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Evaluation Of Economic Efficiency Of Innovative Development Of Pilot Production

Evaluación De La Eficiencia Económica Del Desarrollo Innovador De La Producción
Piloto

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Abstract.

The objective of the scientific and practical research is to assess the economic effect of choosing a scenario for the innovative development of the pilot production of an aerospace enterprise based on modernization and creation of a public-private partnership. The study reveals the innovative potential of physically and morally obsolete production of complex metalworking, the expansion of industrial integration within the enterprise and in the foreign market. Economic modeling of increasing efficiency was carried out by modernizing the enterprise's production following two innovative scenarios, affecting production technologies, business processes, investments, and the organizational structure to different degrees. A methodological approach to achieving this goal provides a scenario-based assessment of the direct economic effect of the pilot production of an enterprise when introducing innovations different in their focuses, duration, and cost. An innovative model has been developed to present production development scenarios with a focus on internal or external factors, on flexibility or on stable development. Assessment of the current level of technological development and economic efficiency of pilot production made it possible to determine the possibilities of managerial and technological innovative development of a nationally significant enterprise; to determine the direct economic effect of modernization and production integration of participants in the innovation process. The degree of the economic effect directly depends on the chosen innovative scenario and the scale of its implementation in the enterprise.

Keywords: innovation scenario, modernization, business processes, economic effect, industrial integration, enterprise innovative development

Resumen

El objetivo de la investigación científica y práctica es evaluar el efecto económico de elegir un escenario para el desarrollo innovador de la producción piloto de una empresa aeroespacial basada en la modernización y la creación de una asociación público-privada. El estudio revela el potencial innovador de la producción física y moralmente obsoleta de la metalurgia compleja, la expansión de la integración industrial dentro de la empresa y en el mercado extranjero. La modelización económica de la eficiencia creciente se llevó a cabo modernizando la producción de la empresa siguiendo dos escenarios innovadores, que afectan las tecnologías de producción, los procesos comerciales, las inversiones y la estructura organizativa en diferentes grados. Un enfoque metodológico para lograr este objetivo proporciona una evaluación basada en el escenario del efecto económico directo de la producción piloto de una empresa al introducir innovaciones diferentes en sus enfoques, duración y costo. Se ha desarrollado un modelo innovador para presentar escenarios de desarrollo de producción con un enfoque en factores internos o externos, en flexibilidad o en desarrollo estable. La evaluación del nivel actual de desarrollo tecnológico y la eficiencia económica de la producción piloto permitió determinar las posibilidades de desarrollo innovador gerencial y tecnológico de una empresa de importancia nacional; Determinar el efecto económico directo de la modernización y la integración de la producción de los participantes en el proceso de innovación. El grado del efecto económico depende directamente del escenario innovador elegido y la escala de su implementación en la empresa.

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Palabras Claves: escenario de innovación, modernización, procesos comerciales, efecto económico, integración industrial, desarrollo innovador empresarial.

Introduction

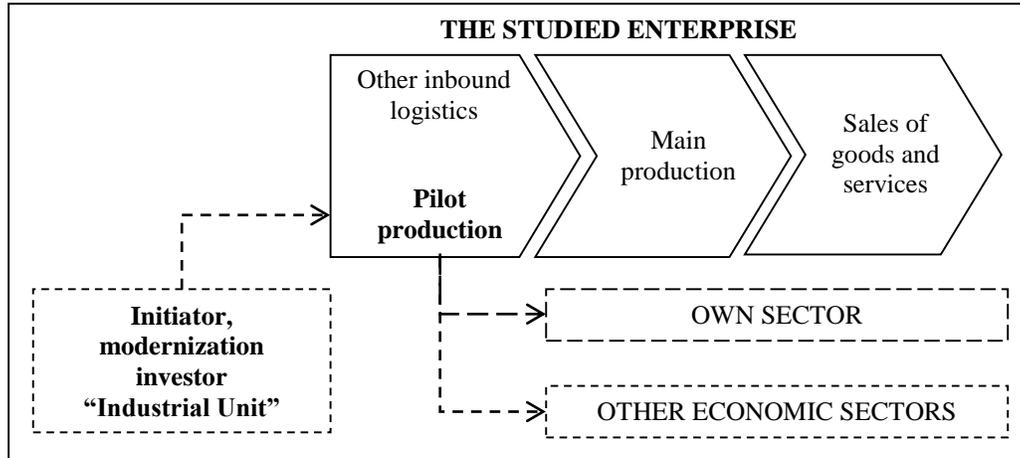
The analysis of the current state of production in the machine building industry of the Russian Federation and domestic experience in developing restructuring programs, innovative development and simulation models of new industries, proves the possibility of introducing international innovations in project, process and organizational development management in order to effectively launch Russian technological innovations in small-scale production. The analysis of the experience of commercial enterprises introducing their own or acquired innovative developments shows the effectiveness of innovative investment projects in the civilian products market, which ensures the national economic effect (Eskindarov & Silvestrov, 2014).

