DOI: 10.29141/2218-5003-2025-16-2-4 **EDN:** PECUEK

JEL Classification: J01, J24

Practices for improving labour productivity in the extractive industry

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Abstract. Digital transformation at the industry level makes it increasingly relevant to explore the impact of high technologies on labour organization and productivity. Due to organizational diversity, the multifactorial nature and complexity of practical tasks, there is no universal toolkit to resolve them. The article formulates recommendations for the implementation of organizational change projects aimed at optimizing staff numbers and increasing labour productivity at industrial enterprises. The foundation of research resides in the theoretical concepts of labour economics and scientific organization of labour, as well as the concept of lean production. The work employs general empirical research methods, as well as the case study method. It draws upon data from a large mining processing plant in Sverdlovsk oblast (Russia) for 2022–2023. The authors have developed practical advice for increasing labour productivity in the extractive industry through organizational changes, including transformation of business processes, reducing labour intensity of operations, improving span of control, outsourcing and outstaffing, etc. The proposed initiatives can be replicated to other divisions of the plant and to all the members of the corporate group that pursue the goal of enhancing labour productivity. The findings show that while maintaining output, reducing labour costs and optimizing the staffing level ultimately leads to increased workforce productivity.

Keywords: labour productivity; organizational efficiency; headcount optimization; organizational change; extractive industry; automation.

Funding: This research was prepared with the financial support of the Russian Science Foundation, project no. 24-28-20469 (https://rscf.ru/project/24-28-20469/) and the Sverdlovsk Region Government.

Article info: received October 7, 2024; received in revised form February 28, 2025; approved March 7, 2025

For citation: Dolzhenko R.A., Dolzhenko S.B. (2025). Practices for improving labour productivity in the extractive industry. *Upravlenets / The Manager,* vol. 16, no. 2, pp. 47–63. DOI: 10.29141/2218-5003-2025-16-2-4. EDN: PECUEK.

Практики повышения производительности труда в добывающей промышленности

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Аннотация. Цифровая трансформация промышленной сферы актуализирует исследование влияния высоких технологий на организацию и производительность труда. Организационное разнообразие, многофакторность и сложность прикладных задач приводят к отсутствию универсального инструментария для их решения. Статья направлена на разработку практических рекомендаций по реализации проектов организационных изменений, ориентированных на оптимизацию численности персонала и повышение производительности труда на промышленных предприятиях. Методологической базой исследования выступили теоретические концепции экономики труда и научной организации труда, а также ряд положений концепции бережливого производства. В работе использованы общенаучные эмпирические методы, а также метод кейс-стади. Информационную базу составили данные крупного горно-обогатительного комбината Свердловской области за 2022–2023 гг. По итогам исследования разработан ряд рекомендаций по повышению производительности труда на производстве за счет организационных изменений, среди которых – трансформация бизнес-процессов, снижение трудоемкости операций, повышение норм управляемости, аутсорсинг и аутстаффинг и др. Предложенные меры могут быть каскадированы по всей структуре комбината и в другие предприятия группы компаний, которым необходимо повысить производительность труда. Продемонстрировано, что при сохранении объемов производства снижение трудозатрат и оптимизация численности персонала ведут в итоге к росту эффективности труда.

Ключевые слова: производительность труда; организационная эффективность; организационные изменения; оптимизация численности персонала; добывающая промышленность; автоматизация.

Финансирование: Исследование выполнено за счет гранта Российского научного фонда № 24-28-20469 (https://rscf.ru/project/24-28-20469/) и Правительства Свердловской области.

Информация о статье: поступила 7 октября 2024 г.; доработана 28 февраля 2025 г.; одобрена 7 марта 2025 г.

Ссылка для цитирования: Dolzhenko R.A., Dolzhenko S.B. (2025). Practices for improving labour productivity in the extractive industry // Управленец. Т. 16, № 2. С. 47–63. DOI: 10.29141/2218-5003-2025-16-2-4. EDN: PECUEK.

INTRODUCTION

Increasing labour productivity is one of the crucial tasks facing Russian enterprises, which requires substantiating the essential tools for enhancing an organization's performance, abandoning non-core activities, and optimizing expenses and other strategic decisions made by the management of industrial enterprises. However, not all managers and their teams have the relevant experience in implementing changes that stimulate labour productivity, e.g., they may lack the managerial will to make and consolidate the necessary developments. Oftentimes, optimization entails staff reduction; therefore, there is a need for precise economic calculations, advanced methodological tools, the managerial will and motivation to implement organizational changes and care for employees affected by labour optimization initiatives.

The purpose of the study is to formulate methodological recommendations for implementing organizational change projects aimed at optimizing staff numbers and increasing labour productivity at industrial enterprises.

To attain the stated purpose, the following objectives are set:

- to systematize academic publications in order to identify key avenues of research on labour productivity;
- to analyse the effectiveness of organizational change projects raising labour productivity through the use of its reserves at a large mining processing plant in Sverdlovsk oblast (Russia);
- to provide methodological recommendations for implementing organizational change projects that contribute to increased labour productivity in view of the projected economic and social outcome.

LABOUR PRODUCTIVITY: THE THEORETICAL FRAMEWORK

Organizational efficiency is a concept that organizations use to evaluate how successful they are in achieving the intended results [Etzioni, 1964]. In this study, the subject area of the concept is narrowed to economic efficiency, which many experts associate with labour productivity and calculate it as the ratio of economic costs and results at the end of a specific period. To improve their efficiency and productivity, most companies introduce organizational changes.

We have conducted a content analysis of research papers on labour productivity and tools for improving it. Publications from the Russian scientific electronic library eLIBRARY.RU were selected for analysis by the keyword "labour productivity" found in titles, abstracts, and keywords; the type of publication is "journal articles". The analysis of publication dynamics (Fig. 1) demonstrates a fourfold increase in scientific interest in the topic under consideration: from 499 papers in 2012 to 1,938 papers in 2023. Until 2012, research interest in the topic had not been strong, which can be due to a greater focus on the global financial crisis and its consequences, as well as stagnation in the economy that intensified the need for new sources of growth, such as organizational changes aimed at optimizing headcount and increasing labour productivity.

There are two reasons behind the increase in the number of publications: a low level or decline in labour productivity noticeable macroeconomically, and the RF President's decrees[1] emphasizing this problem and providing a set of target indicators within the framework of the national project "Labour Productivity and Employment Support" [Potaptseva, Chashchihina, 2023].

