Economics of knowledge-intensive and high-tech enterprises and industries. Management in organizational systems

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RESEARCH ARTICLE

Assessment of the effects of production system development projects: Case study of Lytkarino Optical Glass Factory

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Abstract
Objectives. Effective import substitution can be achieved only through the creation and use of efficient domestic production capacities. The aim of this study is to develop and justify a method for the integrated assessment of the effects of projects aimed at the introduction of new equipment, including import substitution projects.
Methods. The research was based on systemic and dialectical approaches, as well as systemic, comparative, economic and mathematical methods, and statistical analysis.
Results. The paper proposes a method for the integrated assessment of production system development projects. In order to obtain a synthetic assessment, a system of indicators was developed to study the effects of production system development projects, i.e., projects for the introduction of new equipment. The effects of the introduction of new equipment can be divided into internal and external: potential development, socioeconomic, import independence, public, and environmental. The indicators are not current values, but changes in dynamics. A comprehensive consideration of the effects allows the existing criteria for decision-making to be expanded when implementing projects to develop the production system. It also allows the impact on both the enterprise and society to be assessed. The authors define both the quantitative and qualitative indicators for each group of effects. On the basis of the author's system of indicators, a methodology for comparative comparison of indicators using normalized indices was developed and the calculation of a generalized indicator substantiated. The proposed system of indicators was successfully tested at the Lytkarino Optical Glass Factory science-intensive enterprise when assessing a new domestic device for the development of the production system.
Conclusions. The results of the approved method for integrated assessment enabled the use of diverse indicators for the quantitative and qualitative assessment of the effects of the introduction of science-intensive projects. This included projects for import substitution of machinery and equipment. A combination of various effects will be relevant to any socioeconomic system, so the proposed integrated assessment method for evaluating the effects is universal to a certain extent. It can thus be adapted for scientific, technical and technological projects on import substitution of any industrial enterprise.

Keywords: effect, development, import substitution, project, system of indicators, integral index

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НАУЧНАЯ СТАТЬЯ

Оценка эффектов реализации проектов развития производственной системы (на примере АО «Лыткаринский завод оптического стекла»)

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Резюме
Цели. Результативное импортозамещение возможно только за счет создания и использования эффективных отечественных производственных мощностей. Цель исследования состоит в разработке и обосновании методики интегральной оценки эффектов, полученных от проектов по внедрению нового оборудования, включая проекты по импортозамещению.
Методы. Основой исследования явились системный и диалектический подходы, а также методы системного, компаративного, экономико-математического и статистического анализа.
Результаты. В работе предложена методика интегральной оценки эффектов реализации проектов развития производственной системы. С целью получения синтетической оценки разработана система показателей для исследования эффектов проектов развития производственной системы – проектов по внедрению нового оборудования. Эффекты от внедрения нового оборудования подразделяются на внутренние и внешние эффекты различной природы: эффект развития потенциала, социально-экономические, эффект импортонезависимости, общественные, экологические. При этом индикаторами эффектов являются не текущие значения показателей, а их изменения в динамике. Комплексное рассмотрение эффектов позволяет расширить существующие критерии принятия решений при реализации проектов по развитию производственной системы, что позволяет оценить воздействие и на предприятие, и на общество в целом. Авторы определяют количественные и качественные показатели для каждой группы эффектов. На базе авторской системы показателей разработана методика компаративного сопоставления показателей с использованием нормированных индексов и обоснован расчет обобщенного показателя. Предложенная система показателей была успешно апробирована на наукоемком предприятии АО «Лыткаринский завод оптического стекла» при оценке эффектов от внедрения нового отечественного прибора для развития производственной системы.
Выводы. Результаты апробации методики позволили обосновать применение разноплановых показателей для количественной и качественной оценки эффектов от внедрения наукоемких проектов, включая проекты по импортозамещению техники и оборудования. Совокупность различных эффектов будет проявляться для любой социально-экономической системы, поэтому предлагаемая методика для оценки эффектов является в определенной мере универсальной и может быть адаптирована для научно-технических и технологических проектов по импортозамещению любого промышленного предприятия.