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The article considers the choice of the scenario for the innovative development of pilot production of an aerospace enterprise and offers an approach to assessing the economic efficiency of modernization of pilot production for aerospace enterprises, creating a public-private partnership between a state enterprise and an external commercial organization. A specialized enterprise of the aerospace industry with a "pilot production" site was chosen as the object of study. The concept of "pilot production" covers various production divisions, such as experimental production at industrial research institutes and experimental sites for new technological process debugging.

The features of the pilot production of the enterprise considered in the study are a large range of products; uniqueness and frequent change of production facilities; frequent changeover of equipment; short deadlines for a prototype; a large number of design and technical changes. The current pilot production of the aerospace enterprise is equipped with special and universal low-productivity equipment, which allows for a full cycle of product processing and includes sections: blanks, machining, forge-and-press production, heat treatment, assembly and welding facilities, electroplating area, painting area, technical control department. All production sites are located in a single unit of the workshop, equipped with bridge cranes and self-propelled rail platforms, which has a positive effect on labor productivity and terms of order fulfillment (Marketing agency LLC «Business-Class», Report on a field research, 2013).

Figure 1. Value chain and promising markets



Source: compiled by the authors

The current positioning of the pilot production was carried out using M. Porter's enterprise value chain methodology (Trott, 2008). The authors determined the area of the main competitive advantage of pilot production and concluded that it is advisable to change the basic competitive strategy of "focusing" on "differentiation" after upgrading the equipment of the enterprise (Skarzynski & Gibson, 2008). The possibility of the technological implementation of developments in complex metalworking and the launch of their production are due to the high qualification, scientific and technological competencies of employees. However, at the time of modernization and the introduction of innovations, pilot production has a set of sustainable management, economic and investment problems caused by constant underloading of production capacities, lack of production cycles, low productivity, and individual and small-scale orders.

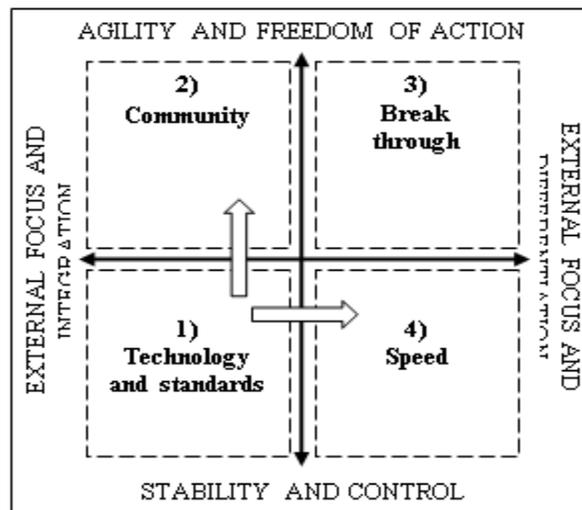
The economic modeling of improving the efficiency of modernization was carried out subject to two innovative scenarios that affected production to different degrees: production technologies, business processes, investments, organizational structure, increased utilization of pilot production, and social significance for the city.