In 2009, McKinsey & Company investigated labour productivity in Russia and other countries through comparative analysis [Alikhanov et al., 2009]. The study showed that labour productivity in Russia was significantly lower than in developed economies. According to factor analysis results, the main reasons behind this were institutional factors, outdated management methods, and excessive regulation. McKinsey experts also presented changes that need to be implemented to enhance labour productivity, both in the entire country in terms of minimizing institutional restrictions and at the level of individual enterprises: modernization of obsolete equipment and technologies, efficient organization of labour, optimal use of labour resources, etc. This study gave rise to vigorous debate on labour productivity among experts from academia [Mishin, 2023].

[1] List of instructions following the Presidential Address to the Federal Assembly: approved by the President of the Russian Federation on March 30, 2024, No. Pr-616; A list of instructions following a meeting of the Council for Strategic Development and National Projects: approved by the President of the Russian Federation on October 8, 2023 No. Pr-2027.

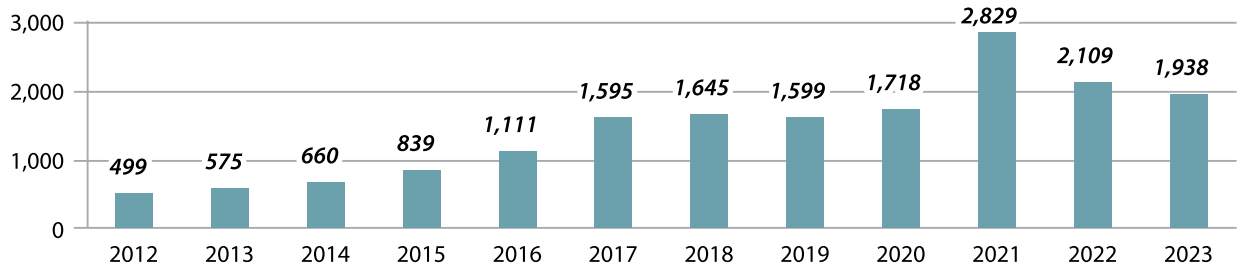

Fig. 1. Number of studies on labour productivity in Russian scholarly journals (eLIBRARY), pieces

Рис. 1. Динамика публикаций на тему производительности труда в российских научных изданиях (РИНЦ), шт.

Of considerable interest is Zaytsev's [2017] dissertation, where the author compares labour productivity levels in the RF regions while focusing on industry specificity, including 13 branches of the processing industry.

The conducted bibliographic analysis of Russian researchers' works identified the following main directions for increasing labour productivity:

- inclusion of the goal of boosting labour productivity in the organizational development strategy [Karimova, 2020];
- lean technologies [Nikitina, Zakharov, 2020; Chuprik, Bayda, 2020; Yamanov, 2012];
- process digitalization and production robotization [Alekseev, 2021; Sokolova, Sazhneva, 2021];
- labour saving technologies [Petushenko, 2020];
- employee health management [Sosnilo, Snetkova, 2020];
- standardization and optimization of the staffing level [Dubovskoy, Nazhipov, Chernysheva, 2022; Pugachev, 2022; Dolzhenko, Malyshev, 2019];
- staff motivation and incentives [Gazieva, 2021; Marinchenko, Chernenkov, 2015];
- mentoring [Tyufyakov, 2020].

Some of the publications reviewed are local and non-systemic in nature and delve into the direction's potential impact on labour productivity; others are unsubstantiated and provided with no supporting analytical data, which does not allow assessing the expected efficiency and applicability of the proposal. A number of fundamental works (see, e.g., [Kapelyushnikov, 2014; Voskoboynikov, 2012]) are systemic in nature, assess labour productivity at the country level and examine various factors influencing it.

Some works concentrate on increasing labour productivity in particular industries: electric power industry [Okulov, 2007], agriculture [Ermakova et al., 2021], etc. However, as highlighted in these works, their developments cannot be transferred to other industries without processing and adaptation. This statement is supported by foreign authors (see, e.g., [Çolak, Vere, 2023; Ampatzidis et al., 2012; Deprins, Simar, Tulkens, 2006]).

Labour productivity as a research area is being actively investigated by academics around the globe. There is a whole layer of internationally recognized publications that determine cross-cutting relationships between a company's performance indicators and various organizational [Langemeier, 2018; Liu, 2011; Inklaar, Timmer, 2008] and institutional factors [Harris, de Vries et al., 2012; Castellacci, Los, de Vries, 2010; Cobet, Wilson, 2002; Trainor, 1997]. An array of works is devoted to productivity and economic growth in Eastern Europe [Voskoboynikov, 2013; Timmer et al., 2011; Alam et al., 2008; Dunford, Smith, 2000]. At the same time, only a few focuses on modern industries or new technologies [Neziraj et al., 2024; Bogoviz, Lobova, Ragulina, 2018; Golabchi, Han, AbouRizk, 2018]. Some research presents factor analysis of reserves for labour productivity growth [Jiang et al., 2024; Sapand et al., 2023; Zeraatgari, 2023; Vanchukhina, Leybert, Khalikova, 2016; Timmer, Voskoboynikov, 2014; Sharpe, Arsenault, Harrison, 2008]. It is worth noting the increase in the quantity and quality of works by researchers from Central Asia (CIS), focusing on applied problems of national economies [Fazliddinova, 2024; Xosilbekovna, 2024; Tukhtabaev, 2023] and key industries [Sobirjonovna, 2023; Tukhtabaev, Soatalieva, 2023; Tukhtabaev et al., 2021]. To our knowledge, there are no foreign studies devoted to the possibility of increasing labour productivity through organizational changes at the level of individual enterprises.

The literature review has revealed a significant number of works on related topics and that labour productivity is investigated at different – macro, meso, and micro – levels. At the enterprise level, researchers identify various organizational changes aimed at improving labour productivity, including through projects to optimize the staffing level, digitalize labour, and implement lean technologies. Analysis of practical experience in optimizing staff numbers and increasing labour productivity allows developing universal algorithms that can be used by industrial enterprises throughout the country.

RESEARCH METHODOLOGY

This study was preceded by activities to analyze production at a specific industrial enterprise. To obtain primary analytical data on its current state, the following steps were made:

- holding expert interviews with the mining processing plant's management (top and middle levels) – 10 persons;
- using timesheets at the work sites identified during the interview, as well as at other sites (divisions) included in the control group – 15 observations;
- examining business processes at the work sites and divisions of the plant under study and compiling process maps – 15 processes.

Based on the analysis of the enterprise's experience, reporting documents, and process maps before and after optimization, we formulate methodological recommendations on the use of basic tools for increasing labour productivity through organizational changes selected by the criteria of efficiency, ease, and speed of implementation and considering the specificity of a particular enterprise. For the purpose of the study, the developed measures are ranked by their potential impact on labour productivity.