Ключевые слова: эффект, развитие, импортозамещение, проект, система показателей, интегральный индекс

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INTRODUCTION

Although the introduction of new technological solutions is aimed at the practical resolution of socio-economic and political objectives [1], such innovations do not always produce the expected consequences. A reasoned analysis of factors and economic calculations allow us to justify the various effects or results of new technologies and equipment after their introduction. In order to properly justify the need for technological innovations, non-economic factors need to be taken into consideration along with economic factors. Only a comprehensive consideration of all interrelated factors will allow a real picture of the economic feasibility and technical feasibility to be established in specific conditions of new machinery or equipment which as a rule require large capital investments.

At the current stage of development of domestic industry, the objective of replacing imported components and equipment is of particular relevance [2–5]. The legal regulation of industrial policy is based on the State Program "Development of Industry and Increasing its Competitiveness" (approved by the Decree of the Government of the Russian Federation No. 328 dated April 15, 2014)[1] and the Federal Law "On Industrial Policy in the Russian Federation" (No. 488-FZ dated December 31, 2014)[2]. At the same time, these documents provide not just for the replacement of imported components and equipment with domestic ones in the domestic market, but for the improvement of the quality of these components and equipment, in order to increase competitiveness in foreign markets.

In the current realities, the approach to import substitution has changed significantly. Starting from the spring of 2022, an impressive list of new legislative bills and a number of amendments to existing regulatory documents have been adopted with the objective of stimulating the domestic market. These include:

1. Decree of the Government of the Russian Federation of December 28, 2022, No. 2461 "On Amending Decree of the Government of the Russian Federation of November 16, 2015, No. 1236 and Annulling Certain Provisions of Certain Acts of the Government of the Russian Federation"[3];
2. New edition of the Decree of the Government of the Russian Federation of December 03, 2020 No. 2014 (ed. of February 28, 2023) "On the minimum mandatory share of purchases of Russian goods and its achievement by the customer"[4];
3. Amendments to the Decree of the Government of the Russian Federation of December 03, 2020 No. 2014 "On the minimum mandatory share of purchases of Russian goods and its achievement by the customer"[5];
4. Decree of the Government of the Russian Federation No. 522 dated December 31, 2022 "On Amendments to the Rules for Granting Subsidies from the Federal Budget to the Autonomous Non-Profit Organization "Agency for Technological Development" to Support Projects Involving the Development of Design Documentation for Component Products Required for Industries"[6], etc.

[1] State Program "Industry Development and Competitiveness Enhancement" (approved by Decree of the Government of the Russian Federation No. 328 dated April 15, 2014). http://government.ru/docs/all/91634/. Accessed March 31, 2023 (in Russ.).

[2] Federal Law "On Industrial Policy in the Russian Federation" No. 488-FZ dated December 31, 2014 (latest version). http://publication.pravo.gov.ru/document/0001201412310017. Accessed March 31, 2023 (in Russ.).

[3] Decree of the Government of the Russian Federation dated December 28, 2022 No. 2461 "On Amending Decree of the Government of the Russian Federation No. 1236 dated November 16, 2015 and Annulling Certain Provisions of Certain Acts of the Government of the Russian Federation." http://publication.pravo.gov.ru/Document/View/0001202212300083. Accessed March 31, 2023 (in Russ.).

[4] Decree of the Government of the Russian Federation No. 2014 dated December 03, 2020 "On the minimum mandatory share of purchases of Russian goods and its achievement by the customer" (as amended as of February 28, 2023). https://docs.cntd.ru/document/573031324. Accessed March 31, 2023 (in Russ.).

[5] Decree of the Government of the Russian Federation No. 2014 dated December 03, 2020 "On the minimum mandatory share of purchases of Russian goods and its achievement by the customer" (as amended and supplemented). https://base.garant.ru/75016819/. Accessed March 31, 2023 (in Russ.).

[6] Decree of the Government of the Russian Federation No. 522 dated March 31, 2022 "Concerning the Introduction of Amendments to the Rules for Granting Subsidies from the Federal Budget to the Autonomous Non-Profit Organization "Agency for Technological Development" for the Support of Projects Involving the Development of Design Documentation for Component Products Necessary for Industries." http://publication.pravo.gov.ru/Document/View/0001202204040037. Accessed March 31, 2023 (in Russ.).

The regulatory and legal documents referred to above indicate the need to produce domestic products, particularly in industries with a high share of imports (mechanical engineering, medicine, etc.).

In the current geopolitical situation, the issue of import substitution of components and equipment are of particular relevance for such a unique Russian industrial enterprise as the Lytkarino Optical Glass Factory (LZOS in Russian abbreviation).