Methods and Materials

A methodological approach to achieving this goal provides a scenario-based assessment of the direct economic effect of the pilot production of an aerospace enterprise when introducing innovations different in their focuses, duration, and cost (Gordon, 1962). The direct economic effect is based on increasing productivity to fulfill a larger volume of orders, reducing labor costs, cost and downtime of equipment, entering new markets for products, saving time on ordering, designing parts and developing documentation for equipment with numerical control. The effect is calculated on the basis of the return on investment in equipment modernization, strengthening the composition of managers and technologists. The magnitude of the economic effect directly depends on the selected innovative scenario and the extent of its implementation at the enterprise (Ministry of Chemical Industry of the Russia, 1978).

To select the main direction of increasing efficiency, we consider four innovative scenarios according to the model of resource-competing innovative development values (Damodaran, 2011). The innovative model considers the features of practices existing in the pilot production: corporate culture, staff competence, and processes. For each of the innovative scenarios, key performance indicators, priority project plans, and financial parameters are identified.

Figure 2. Vectors and innovative development scenarios



In accordance with this model, the emphasis in creating joint production can be placed on internal or external factors, on flexibility or on stable development. Combinations of alternatives allow us to identify four innovative scenarios for the development of pilot production: “*Technology and Standards*” combines a focus on internal processes and the integration of resources with a priority of stability and control with a fundamental goal - “do better, cheaper, more reliable”;

“*Community*” (or “*Sustainable Development*”) combines a focus on internal processes and integration of resources with a priority of agility and freedom of action with a fundamental goal - “support development based on culture and people”;

“*Break-through*” combines focus on the external environment and differentiation of services with a priority of agility and freedom of action with a fundamental goal - “create the future”;

“*Speed*” (or “*Quick Victories*”) combines a focus on the external environment and differentiation of services with a priority of stability and control, with a fundamental goal - “create value now and every day”.

Based on current goals, the pilot production of an aerospace enterprise considers existing state and business restrictions according to the scenario of innovative development “*Technologies and Standards*”. Following the methodology for changing related innovation scenarios, we formulated a hypothesis for modeling the economic effect of modernization:

- The first innovative scenario “*Sustainable Development*” is focused on the balance and continuity of development of pilot production of an aerospace enterprise based on the introduction of new technologies, standards and continuous improvement of professional competence. In terms of mastering new technologies, this scenario assumes the systematic implementation of joint work of technologists of the aerospace enterprise and the Industrial Unit with new and existing orders at the existing pilot production facilities.

- The second innovative scenario “*Quick Victories*” is aimed at solving the urgent problems of the current pilot production of an aerospace enterprise based on the introduction of new technologies, the complete modernization of equipment, and the reengineering of management standards. To test the technologies, it is planned to implement a set of projects of integrated metalworking orders.

The methodology of this study involves the implementation of the following main stages. At the first stage, the results of an interview with the production director, chief technologists, chief economists, lawyers and the initiator of modernization were collected and processed. The competitive situation and market demand were studied, and a technological audit of all pilot production sites was conducted (Denzin & Lincoln, 2011; Kuchugin, 2008).

The second stage involves analysis of the collected primary and secondary information, a SWOT analysis, and examination for the selection of innovative scenarios for the development of pilot production. The analysis of modernization plans was made according to the guidelines for the evaluation of UNIDO investment projects and the calculation was carried out in the financial model (Blokdyk, 2019).

The third stage involves modeling of the economic effect of each modernization scenario, sales plan, production plan, supply plan, organizational plan, financial plan, priority project plan, project risk maps, and legal interaction schemes of the two participants in the modernization project based on the forecast data on sales, technological and investment opportunities (Shchepkina, 2019; Lapteva, 2019).

The economic model is designed for two innovative scenarios: *Sustainable Development* and *Quick Victories*. For product calculation, we use the method of relative cost calculation. In the framework of the financial model, a plan of income and expenses of operating activities on an accrual basis has been formed. The plan of cash receipts and payments, in contrast to the plan of income and expenses, is drawn up “for payment” and reflects the actual cash flow in the framework of the project. In accordance with IFRS, “Cash flow” was determined by two methods: direct and indirect.