The tools are established based on the experience of real companies, as well as the possibility of their use at a specific industrial enterprise. The choice is due to the research purpose and objectives that are of the applied nature and require the formulation of clear recommendations to further adapt them to the tasks of enterprises operating in other industries.

The object of the research is a mining processing plant (MPP) that relies on traditional beneficiation technologies

and uses outdated equipment with low energy efficiency and environmental safety. The subject of the research is the development and implementation of organizational changes aimed at optimizing the number of personnel.

The management of the MPP set the task of finding ways to increase labour productivity through the implementation of organizational change projects in the context of a growing blue-collar labour shortage and the need to ensure the timely fulfilment of obligations to participate in large-scale infrastructure projects. The plant's staffing level stands at 6,000.

The results of the empirical study of business processes at the work sites and divisions, as well as timesheets completed by the working groups' members (including the authors) in the period between March and November, 2023 were used to juxtapose the enterprise's priority goals, options for organizational change and divisions:

- production optimization and reorganization of processes in divisions using the cases of a blasting site, a crushing division, a filter and dry house, and engine crews;
- automation of processes and reduced workplace presence of workers and operators (using the case of the plant's gas station);
- changing the labour intensity of operations (using the case of a power generating station);
- search for outsourcing (outstaffing) opportunities at certain stages of production.

METHODOLOGICAL APPROACHES TO IMPLEMENTING ORGANIZATIONAL CHANGES

Having analysed the business processes, timesheets and methodological materials produced during the analytical work, we proposed organizational changes that can ensure labour productivity growth (Table 1). The best prac-

Table 1 – Recommendations for improving labour productivity at manufacturing enterprises
Таблица 1 – Рекомендации по повышению производительности труда на производственных предприятиях

Recommendations	Basic approaches	Description
Bringing headcount in line with staffing needs	Best practices or achieved labour productivity	Researching best practices in a high productivity industry. Examples of successful solutions include evidence from other companies and performance indicators for specific periods
	Developing a staffing model	A multifactor model for determining the required staff numbers is applicable exclusively to mass professions
Expanding responsibility areas	Combining jobs	If the proportion of downtime is significant, it is worth delegating additional duties or combining jobs to increase the effective time. Expanding responsibility areas is suitable for shop-floor workforce
	Centralization	Restructuring business processes and centralizing the functions of support units will reduce the number of administrative personnel and boost the efficiency of blue-collar jobs by eliminating losses due to headcount optimization
Modernization, automation, and mechanization	Equipment modernization	Replacing outdated systems with more efficient ones, e.g., the use of robots in production
	Automation / mechanization of processes	Automation and mechanization reduce labour intensity and increase productivity by replacing manual work that is riskier and more time-consuming
Reducing labour intensity of operations	Updating standards and process sheets	Analysing and updating standards and process sheets to reduce working time per unit produced
Outsourcing and outstaffing	Hiring contractors	Transferring business processes to a contractor in a specific area, e.g., transport, repair, etc. The contractor is responsible for carrying out its obligations under the contract
	Hiring contract staff	Concluding an agreement with a contractor to assign a worker for a period of one month to one year. The client manages the staff, and the contractor is not held responsible for the results of the work. The worker's specialization and the job they are assigned to should be congruent
Make-or-Buy	Calculating purchase and production costs	Prior to entering into contracts, manufacturing enterprises need to decide whether it is more profitable for them to manufacture individual components in-house rather than purchase them from an external supplier. To do this, they compare purchase and production costs (per unit and total)
Cutting the number of management levels, improving span of control	Optimizing the organizational structure	The number of management levels should be predetermined by span of control. In Russian practice, it is optimal for a manager to have 7 direct subordinates. An additional level can be added if this norm is exceeded or erased if the norm can be lowered
Optimization of business processes	Building an ordered system	Changes in business processes are aimed at increasing productivity through reorganization. The primary goal is to create an ordered system, where process boundaries are consistent with each other and bound with intermediate products, and participants' responsibilities and structure are clear and related to the boundaries
	Creating an integrated system of digital services	For each business process, a digital clone is created that automatically records the metrics prior any action is taken. The analytics system discovers relationships between variables and creates optimal conditions for maximum productivity. Digitalization projects are combined into portfolios "Digital production", "Digital casting", "Digital melting", etc.

tices for the period of 2019–2023 were selected on the basis of the Ural industrial holding (more than 10 factories operating in the same field with a total staff exceeding 80,000 employees). The stipulation was a justified economic effect produced by these practices.

It is worth noting that the list includes mainly organizational tools as being typical and not involving significant financial resources.

Some of the recommendations from Table 1 are often merged with the others, so below we concentrate only on the key ones.

1. Bringing headcount in line with staffing needs

Such practices are aimed at optimizing staff numbers to a target level using a model that considers all factors affecting labour input and productivity. Staff numbers are calculated and modelled based on current labour intensity drivers. Typically, such analysis shows that the current staffing level exceeds the one calculated by the model, which creates a potential for optimization. The steps to implement such an initiative are given in Table 2.

Using the sequence of steps, the enterprise implements a whole range of organizational measures – from collecting documents and auditing to obtaining economic results and replicating the initiative to other divisions for a specific period of time.

Consider this productivity-enhancing tool taking a blasting site as example.

To analyse productivity of blasters, key documents were requested: the staffing table, the staffing list, one-year production plan and annual costs estimates per one full-time employee. The total volume of borehole charging amounted to 760,000 linear meters/year, which is the main planned indicator. The division has 3 shifts per day, shift duration is 6.83 hours, and the number of working days per year is 364 days. The coefficient of transition from the shop-floor to the total size of the workforce is 1.61. Next, the tasks of blasters are identified, including cleaning and charging of boreholes manually and using Orika and Chamec blasting machines. During the interview with the department head, the workload distribution was specified according to the equipment and work method utilized, and key four types of work were distinguished. To create a tree of headcount drivers, the volumes of work and the coefficients of transition from the shop-floor to the total size of the workforce were calculated. The work methods were clarified during the interview: 5% of boreholes are cleaned manually, 45% – with Charmec machines, 95% are charged with Orika machines, 5% – with Charmec machines. There were 73 blasters on the staffing table. Labour productivity for the four types of work is presented in Table 3.