At present, LZOS produces optical glass and glass fiber, large-size astronomical and space mirrors, space lenses, various optical parts and devices. The enterprise has its own scientific and technical center which is constantly developing new types of products and relevant technologies. At present, the development of the enterprise is based on the projects for the modernization and technical re-equipment of glass-making and optical-mechanical production facilities.

Since 2014, in order to obviate the purchase of imported components, spare parts, equipment and services, a number of projects have been implemented in LZOS:

1. Technical re-equipping with the establishment of a competence center for the development of technology for the production of special glasses and optical parts;
2. R&D work "Technology development and manufacturing of the precision matrices made of astrositall CO-115M for the panels of the main mirror of the Millimetron Observatory";
3. R&D work "Development of automated technologies for manufacturing blanks from optical colorless and colored glass by hot and cold processing methods";
4. R&D work "Development of technology for automation of optical glassmaking production";
5. R&D work "Development and production of a set of lens mirrors for the Zorkii optical station".

The active implementation of in-house designs, as well as the acquisition and implementation of domestically manufactured equipment has enabled LZOS to expand the product range and launch new products. The following objectives were set: development and production of competitive products with a higher potential for growth of own production; efficient use of limited resources; and cheaper production with optimal product quality.

METHODS

The study uses the example of the development project "Design and manufacture of a set of mirrors of the lens of the Zorkii optical station" implemented at LZOS to substantiate the possible effects of the introduction of the KP-119 interferometer (developer LZOS, Russia) for the control of off-axis aspherical surfaces.

The main results (effects) of the incorporation of the KP-119 device in production activities, both internal and external (Fig. 1), is highlighted here. This branching is due to the fact that the measurement of phenomena pertinent to economic relations simultaneously constitutes the subject of research of economic sciences, while also representing the object of metrology measurements [6].

The internal effects are related to the functioning of the plant and are aimed at increasing its potential. They can reasonably be divided into the following areas: development of the plant's potential and socioeconomic effects.

