–49. <https://doi.org/10.18288/1994-5124-2018-5-24-49>
- Цветков В. А., Дудин М. Н., Лясников Н. В., Зоидов К. Х. (2017). Исследование проблемы производительности труда в контексте ключевых теоретических положений неомарксистской парадигмы, теории справедливости и нейроэкономики // *Сегодня и завтра российской экономики*. № 81-82. С. 27–54.
- Aghion P., Howitt P. (1992). A model of growth through creative destruction. *Econometrica*, vol. 60, no. 2, pp. 323–351.

- Arrow K. (1962). The economic implications of learning by doing. *Review of Economic Studies*, vol. 29, no. 3 (Jun), pp. 155–173.
- Bhattacharya M., Narayan P. (2015). Output and labor productivity in organized manufacturing: A panel cointegration analysis for India. *International Journal of Production Economics*, vol. 170 (A), pp. 171–177.
- Domar E. (1946). Capital expansion, rate of growth and employment. *Econometrica*, vol. 14, no. 2, April, pp. 137–147.
- Fan D., Lo Ch. K. Y., Yeung A. C. L., Cheng T. C. E. (2018). The impact of corporate label change on long-term labor productivity. *Journal of Business Research*, vol. 86, pp. 96–108.
- Gollin D., Lagakos D., Waugh M.E. (2014). The agricultural productivity gap. *The Quarterly Journal of Economics*, vol. 129, no. 2, pp. 939–993.
- Grossman G. M., Helpman E. (1991). *Innovation and growth in the global economy*. Cambridge, MA: MIT Press. 359 p.
- Harrod R. F. (1939). An essay in dynamic theory. *Economic Journal*, vol. 49 (March), pp. 14–33.
- Huselid M. A. (1995). The impact of human resource management practices on turnover, productivity and corporate financial performance. *The Academy of Management Journal*, vol. 38(3), pp. 635–672.
- Ichniowski C. (1990). Human resource management systems and the performance of U.S. manufacturing businesses. *National Bureau of Economic Research Working Paper*, no. 3449.
- Koch M. J., McGrath R. G. (1996). Improving labor productivity: human resource management policies do matter. *Strategic Management Journal*, vol. 17, no. 5, pp. 335–354.
- Lannelongue G., Gonzalez-Benito J., Quiroz I. (2017). Environmental management and labour productivity: The moderating role of capital intensity. *Journal of Environmental Management*, vol. 190, no. 1, pp. 158–169. DOI: 10.1016/j.jenvman.2016.11.051
- McCullough E. B. (2017). Labor productivity and employment gaps in Sub-Saharan Africa. *Food Policy*, vol. 67, pp. 133–152. DOI: 10.1016/j.foodpol.2016.09.013
- Pritchard R. D. Organizational productivity. In: Dunnette M. D., Hough L. M. (eds.) (1992). *Handbook of Industrial and Organizational Psychology*. 2nd ed. Palo Alto, CA: Consulting Psychologists Press, vol. 3, pp. 443–471.
- Romer P. M. (1986). Increasing returns and long-run growth. *The Journal of Political Economy*, vol. 94, October, pp. 1002–1037.
- Samuelson P. A., Nordhaus W. D. (1989). *Economics*. 13th ed. N. Y.: McGraw-Hill. 1013 p.
- Solow R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics*, vol. 70, no. 1, pp. 65–94.
- Solow R. M. (1957). Technical change and the aggregate production function. *The Review of Economics and Statistics*, vol. 39, no. 3, pp. 312–320.
- Swan T. W. (1956). Economic growth and capital accumulation. *Economic Record*, vol. 32, Nov, pp. 334–361.
- Tarancón M.-A., Gutiérrez-Pedrero M.-J., Callejas F. E., Martínez-Rodríguez I. (2018). Verifying the relation between labor productivity and productive efficiency by means of the properties of the input-output matrices. The European case. *International Journal of Production Economics*, vol. 195, pp. 54–65. DOI: 10.1016/j.ijpe.2017.10.004
- Uzawa H. (1965). Optimum technical change in an aggregative model of economic growth. *International Economic Review*, vol. 6, no. 1. (Jan.), pp. 18–31.

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