Table 2 – Steps in developing the initiative to bring headcount in line with the actual need
Таблица 2 – Алгоритм проработки инициативы по оптимизации численности персонала

Stages	Steps	Description
Data collection	Request for documents	Request for required data
	Identifying the drivers of labour input	Compiling a list of factors (drivers) affecting labour intensity of work processes, including types of work, their characteristics, and the type of equipment used
	Creating a driver tree	Based on the drivers identified in the previous step, a tree of headcount drivers is created that will underlie the future staffing model
	Obtaining additional timesheets and collecting missing driver parameters	Several timesheets for each combination of labour intensity drivers are compiled for analysis. This will help clarify labour productivity indicators. If unknown, the drivers' technical characteristics (for example, the length of boreholes, workload distribution between technicians) are specified
	Determining current staff numbers by profession	Assessing current staff numbers by profession to calculate the effect of the initiative
Analysis	Defining planned production volumes	Planned production volumes for each type of work are decided. The volume of work is used to calculate the target staff number using a multifactor model based on actual labour productivity
	Timesheet analysis	A timesheet shows the proportion of effective time and actual productivity for each driver combination. The proportion of effective time is the ratio between the effective working time per shift and its total time. Actual productivity is the ratio of the work volume performed to the time it takes to complete it. The product of shift time, the proportion of effective time and productivity equals the actual volume of work per shift
Formulating conclusions	Building a staffing model	The target staff number is contingent on the labour input calculated as the ratio of the planned volume of work to the actual productivity per unit of time
	Calculating the target staff number	The target staff number is the result of calculating the staffing model based on planned volumes of work and actual labour productivity
	Calculating the potential of the initiative	The potential in full-time employees is calculated by formula: *Potential = Current staff – Target staff*
Designing a schedule	Calculating the economic effect of the initiative	*Economic effect = Potential × Annual costs per one full-time employee*

Table 3 – Effective time and productivity for different types of work by the timesheet method
Таблица 3 – Полезное время и производительность разных типов работ согласно фотографии рабочего дня

Types of work		Effective time, %	Productivity, linear meters/hour
Cleaning	Manually	46	106.98
	Charmec	60	46.81
Charging	Orika	18	260.85
	Charmec	17	135.00

The staffing model is a driver tree in a flat table format with numerical values. An example of a driver tree for the profession of blaster in the division under review is shown in Fig. 2.

After applying the model and performing calculations, the target staffing level was 68 full-time employees based on the planned volumes and actual labour productivity. The potential for optimization was 6.85% of the current staff (*Potential = Current staff – Target staff* = = 73 – 68 = 5 employees, or 6.85%). Considering all deductions, the annual costs for one full-time blaster amounted

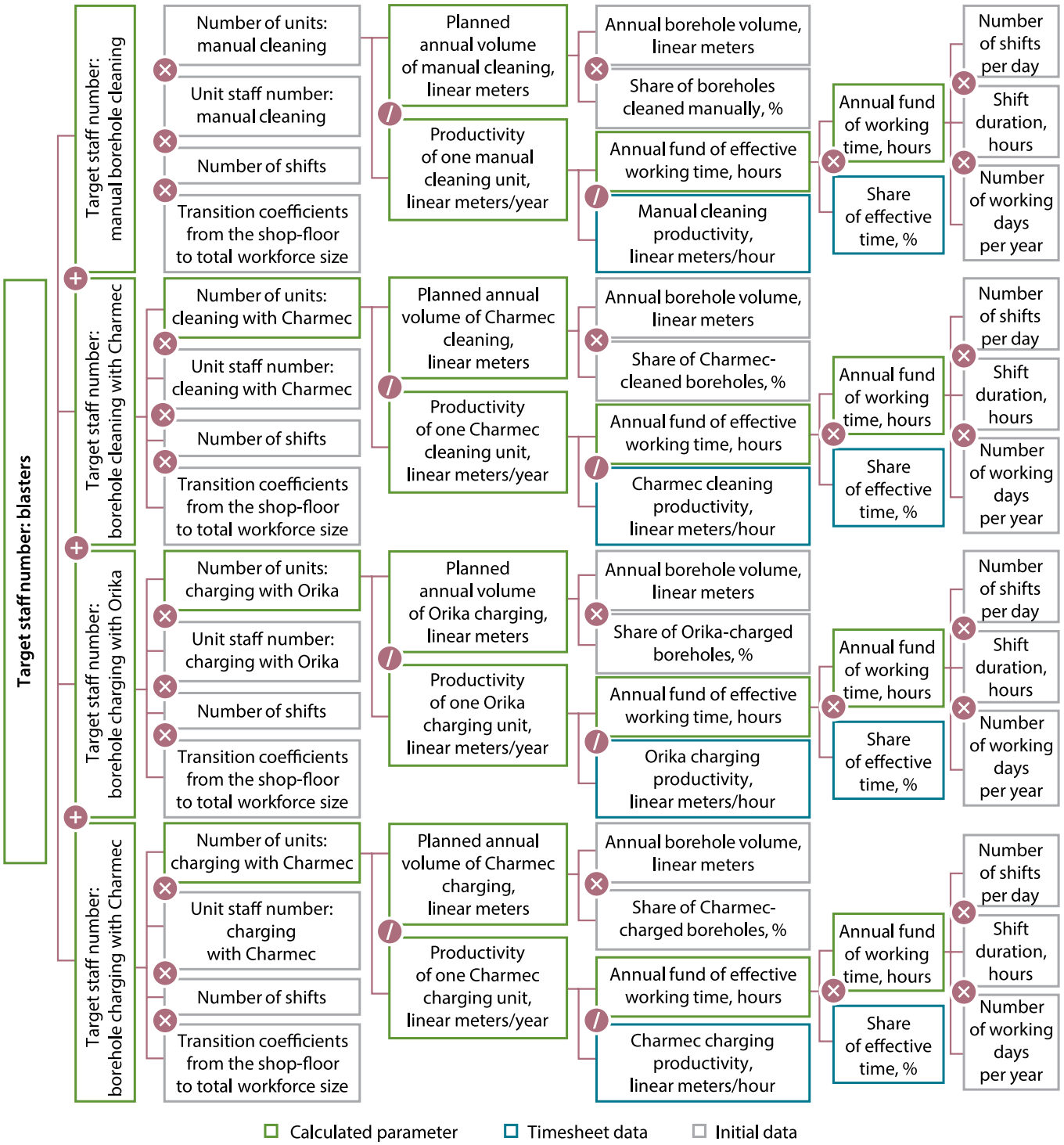

Fig. 2. A driver tree for the profession of blaster

Рис. 2. Дерево драйверов для профессии «взрывник»

to 850,000 rubles. Hence, the economic effect of the initiative was 4,25 million rubles per year (*Economic effect* = = *Potential* × *Annual costs per one full-time employee* – – *Costs of reduction* = 5 × 850,000 – 850,000 = 3,4 million rubles). The costs of staffing reduction are calculated based on the standard of two average salaries. Other potential expenses (replacement, possible sick leave) are not taken into account due to the probable nature of the events.