Based on the results of a comprehensive survey, a strategic analysis was carried out and a list of opportunities and threats of modernization was formed based on SWOT analysis (Blokdyk, 2019).

- *Threats*: An ongoing decline in industrial production in the Russian economy; delay in financing state programs of the aerospace industry; increase in the cost of metallurgical raw materials for the production of finished products.
- *Opportunities*: resolution of the crisis in the project design; regular funding of state programs; development and state support of the innovation environment in import substitution.
- *Weaknesses*: there is a risk of an increase in the need for project financing in case of delayed commissioning of the equipment or incomplete implementation of the sales plan; lack of a transparent system for managing the production economy; low automation of management activities. Currently, due to the low speed of compiling a high-quality technological process due to the insufficient number of technologists; the absence of an end-to-end computer-aided design system, the sales volume of pilot production decreased from \$2.65 to \$2.27 million, the number of employees decreased from 79 to 65 people, the residual value of the equipment is only \$0.79 million.
- *Strengths*: the presence of highly professional metalworking technologists; acquisition of a new fleet of high-performance equipment; full project financing by one of the project participants; production of new equipment will be cost-effective; short payback period of the project; end-to-end automation at a modern level.

Results and Analysis

Based on the results of a comprehensive survey and SWOT analysis, the hypothesis about the possibility of changing the current innovative scenario “*Technologies and Standards*” of the pilot production of an aerospace enterprise to one of the adjacent ones with an appropriate economic assessment was confirmed at a qualitative level:

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- The innovative scenario “*Sustainable Development*” provides for a set of measures lined up in a logical chain for the gradual implementation of strategic and innovative goals of the company from top to bottom. A set of plans will be developed, a comprehensive assessment will be carried out to identify the potential of operational activities, and a number of interrelated technological measures will be launched to increase production efficiency in the long term. Investments and commissioning of new high-performance equipment are not provided for in this scenario (Mishlanova, 2019; Badiru, 2011).
- As part of the innovative scenario of “*Quick Victories*”, a set of innovative measures will be implemented aimed at quickly modernizing the existing pilot production, as well as a set of measures that increase the effectiveness of functional areas of activity in the field of project management, business processes, economics, and personnel management. A prerequisite for the implementation of this scenario is large-scale investments and the commissioning of new high-performance equipment. Further, the authors developed a set of priority modernization projects in two development scenarios:

The sales plan and production program are based on pre-orders from existing and new consumers for four groups of finished products: products with high processing complexity, other products (metal structures and products with low processing complexity), orders for the main production of the aerospace enterprise and intrasectoral demand, and “x” series integrated devices.

In the first scenario, 3 groups of products are produced on existing equipment - without the “x-series integrated devices” group. In the second scenario, all 4 product groups are produced. At the same time, sales volumes of products with high processing complexity increase five-fold, both due to production growth and due to the transition to more complex products with high sales prices. Intra-industry consumption remains unchanged.

“Sustainable Development” is to be implemented on the existing machine fleet of the enterprise. At the same time, production efficiency will be achieved by managerial innovations in terms of organizing production processes, applying new processing technologies, increasing the mass of orders, as well as expedited procurement of raw materials for additional funds in the form of commodity lending by the Industrial Unit modernization initiator for pilot production of an aerospace enterprise.

Choosing “Quick Victories” for the successful operation of the pilot production of the enterprise, in the investment phase of modernization, “Industrial Unit” plans to purchase and commission at least 10 new high-performance and high-tech foreign machines for a total amount of up to \$3.48 million.

Modeling of financial performance is presented in the table.