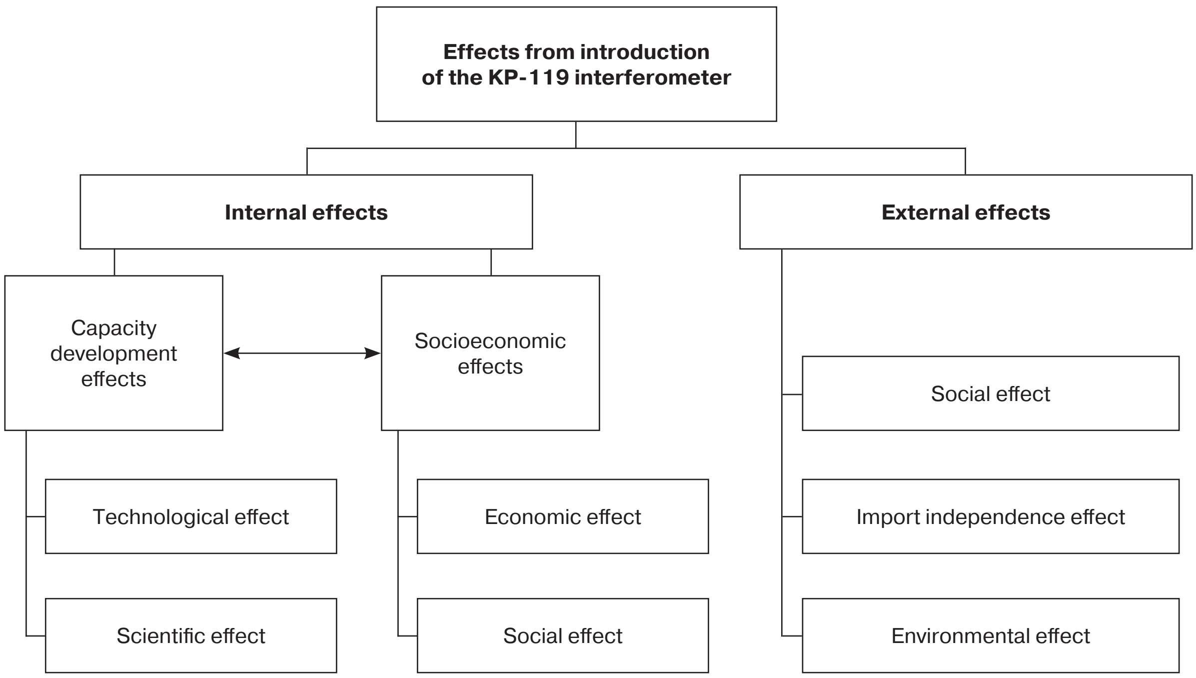

Fig. 1. Effects manifested by the introduction of the KP-119 interferometer

In turn, the effects of plant capacity development can be divided into two types: technological and scientific. The technological effects are conditioned by the availability of new machinery or equipment with better characteristics when compared to existing means of production (resource saving, including energy saving, productivity and reliability). The scientific effects consist in the accumulation of new knowledge and are conditioned by the scale of novelty of the newly introduced device, patentability and prospects of the idea.

Acceleration of the production cycle, reduction of production costs and increased investment will undoubtedly lead to an increase in the financial and economic performance of the enterprise, and to positive economic effects. The increasing value of intangible assets will indicate not only the innovative nature of the project, but also provide economic security and technological sovereignty of the organization. In turn, the social effect from the introduction of new technology will also lead to an improvement in the working conditions of employees and economic conditions.

The internal effects of enterprise potential development and socioeconomic effects are diverse, yet interrelated.

The external effects can be seen in the positive benefits for third parties not involved in the process of introduction and operation of new techniques and equipment, as well as for society as a whole. The public effect from the incorporation of the KP-119 device into production activities can be seen in the impact on social processes, increased capacity of related industries, as well as in the creation of prerequisites for secondary innovations. The effect of import-independence can also be seen in the strengthening of national security and national interests. This can be summed up as the localization of production of machinery and equipment in the territory of the Russian Federation, reduction of the share of imported components and materials in the production of own products. The environmental effect is associated with the improvement of the environment, for example, saving the use of natural resources, reducing the negative impact on the environment.

The external effects are characterized by interconnectedness and are aimed at a long-term perspective, including in related industries.

In terms of composition, the indicators of various effects can vary depending on the nature of technology and equipment introduced. In order to assess the effects of the introduction of the KP-119 interferometer for the control of off-axis aspherical surfaces, an original system of indicators needs to be developed. This system needs to include both quantitative and qualitative indicators. Quantitative indicators are used to establish measurable results and are used for quantitative evaluation. Qualitative indicators allow qualitative parameters to be evaluated on the basis of expert methods.

The selection of indicators was carried out on the basis of the scientific principles set out in the works of R. Kaplan and D. Norton [7–9]: visibility, tree structure of the system and reliability of information. Following these principles, the system of indicators is further divided into projections characterizing various aspects of the development of the research object. The number of indicators in the system should not exceed 30–35, and their number in one projection should be 3–7. At the same time, the indicators of effects are not the current values of indicators, but their changes (the values of indicators before and after the introduction of the interferometer are studied).

Analysis of the effects of the introduction of the KP-119 device was based on a comparison of indicators before and after its introduction. The approach to the comparative analysis of key indicators used to measure the effect of the introduction of the KP-119 device was based on the use of normalized indicators. These are relative indicators which reflect the changes in the values of indicators before and after the incorporation of the KP-119 device in the production activities of the enterprise.

The choice of such an approach is conditioned by the following considerations. First, the use of such indicators allows us to assess the change of complex phenomena in dynamics. Second, the use of indicators enables various types of comparative analysis (temporal, spatial, comparison with a benchmark, forecast, etc.) to be conducted. Third, the use of relative values allows us to analyze indicators in the same axes in a single graph (for example, using bar histograms or petal charts). It also enables integral indicators to be calculated for the study of generalized effects or synthesized indicators of the system state, Thus, this paper proposes to apply the normalization of the initial system indicators on a single dimensionless scale.

One result of the effects of the implementation of the KP-119 device is that the indicators characterizing these effects can be divided into positive and negative as per tradition. In order to increase the effects of the project, positive indicators should be maximized, and negative minimized.

In order to translate the initial data into dimensionless indicators, we will use the following formalized expression [10]:

$$y_{ij} = \begin{cases} 2^{-\frac{K_{ij0}}{K_{ij1}}} \text{ – for positive indicator,} \\ 2^{-\frac{K_{ij1}}{K_{ij0}}} \text{ – for negative indicator,} \end{cases} \quad (1)$$

where i is the number of the projection of the system of indicators; j is the index of the indicator within the projection; K_{ij0} and K_{ij1} are the values of the jth indicator of the effect of the ith projection before and after the introduction of the device KP-119. After calculation of the normalized index, all indicators become positive and change within the interval [0; 1].