2. Expanding responsibility areas

These are initiatives to delegate additional responsibilities to employees by optimizing span of control, removing duplication of functions, and centralizing/decentralizing to improve productivity. When expanding responsibility areas, duplicate functions should be eliminated and the released personnel optimized. Such an approach is effective in a situation of staff shortage. Enhancing top managers' responsibility and optimizing the administrative apparatus are more productive than cutting rank-and-file employees. To implement the approach, it is necessary to compare the organizational structures of the company's similar segments (for example, if it has several MPPs) and other enterprises in the same industry (through the exchange of requests and responses) for assessing best practices and identifying excessive management levels. It is recommended to approve methodological recommendations for building an organizational structure with staffing standards for each type of division developed according to the enterprise's experience and specificity.

The recommendations to the MPP under review are as follows: to form a separate department with headcount of 4–15 employees; the position of deputy head of the department is created when employee count is 10 persons or more; management is introduced when the department staff number reaches 15 persons with broad functional responsibility; and service functions (accounting, HR, legal affairs, and security) are transferred to a single centralized unit. However, in order to avoid a decline in employee productivity, it is important to methodically and instrumentally justify the increase in span of control and plan a best practices training, including transition to electronic document management systems, use of ERP systems, task delegation, logistics optimization in the workshop, etc. The algorithm to implement the initiative is presented in Table 4.

Table 4 – Steps in developing the initiative to expand responsibility areas
Таблица 4 – Алгоритм разработки инициативы по расширению зон ответственности

Stages	Steps	Description
Preparation and data collection	Request for documents	Request for documents to compare organizational structures, staffing tables, job descriptions and work schedules of the units and enterprises compared
	Conducting interviews	Organizing and holding interviews in departments to clarify details and obtain questionnaires, interview transcripts, etc.
	Juxtaposing organizational structures of the units	Forming an up-to-date organizational structure with details on employees
	Juxtaposing positions and responsibilities	Based on job descriptions and questionnaires, a matrix of positions and processes is formed. If necessary, the matrix is refined through interviews with employees
	Deciding on the methods	Comparing the organizational structures of the units and enterprises: divisions with a higher span of control and a smaller number of management levels, the type of subordination, and the number of managers per one position. Analysis of duplicate functions and centralization of non-core functions into a separate division
Analysis	Comparing the organizational structures of similar units	The number of employees at all levels and the distribution of functions between the units are compared. As a result, internal benchmarking of the enterprise's management structure is performed and hypotheses for improvement formulated
	Analysis of the number of subordinates	Compiling a list of managers and their subordinates, defining areas of responsibility, and identifying discrepancies between the actual and target number of subordinates. At this step, span of control is assessed and hypotheses for improvement are formulated
	Analysis of the key responsibility area	Based on the matrix of the department's positions and processes, unclear purposes and rationale behind functions are revealed. Here, it is possible to evaluate the possibility of eliminating specific functions or their duplication by expanding other employees' responsibility areas
	Analysis of opportunities for centralization	The division's structure is compared with best practices and service functions are centralized
Formulating conclusions	Calculating the initiative's potential and economic effect	The initiative's economic effect is calculated by formula: $EE = P \times AC - 0.2 \times (P \times AC) \times (1 + I)$, where *EE* is economic effect; *P* is potential for optimization, in full-time employees; *AC* is annual costs per one full-time employee; *I* is an increase in labour intensity (up to 20%)
Designing a schedule plan	Arranging an initiative implementation schedule	The schedule plan specifies steps, deadlines and those responsible for its implementation

Consider the responsibility area of the site foreman and production workers of the crushing division of the beneficiation sector. To analyse the organizational structure, 6 staffing tables of the MPP were collected and the enterprise's management was interviewed using the developed questionnaire. This allowed constructing the current organizational structure of the crushing section and the matrix of positions. Internal benchmarking of 3 beneficiation sectors of other plants from the studied corporate group and external benchmarking of 3 other MPPs (production volume, number of employees, labour productivity, and the number of management levels were analysed) made it possible to formulate and describe best practice concerning the head of the department and its deputy. The analysis showed low span of control of the department head – 1:1. It is recommended to expand the area of responsibility and revise span of control according to the complexity of work, the head's qualifications, subordinates' expertise, delegation skills, and personal responsibility. The study of the matrix revealed duplicate functions and the optimization potential for one full-time position, namely the deputy. Based on the company payroll, the economic effect for one year was calculated. The schedule plan providing for downsizing was arranged according to the Labour Code of the Russian Federation. Prior to optimization, there were 6 full-time employees in the crushing division. The analysis showed that job functions are distributed unevenly and excessively (Table 5).

Following adoption of the recommendations to improve the organizational structure and eliminate the position of deputy head, the MPP is calculated to receive 1.5 million rubles in payroll savings per year.

3. Modernization of equipment, automation and mechanization of processes

In this approach, productivity improvement initiatives can be classified into three categories:

1) modernization of the equipment and machinery being utilized to improve their characteristics and performance;

2) mechanization of processes to minimize workers' unproductive manual labour, especially short-cycle monotonous operations;

3) automation of technological processes while minimizing the operator's involvement.

The steps to implement the initiative is presented in Table 6.

Table 5 – Job functions distribution of the crushing division employees, %
Таблица 5 – Распределение функционала сотрудников дробильного отделения, %

Key functions	Deputy head of the division	Head of the division	Production workers
Operations management	80	34.6	91
Collecting information for calculating and paying salaries	9	2	–
Inspections and monitoring of the elimination of violations	2	18.1	6
Control over safe operation of machinery	2	–	2

Table 6 – Steps in developing the initiative for modernization, automation and mechanization
Таблица 6 – Алгоритм разработки инициативы по модернизации, автоматизации и механизации

Stage	Steps	Duration	Description
Data collection	Request for documents	3–4 days	Key data for analysis are gathered through information requests. Additional materials may be required when developing initiatives
	Obtaining timesheets	4–6 days	Three timesheets for one profession within the same technological process are required to determine operations and their duration
Analysis	Analysis of timesheets to classify operations and time expenditures	1–2 days	Digitization of all records, classification of operations by types of losses and computing the time needed to complete each. As a result, a table with a list of operations and time for their execution is compiled
	Creating list of machinery and equipment subject to automation, mechanization and modernization	3–4 days	Making a list of means for increasing labour productivity. Analysis of technical documentation and production quantities to assess the current performance of the equipment. Evaluation of the potential for enhancing productivity when purchasing equipment (comparison of the current and desired performance characteristics)
	Assessing the possibility of automation, mechanization or modernization	5–6 days	Evaluating the possibility of technological process automation and the need for additional resources to comply with production standards and regulations. Considering the possibility of outsourcing non-automated functions (cleaning, maintenance, etc.)
	Market analysis and search for potential service providers	3–6 days	Providing terms of reference for technical upgrades. Analysis of the service provider market to calculate economic benefits using the cost comparison method. Receiving technical and commercial proposals
	Initial calculation of implementation costs	1–2 days	Calculating implementation costs based on the technical and commercial proposal of a third-party organization