Table 1. Planned financial indicators for innovation scenarios

Parameter	unit of measurement	2020		2021		2022		2023	
		(1) “SD”	(2) “QV”						
Innovation scenario:		(1) “SD”	(2) “QV”						
Net profit (loss)	million US dollars	0.23	0.79	2.79	11.81	4.79	16.45	7.43	24.52
Net profit margin	%	6%	11%	18%	25%	22%	27%	24%	28%
EBITDA	million US dollars	0.36	1.25	3.63	15.30	6.13	21.09	9.43	31.18
Budget cash flow BCF	million US dollars	0.49	0.47	2.13	6.69	3.08	8.93	4.32	12.70

Funding needs	million US dollars		3.42						
Payback period	Month(s)		7						

Source: compiled by the authors

The break-even schedule is built only according to the “Quick Victories” scenario, in which the project reaches the break-even point when production is launched on new equipment. Up to this point, the fixed costs of the project exceed the proceeds from the sale of products. According to the “Sustainable Development” scenario, there is no need to build a schedule, as the project starts from the point at which breakeven has already been achieved.

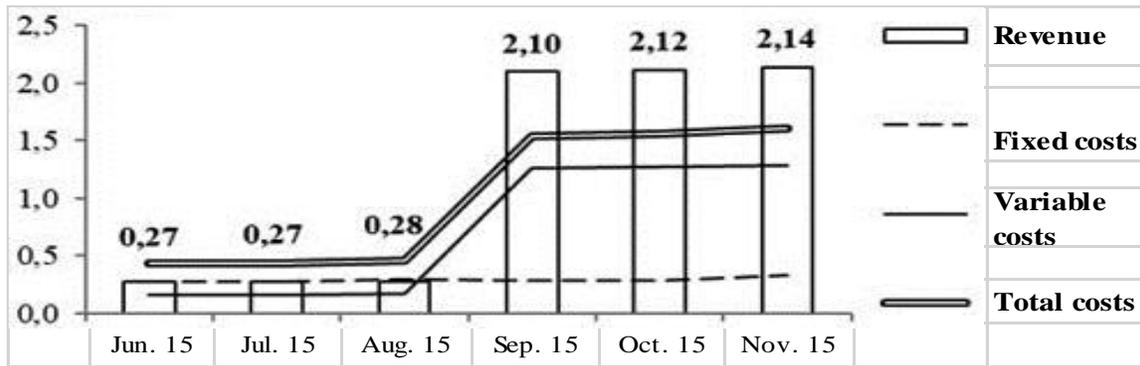


Figure 3. The break-even plan for “Quick Victories”, million US dollars

Source: compiled by the authors

Conclusions

The main result of the study can be the possibility of combining and implementing proven international methodologies for managing processes, projects, indicators with Russian technical developments to obtain direct economic effect at specific production sites (Christiansen, 2000; Brovko & Petruk, 2017). The results of calculating the modernization indicators in the financial model show the high economic efficiency of such innovative measures, especially when replacing a fleet of obsolete equipment with high-performance equipment, as well as carrying out technological reengineering. Natural indicators of the effectiveness of the modernization of the innovation scenario “Quick

Victories" exceed the indicators of the scenario "*Sustainable Development*" by 2.5 - 3 times, relative to 1.5 times. Only in the third year of modernization, the profitability of sales according to the net profit of *Sustainable Development* overcomes a significant gap, but still does not come close to *Quick Victories*.

As part of the research topic, we focus primarily on innovative development, the economic effect of modernization and do not consider in detail the sales plan, production plan, supply plan, organizational plan and risk map (Miroshnikova & Taskaeva, 2016; Miroshnikova & Taskaeva, 2019; Osipov & Krasova, 2017). However, as a result, a number of significant effects of modernization of pilot production can be stated: the activities of pilot production are moving into an innovative channel, both in the field of management and in terms of technology; full modernization of equipment makes it possible to fulfill orders that were previously unrealizable; significant sales growth as a result of a twenty-fold increase in production in the innovation scenario. *Quick Victories* will lead to an increase in the profitability of pilot production; as a result of all innovative measures and modernization, the load on the maintenance of the infrastructure is reduced: utility and maintenance costs for the maintenance of the pilot production, part of the costs of staff remuneration and depreciation of fixed assets are covered by joint activities with the initiator - Industrial Unit. Another important thing is that the volume of state subsidies from the federal budget for the maintenance of underutilized capacities of pilot production is reduced.

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