Thus, the value of the normalized indicator y_{ij} is interpreted as follows. If $y_{ij} = 0.5$ ($K_{ij0} = K_{ij1}$), there is no growth in this indicator. If $y_{ij} > 0.5$, then growth in this indicator can be recorded. Finally, if $y_{ij} < 0.5$, there was a decrease in the value of the indicator.

After the procedure to calculate the normalized indices, an integrated indicator for assessing the effects of the introduction of the KP-119 device can be calculated. The use of generalized indicators also allows for key aggregated trends to be studied both in individual projections of the project and for the entire set of characteristics under study. In this case, a variety of approaches to the calculation of the generalized characteristic and the choice of weighting coefficients when performing the convolution [11–13] can be applied. In this study, the approach used was based on the calculation of the integrated indicator as the sum of normalized indices taking into account their weighting coefficients according to the following formula:

$$\begin{cases} \Omega = \sum_{i=1}^{n} \left(\sum_{j}^{m_i} y_{ij} w_j \right) w_i, \\ \sum_{j=1}^{m_i} w_j = \sum_{i=1}^{n} w_i = 1, \end{cases} \quad (2)$$

where n is the number of projections in the system of indicators; m_i is the number of indicators in the ith projection; w_j is the weight coefficient of the indicator significance in the system; w_i is the weight coefficient of the projection significance. The integrated indicator, as well as normalized indices, can vary from 0 to 1. The value of 0.5 is also accepted as a threshold (criterion) value for the integrated indicator separating the positive effect from the negative one. This is justified by the fact that with $\Omega < 0.5$ there is a generally negative dynamics of indicators, and with $\Omega > 0.5$ there is a positive one.

The principles of analysis, synthesis, decomposition and integration, which are known and successfully used in theory and practice, lie at the root of the effects assessment tool presented in this article [14]. The use of normalized indices and generalized indicators allows conclusions to be drawn about both individual effects in the development of the system and the integral effect of the project implementation as a whole.

RESULTS

According to the methodology described herein for selecting indicators, the entire system of indicators for assessing the effects of the introduction of the KP-119 interferometer for the control of off-axis aspherical surfaces can be divided into two projections. These two projections reflect the internal and external effects of the incorporation of the project into the production activities of the enterprise. In turn, the "Internal effects" can be divided into subsystems of indicators related to technological, scientific and socioeconomic effects. Further by analogy, each subsystem can be detailed by indicators which characterize the individual effects from the implementation of the KP-119 device.

When calculating the qualitative indicators, individual assessment of indicators was performed by individual experts each acting independently [15]. The expert group consisted of qualified representatives of LZOS (managers of the enterprise, employees of the "Optical Systems and Technologies" department of RTU MIREA, engineers and project managers). The experts established the statistical characteristics of the indicators according to a ten-point system (0 – no effect, 10 – maximum effect from the implementation of the device KP-119). Subsequently, the sum of the scores assigned by the experts and the arithmetic mean of the indicators were calculated. Thus, qualitative indicators were translated into quantitative ones.

The following table shows the composition of the system of indicators for assessing the effects from the implementation of the KP-119 device. The indicators take into account the specifics of the project and modern realities, calculation formulas and economic content of each indicator. Here, it is not the indicators per se which are of scientific interest, but their combination. Of interest also is the methodology of establishing a generalized index to determine the integrated assessment of the effect of the project implementation.

Table. System of indicators for assessing the effects of the introduction of the KP-119 interferometer