Table 6 (concluded)
Окончание табл. 6

Stage	Steps	Duration	Description
Formulating conclusions	Calculating working time freed up due to the implementation of the initiative	1 day	Calculating the number of full-time employees and working hours freed up through technical initiatives. The number of freed-up hours is divided by one employee's timesheet, taking into account all the coefficients (breaks, transfers, absenteeism, etc.).
	Calculating the initiative's economic effect and payback period	1 day	The economic effect of the initiative is computed by formula: *Economic effect = Number of full-time employees × × Annual costs per full-time employees.* The payback period is calculated by formula: *Payback period = Implementation costs / Economic effect.* Schedule plan is adjusted depending on the payback period
Designing a schedule plan	Arranging an initiative implementation schedule	2–3 days	The schedule plan specifies steps, deadlines and those responsible for its implementation

Consider an example of automation of a gas station. During the audit, information was collected on the layout of the complex, equipment, the number of refill stations working day and night shifts, schedules of planned preventive maintenance, and the staff number. Three timesheets were obtained to determine the workload of operators. Analysis of the timesheets showed that cleaning the area takes 5.6 hours, filling out documents – 3.1 hours, movement – 1.2 hours, organizational activities and lunch – 1.8 hours for a 12-hour shift. A list of equipment indicating machine capacity was compiled. New refill stations were purchased as the old ones were found to be outdated. The possibility of equipping the station with night vision cameras and street lighting was explored. Some operations, such as sealing and cleaning the area, were transferred to other employees. A request for technical and commercial proposals on automation was submitted. Having analysed several alternatives, terms of reference and a project were designed, as well as a quote on equipment and work was given. Total implementation costs were 4.85 million rubles, covering terminals, cameras, lighting, and a fire safety project. Once the station was automated, there was no longer a need for round-the-clock presence of operators, which freed up 5 full-time positions. The economic effect amounted to 1.6 million rubles. The payback period for the initiative is 41 months, including the costs of equipment and outstaffing. Considering the schedule plan (from preparing documentation to providing the IT infrastructure), the final date of discharging operators was set and outplacement procedures were carried out.

4. Reducing labour intensity of operations

Reducing labour intensity of operations is of high importance for all staff categories, as it improves work processes and efficiency. The approach implies comparing actual and planned time expenditures and is applicable for repetitive standard-based operations. To that end, one measures the timeframes of operations, updates the standards and adjusts the staffing table. The approach's key advantages are the evidence base, simplicity of analysis and ease of implementation, but it is applicable only if there is untapped optimization potential. Data on the standards, human resources, timing, and observations are required to conduct the analysis. This method helps adjust the number of persons employed, transfer operations from outsourcing to insourcing or vice versa, and evaluate the reduction of labour input standards using a matrix in Fig. 3.

Let us look at the case of the industrial ventilation and communications team of the enterprise's ventilation and air conditioning section. The estimated time for planned preventive maintenance (PPM) = 36 pcs. (RU16 valves) × 5 hours (time standard per piece*[1]) ×

[1] (*) Based on: Yashchur A.I. (2006). System of technical maintenance and repair of general industrial equipment. Moscow: NTs ENAS.

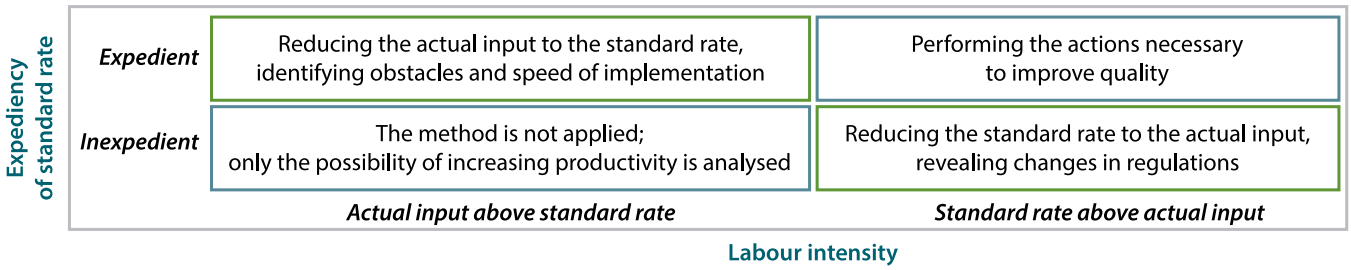

Fig. 3. The expediency matrix of reducing labour input standards

Рис. 3. Матрица целесообразности снижения норм трудоемкости операций

× 2 (number of repairs per year*) = 285 man-hours. PPM actual time = 36 pcs. (RU16 valves) × 2.3 hours (a result of measurements) × 2 (number of repairs per year*) = = 83 man-hours. After measuring the timeframes of all operations (repairs) and obtaining the inventory of equipment, one can calculate the coefficient of time deviation from the standard by measuring the time needed to complete the works (Fig. 4).

Based on calculations, measures were suggested to optimize equipment maintenance in order to ensure timely and high-quality repairs. Works are performed under emergency conditions, there are no breakdown statistics, planned data exceed actual data, and repair technologies are recorded in the instructions. Major violations are due to human failure, and the power systems do not have a direct impact on production.

Among the recommendations are:

- to adjust the impact of repairs on the production process;
- to establish the degree of wear and tear of machines;
- to bring labour input in line with the actual time expenditures.

Timesheet analysis demonstrated float time of 28%. Before optimization, total labour input amounted to 34,000 man-hours; after optimization – 11,000 man-hours. The staff was reduced from 15 to 12 people (3 full-time electricians were made redundant).

5. Cutting the number of management levels

Standards of managerial work were defined in the Soviet period, and many of them have lost their relevance since then. New standards are set in practice considering the company's development, scope and scale, branches and divisions, diversification, complexity of operations, etc. To improve labour productivity, one can focus on best practices in the industry. For example, an organization may have 3–5 management levels (3 levels are preferable) [Mescon, Albert, Khedouri, 2000]. Each level may have its own span of control: 10–40 subordinates for foremen (according to the type of production and complexity of work), and 4–9 subordinates for top and middle management. Each function must be assigned to one performer. Based on the study of the organizational structure and business processes of the MPP, we recommend using the following generalized criteria for assessing the maximum span of control at the enterprise (Fig. 5).