Indicator	Calculation formula	Methodological explanations
Internal effects		
1. Technological effect		
1.1. Resource saving indicators		
1.1.1. Energy capacity	$K_{111} = W/Q$, W is the total volume of consumed energy sources (electricity, heat energy, process fuel, etc.) for the product production; Q is the amount of products produced during the calculation period	Indicates the expenditure of energy (energy resources and energy carriers) on the production of a unit of the product
1.1.2. Resource capacity	$K_{112} = TC/Q$, TC is the total production costs	Indicates the cost of resources (in monetary terms) to produce a unit of the product
1.1.3. Duration of operations performance by the production workers when producing a unit of the product	$K_{113} = \sum_{i=1}^{n} t_i \,/\, n$, t_i is the duration of the ith operation, set according to timekeeping observations; n is the total amount of operations	Indicates the time spent on individual production processes in the production of a unit of the product
1.1.4. Yield of usable products	$K_{114} = QG/SR$, QG is the quantity of the used products produced during the calculation period; SR is the scope of the actually consumed raw materials	Indicates how efficiently raw materials are used, as well as characterizes the technical and organizational level of the technical process
1.2. Performance indicators		
1.2.1. Equipment performance	$K_{121} = Q/T$, Q is the scope of the produced products; T is the total operating time of the equipment	Indicates the scope of a product (work) produced per unit of time
1.2.2. Labor efficiency	$K_{122} = QS/R$, QS is the scope of the produced output in financial (value) terms; R is the number of workers producing products	Indicates how efficiently a worker (or group of workers) has invested his or her labor to create a unit of the product
1.2.3. Resource utilization factor	$K_{123} = FQ/TC$, FQ is the actual amount of resources; TC is the total capacity (maximum amount of utilized resources)	Indicates the degree (intensity) of the resource utilization
1.3. Reliability indicators		
1.3.1. Mean time between failures (failure-free operation)	$K_{131} = \sum_{i=1}^{m} t_i \,/\, m$, t_i are the time intervals of the equipment failure-free operation; m is the number of the equipment failures that occurred during the calendar period under consideration	Is a statistical measure and is used to predict behavior as the probability of equipment failure-free operation in a given period of time
1.3.2. Technical service life (durability)	$K_{132} = T_{resource}$, $T_{resource}$ is the technical resource of equipment (reserve)	Characterizes the reserve of a possible operating time of the equipment (time) from the beginning of its operation or resumption of its operation after repair to the onset of its limit state or overhaul to ensure its serviceability within a certain period of time

Table. Continued

Indicator	Calculation formula	Methodological explanations
1.3.3. Average restoration time (maintainability)	$K_{133} = \frac{1}{n}\sum_{i=1}^{n} t_i,$ n is the number of restorations; t_i is the time spent on restoration (detection, search for the cause and elimination of failure)	Characterizes the mathematical expectation of the time of restoration of the operable state of the object after failure
1.3.4. Price of reliability	$K_{134} = Z_{pr} \cdot \left(\frac{NA}{NA_o}\right)^{\alpha},$ Z_{pr} is the price of reliability of the prototype (analog); NA and NA_o are the mean time between failures or average service life of the equipment and the prototype; α is the empirical indicator characterizing the level of production, usually α ≈ 0.5–1.5	Indicates how many times the cost to the plant due to unreliable equipment exceeds the cost of production or how much of the cost of production is due to unreliable equipment or how much of the cost of operation is due to unreliable equipment
	2. Scientific effect	
2.1. Prospects for further development	$K_{21} = \sum_{i=1}^{N} K_{21i} / N,$ K_{21i} is the score (from 1 to 10) of the *i*th expert; N is the number of experts participating in the survey	Indicates the potential of the underlying idea for further development at the plant. It is calculated according to expert assessments
2.2. Novelty	$K_{22} = \sum_{i=1}^{N} K_{22i} / N,$ K_{22i} is the score (from 1 to 10) of the *i*th expert; N is the number of experts participating in the survey	Indicates the level and scale of novelty of the installation, its components; as well as superiority over analogs. It is calculated according to expert assessments
2.3. Patentability	$K_{23} = \sum_{i=1}^{N} K_{23i} / N,$ K_{23i} is the score (from 1 to 10) of the *i*th expert; N is the number of experts participating in the survey	Indicates the protectability and prospects for patenting. It is calculated according to expert assessments
	3. Economic effect	
3.1. Production cost	$K_{31} = \sum_{i=1}^{n} Z_i,$ n is the number of cost items; Z_i is the sum of a specific cost	It is formed taking into account the costs associated with the production and output of a unit of the product
3.2. Carrying value of the equipment	$K_{32} = S - A - Ob,$ S is the carrying value of the equipment, including acquisition, delivery, installation, cost of new units; A is the amortization; Ob is the depreciation	Indicates the carrying value of the equipment. After modernization, the carrying amount of the equipment is to be recalculated
3.3. Cost of intangible assets	$K_{33} = NA,$ NA is the carrying value of intangible assets	Indicates the value of objects that have no tangible, physical form and are intended for use in the production process

Table. Continued

Indicator	Calculation formula	Methodological explanations
	4. Social effect	
4.1. Number of jobs reconstructed/created	$K_{41} = Rm$, Rm is the number of jobs reconstructed/created as a result of equipment implementation	Indicates the number of reconstructed/created jobs where the new/modernized equipment is used
4.2. Index of salary level at reconstructed/created jobs	$K_{42} = a/a_{av}$, a is the average salary level of at the jobs being reconstructed/created; a_{av} is the average salary level in the region	Indicates the ratio of the average salary level of the jobs being reconstructed/created to the average salary level in the region
4.3. Employees satisfaction with working conditions	$K_{43} = \sum_{i=1}^{N} K_{43i} / N$, K_{43i} is the score (from 1 to 10) of the ith expert; N is the number of experts participating in the survey	Indicates employee satisfaction with working conditions. It is calculated according to expert assessments
4.4. Development/optimization of the production and organizational processes	$K_{44} = \sum_{i=1}^{N} K_{44i} / N$, K_{44i} is the score (from 1 to 10) of the ith expert; N is the number of experts participating in the survey	Indicates how efficiently production and organizational processes function during equipment operation. It is calculated according to expert assessments
	External effects	
	5. Social effect	
5.1. Potential for development of the related industries	$K_{51} = \sum_{i=1}^{N} K_{51i} / N$, K_{51i} is the score (from 1 to 10) of the ith expert; N is the number of experts participating in the survey	Indicates the prospects for the development of related industries as a result of the development of the idea, novelty of the installation, its components. It is calculated according to expert assessments
5.2. Prerequisites for secondary innovations	$K_{52} = \sum_{i=1}^{N} K_{52i} / N$, K_{52i} is the score (from 1 to 10) of the ith expert; N is the number of experts participating in the survey	Indicates the prospects for further development of the idea/equipment and its components. It is calculated according to expert assessments
	6. Import independence effect	
6.1. Import dependence level	$K_{61} = \frac{Q_{subst}}{Q_{total}}$, Q_{subst} is the scope of imported products/equipment/technologies; Q_{total} is the total current scope of consumption or use of products/equipment/technologies in the process of functioning enterprises	Indicates the proportion of imported products/equipment/technology in the total volume of products/equipment/technology
6.2. Production localization ratio	$K_{62} = (P_{selling} - P_{imp})/P_{imp}$, $P_{selling}$ is the selling price of the product; P_{imp} is the price of the imported components, parts, and materials	Indicates the ratio of the difference between the selling price of the product and the price of the imported components, parts and materials to the selling price of the final product

Table. Continued

Indicator	Calculation formula	Methodological explanations
7. Environmental effect		
7.1. Index of environmental innovations introduction	K_{71} is derived from the Form 4-Innovation (Section 16)[7] and is defined as the sum of code "1" in lines 1101–1110 divided by 10	The index varies from 0 to 1 (0, no environmental innovation; 1, maximum level of its effectiveness)
7.2. Environmental legislation compliance index	K_{72} is derived from Form 4-Innovation (Section 16)[8] and is determined as the sum of code "1" in lines 1111–1117 divided by 7	The index varies from 0 to 1 (0, no environmental regulatory compliance; 1, maximum level of compliance)

Source: developed by authors.

[7] Order of the Federal State Statistics Service No. 538 dated July 29, 2022 "On Approval of Federal Statistical Observation Forms for Organization of Federal Statistical Observation of Activities in the Sphere of Education, Science, Innovation and Information Technology." Form No. 4-innovation "Information on innovation activity of the organization." https://docs.cntd.ru/document/351745217. Accessed March 31, 2023 (in Russ.).

[8] Ibidem.

Figure 2 shows the values of normalized indexes of the effects from the introduction of the KP-119 device, obtained by formula (1) by comparative comparison of data on the indicators presented in the table before and after the introduction of the device. The calculation period of indicators amounted to one year. Price indicators were calculated taking into account the discount rate.

The last line of the figure shows the result of calculation of the generalized indicator of the effect from the introduction of the KP-119 interferometer. Weighting coefficients in calculations of the integral indicator were chosen by experts.

Analysis of the values of normalized indicators allows the following conclusions to be drawn:

1. The values of most indices exceeded the value y = 0.5, which indicates positive effects from the introduction of the KP-119 interferometer for the control of off-axis aspherical surfaces.
2. Some indices were below the reference level y = 0.5. These include the indices of resource intensity, environmental innovation and production costs.
3. The value of the generalized index calculated by formula (2) turned out to be equal to Ω = 0.57, indicating a positive integral effect obtained from the introduction of the interferometer.