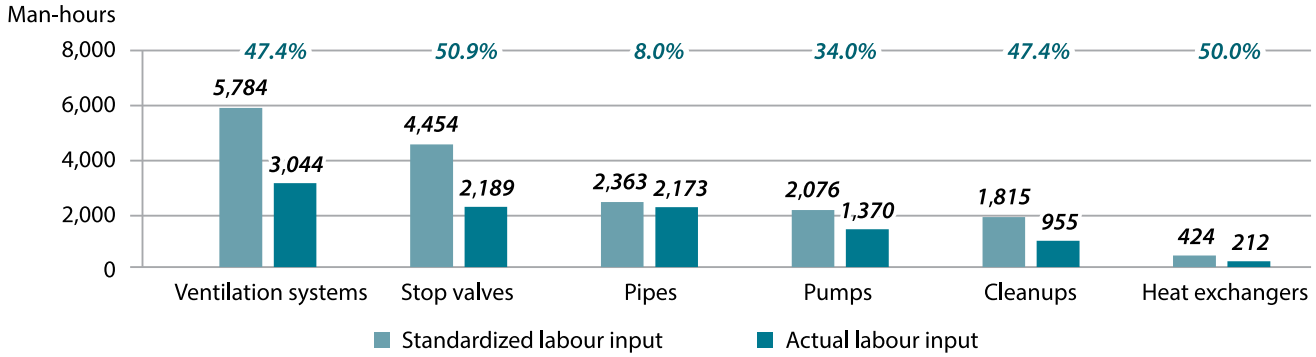

Fig. 4. Planned and actual labour input compared with the standard, indicating the percentage of deviation

Рис. 4. Плановые и фактические трудозатраты в сравнении с нормативными с указанием процента отклонения

Stability of process	Low		High
Significance of process	Large material flows		Poor material flows
Worker density	Low		High
Complexity of tasks	High		Low
Time to memorize the content of the work	>100 hours		<10 minutes
Recommended improvement rate	Daily		Monthly
Role of the management	Direct		Indirect (control only)

Fig. 5. Matrix of criteria for assessing the maximum number of subordinates

Рис. 5. Матрица критериев оценки максимального количества подчиненных

We also determined the optimal number of subordinates for managers at different levels: from 4 to 40 for foremen, and from 4 to 9 for senior management. It is noteworthy that there is no single span of control, so the proposed criteria can serve as guidelines. If there are excessive functions, they are reorganized: unnecessary ones are eliminated, job descriptions are revised, duties are redistributed, or qualification requirements are lowered. If there is a shortage of subordinates, departments are merged, responsibilities are distributed, or the number of managers is reduced. If the span of control is excessive, the functions and possibilities to unite them are analysed, and one of the managers is promoted. There must be at least 12 employees and two deputy heads in administrative divisions; at least 4 employees in departments; and at least 3 employees in sectors. Groups of specialists may report directly to the head of a functional unit.

6. Transformation of business processes / process reengineering

Business process reengineering is a key tool for using untapped reserves to enhance labour productivity. It can be implemented in two ways: top-down and bottom-up. The top-down approach involves centralization, decentralization, outsourcing, or introducing new functions to improve control and accounting planning. The "physical" level of the processes remains unchanged. The bottom-up approach focuses on particular operations and activities, reducing lead times and boosting process efficiency, which results in customer satisfaction and the company's development. To increase labour productivity, the bottom-up approach is preferable because it involves less investment.

To formulate business process reengineering initiatives, three key levels of process mapping detailing are used:

1) SIPOC method for analysis of a business as a whole and high-level definition of the process frames: boundaries, inputs, outputs, suppliers, and customers;

2) a value stream map for a middle-level description of the steps: a graphical representation of a process flow and its stages, input and output data;

3) a cross-functional process map for low-level detailing of the process: it displays not only the sequence of actions, but also the roles involved in the business process, e.g., Business Process Management Notation (BPMN).

It is worth noting that the cross-functional process map is the most used one for analysing administrative functions, since it allows identifying losses and operations that do not add value within the process.

The sequence of steps implemented is as follows:

1) describing the process "as is": the title, the number of participants, the order of operations, actual time consumed;

2) process analysis for value-adding and non-value-adding activities and losses;

3) finding the cause of losses (Ishikawa diagram, etc.) and exploring the possibility of abandoning such actions;

4) determining a given (necessary) state (brainstorming, prioritization matrix) with selected criteria (deadlines, quality, volumes of resources, etc.);

5) drawing up a work plan (project passport, roadmap).

To effectively improve labour productivity, initiatives are documented in passports, indicating goals, objectives, planned results, schedule, resources, participants and risks. The Type of Initiative section defines its characteristics:

- an organizational initiative is one that affects the organizational structure of the enterprise;
- an investment initiative is one that involves additional funding to be realized and may affect the organizational structure;
- outsourcing is an initiative that does not influence the organizational structure, but suggests using external providers to carry out a process or a part of it.

Consider the process of forming an investment initiative's passport using the example of production process optimization. A preliminary audit showed that automation of copper and zinc concentrate pulp sampling in the filter and dry house (FDH) could discharge up to 5 full-time filter operators.

The FDH employs three full-time filter operators, who service the conveyor (1st operator) and the Larox press filters (2nd operator) and collect pulp samples (3rd operator). Sampling takes up 15% of the working time, and cleaning the separator takes up 2%. To automate the process, it is proposed to install pulp density analysers and video cameras above the coarse separators. This will free up one full-time filter operator per shift.

The target staffing level is calculated by formula (1):

$$Q_n = N_{per} \times n \times K_{tr}, \quad (1)$$

where N_{per} is the number of persons per shift; n is the number of shifts; K_{tr} is coefficient of transition from the shop-floor to the total size of the workforce.

Calculation of the target staffing level: $Q_n = 2 \times 2 \times 2.3 = 10$ full-time employees.

Calculation of the effect: *Actual staffing level* (Q) – *Target staffing level* = 15 – 10 = 5 full-time employees.

Required resources: 2,670.7 thousand rubles for the purchase of density analysers and their testing.

It will take 11 months to realize the project, including purchase and installation of equipment, as well as formulation and implementation of a downsizing plan. During this period, the effect will be 3,347.2 thousand rubles.

A roadmap can be used to track the project in progress. The roadmap schedule describes the step-by-step implementation of the initiative in accordance with the deadlines for milestones and persons in charge, by periods.

The economic effect of the project (*EEp*) is calculated as the sum of the effects of the initiatives included in the package by formula (2):

$$EE_p = \sum EEin, \quad (2)$$

where *EEin* is the economic effect of the initiatives, million rubles.