CONCLUSIONS

The article presents the author's methodology for the integrated assessment of a production system development project. A system of indicators for the integrated study of the effects obtained from the project of implementation of a new device within the framework of the import substitution policy was developed, in

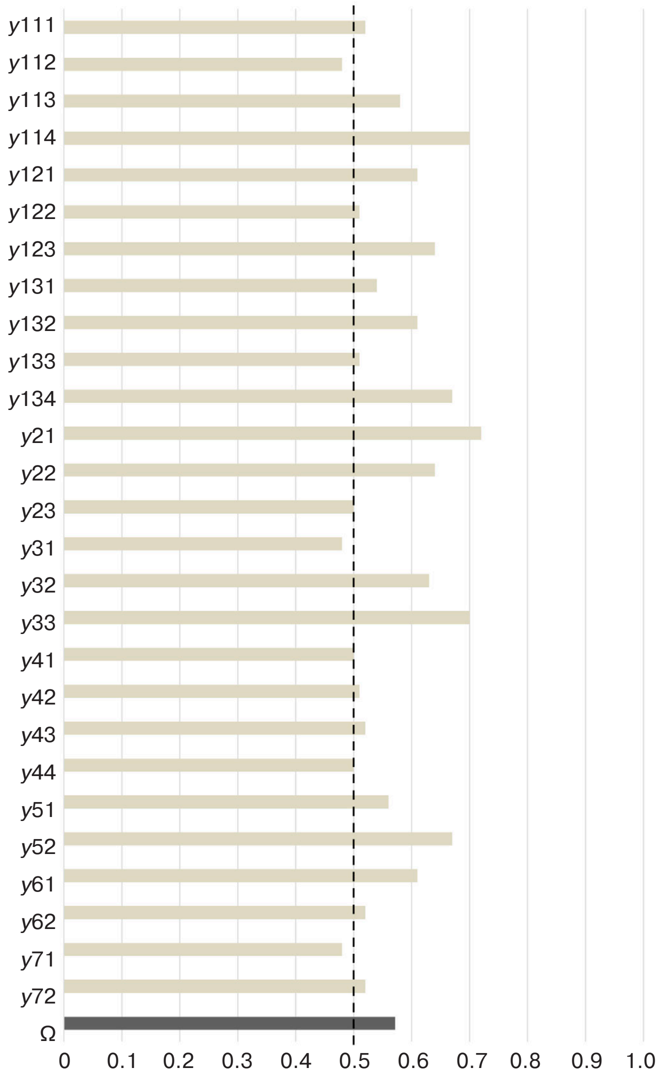

Fig. 2. Normalized indices of estimation of effects from the introduction of the KP-119 interferometer

order to obtain a synthetic assessment. The system of indicators is characterized by the various effects of the introduction of machinery and equipment (internal and external effects of different nature: capacity development, socioeconomic, import-independence, social, environmental). It also involves a comparison of quantitative values of indicators calculated before and after the incorporation of the project into the production system.

Confirmation of the results was based on the example of the "Development and manufacture of a set of lens mirrors of the Zorkii optical station". This project was undertaken at LZOS, consisting of the introduction of the KP-119 interferometer for the control of off-axis aspherical surfaces, and demonstrated a positive integrated effect.

The proposed methodology of integrated assessment of the effects of the introduction of a new device is to a certain extent universal and can be adapted to the scientific, technical and technological projects of any industrial enterprise. However, in order to assess the feasibility of the import substitution project, the rationality of integrating a new device into the production and technological value chain also needs to be analyzed. Thus, further development of the system of indicators needs to be associated with the addition of indicators to enable assessment of the impact of the project on the development of the production system as a whole, the reduction of dependence on imported equipment, the quality of manufactured products, total costs and the cost of manufactured products. These indicators will make it possible for the effects obtained from the import substitution project to be assessed.

Authors' contributions

M.A. Abdulkadyrov—presentation of data for calculations, scientific editing.

A.N. Ignatov—presentation of data for calculations, scientific editing.

N.N. Kulikova—the idea of the study, literature analysis, development of a system of indicators, writing and editing the text of the article.

E.S. Mityakov—literature analysis, development of calculation methods, research, preparation of graphic materials, writing and editing the text of the article.

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