In turn, the economic effect of a specific initiative is computed by the core components (planned salary, number of full-time employees, insurance rates) using formula (3):

$$EEin = \sum FTEi \frac{Si_{pl}}{1{,}000} \times 12 \times (1 + IPR), \quad (3)$$

where *FTEi* is full-time employees freed-up according to the initiative, persons; Si_{pl} is planned salary of a freed-up full-time employee, thousand rubles; *IPR* is insurance premium rate in accordance with current legislation, %; 12 is the number of months for calculating the annual economic effect.

Up to 20% of the freed-up payroll is directed towards raising the salary of the employees, whose labour intensity increases; at the same time, the economic effect is reduced to an equivalent extent. The rise in labour input must be documented. After the project is completed and tested for sustainability, the results are introduced to operating activities, HR training, and implementation monitoring. If the effect and universality of the solution are confirmed, the project can be replicated horizontally across the enterprise's divisions.

Look at the following example. At the end of the year, the engine crew's staffing table comprised 21 full-time engine drivers and 22 full-time assistant engine drivers. The total freight turnover over year amounted to 2.5 million tons. The current staffing plan is 4–5 crews per shift. Between January and May, the actual output was 4 diesel locomotives in 95% of shifts and 5 diesel locomotives in 5% of shifts. To assemble engine crews, a multifactor model was used that takes into account the actual demand for diesel locomotives, freight turnover of wagons, cycle processing time and other parameters. The demand for diesel locomotives per shift in the planned year is set at 3.88 pcs. The planned outcome: freeing up 3 full-time engine drivers and 3 full-time assistant engine drivers.

The target staffing level is calculated by formula (4):

$$Q_n = N \times h \times n \times K_n, \quad (4)$$

where *N* is demand for diesel locomotives per shift, pcs.; *h* is the number of full-time employees in an engine crew, persons; *n* is the number of crews; K_n is the coefficient of transition.

Calculation of the target staffing level: $Q_n = 3.88 \times 2 \times 4 \times 1.19 = 37$ full-time employees.

Calculation of the effect: $Q_{spare} = Q_{actual} - Q_{target} = 43 - 37 = 6$ full-time employees.

A range of development activities were identified:

- organizing monthly steering committees on productivity improvement projects with immediate involvement of senior management, listening to project summaries and holding debriefing sessions that help understand the compliance with the roadmap, initiative funnel, current and projected results;
- staff training in the project's logic, the procedure for collecting and using data, and algorithms for calculating effects using multifactor models;
- providing guidance on relevant topics (transfer of non-core activities to outsourcing, optimization of internal logistics, standards for planning and filling functional premises, etc.).

Fig. 6 shows the assessment criteria for the effects produced by a project on organizational efficiency improvement.

To assess how effectively the projects on labour productivity improvement are implemented, it is proposed to update the enterprise's key performance indicators (KPIs). In particular, one should consider:

- capital expenditures and equipment modernization costs;
- a 1 full-time employee increase in EBITDA;
- reduction in staff turnover in participating divisions compared to the entire enterprise;
- the share of divisions participating in the projects in the total number of divisions;
- the share of employees trained to use multifactor staffing models, the basics of lean thinking, process optimization technologies, and industrial labour economics;
- the share of IT services active users among the employees involved in the projects.

Table 7 presents the results of the implementation of the organizational change projects aimed at increasing labour productivity at the enterprise.

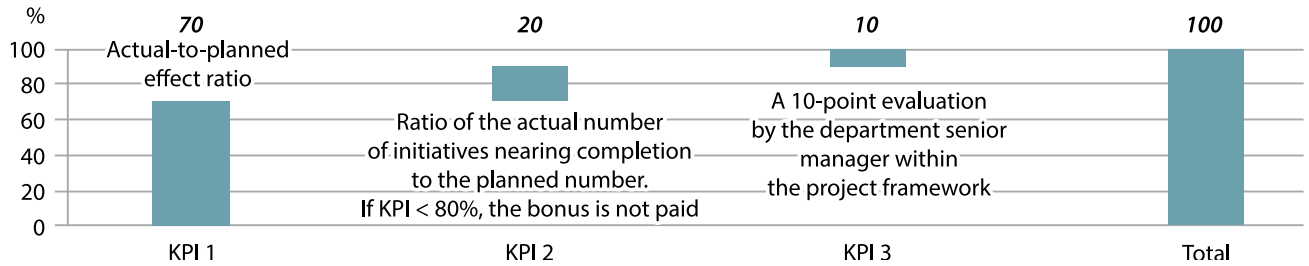

Fig. 6. Key performance indicators by organizational efficiency

Рис. 6. Ключевые показатели эффективности с учетом организационной эффективности

Table 7 – Economic effects from the implementation of the organizational change projects
Таблица 7 – Экономические эффекты от реализации проектов организационных изменений

Recommendations	Staff category optimized	Economic effect		Payback period, months
		full-time employees	million rubles	
Optimization of business processes	PS and AMS	15	9.9	48
Bringing headcount in line with staffing needs	PS and AMS			12
Make-or-Buy	PS and AMS			12
Reducing labour intensity of operations	PS	42	31.0	12
Modernization, automation and mechanization	PS			18
Expanding responsibility areas	PS			12
Outsourcing and outstaffing	AMS	36	16.0	6
Cutting the number of management levels, improving span of control	AMS			6
Total	–	*93*	*56.9*	–

Note: PS is production staff; AMS is administrative and management staff.

The results are summarized by directions for optimization and staff categories; for each direction the overall effects (in full-time employees and million rubles) and payback periods are calculated. The organizational change projects implemented for only a few basic initiatives allowed optimizing 1% of the staff of the divisions involved in the projects with a payback period of 0.5–4.0 years and the economic effect of 56.9 million rubles, with a possibility of replicating the initiative to other divisions of the MPP and all the members of the corporate group. The initiatives are expected to optimize up to 15% of the workforce across the whole company. Thus, we can claim that at an enterprise completing orders with an accuracy of 1 kg, where a mining processing plant is one of the links of the production chain, there is no point in increasing production volumes; it is more expedient to focus on reducing labour costs (the number of workers involved). While maintaining production volumes, headcount optimization and cut in labour costs ultimately lead to increased labour productivity.

CONCLUSION

In the present study, we have developed and summarized methodological recommendations for implementing organizational change projects at industrial enterprises aimed at optimizing staff numbers and increasing labour productivity. These recommendations contain specific procedures and a list of organizational actions. At the same time, it is critical to carefully consider the implementation of any changes affecting labour productivity and headcount, since they are not only associated with optimization, but can also lead to irreversible shifts and losses in developments, approaches, and labour values. Responsibilities for implementation of such initiatives should be assigned to a specialized unit responsible for monitoring and auditing projects, providing methodological support to employees on the ground, training, and stimulating initiative. However, it is line (functional) managers that should drive change, since, recognizing the value of increased labour productivity, they are able to implement organizational change projects. ■

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