INTERNATIONAL MULTI DISCIPLINARY JOURNAL FOR RESEARCH & DEVELOPMENT
eISSN 2394-6334 Impact factor: 7,854 Volume 12, issue 12 (2025)

# IMPACT OF INNOVATION ON THE PRODUCTION EFFICIENCY OF AN ENTERPRISE: A METHODOLOGY FOR EVALUATION AND DEVELOPMENT OF SOLUTIONS

**Elnara A. Alieva**
Namangan State Technical University
Doctor of Economics (DSc), Associate Professor, Department of Economic Theory
ORCID: 0009-0002-5935-2708

**Yevgeniy S. Tabakov**
Namangan State Technical University
Master's Student, Department of Economics

**Abstract.** The article examines the impact of innovation on the production efficiency of an enterprise and proposes a methodology for the comprehensive evaluation of innovations and the development of corresponding innovation solutions. It is demonstrated that most existing approaches rely on a limited set of economic indicators and do not sufficiently account for the multidimensional nature of innovation. Based on an analytical synthesis of the literature and identified methodological gaps, an improved methodology is developed that incorporates technological novelty, organizational change, ecological effects, and innovation-related risks. The findings may be applied by enterprises to enhance the justification of innovation policies and to select optimal directions for improving production efficiency.
**Keywords:** innovation, production efficiency, innovation assessment, methodological approach, innovation solutions, technological upgrading, innovation risk.

## INTRODUCTION

The current stage of global economic development is characterized by a high intensity of technological change, increasing complexity of cross-border production interactions, and an accelerated transition toward environmentally oriented models of economic activity. Under these conditions, innovation activity serves not only as a factor enhancing competitiveness but also as a fundamental mechanism for ensuring the sustainability of production systems. The emergence of new technological paradigms, the digitalization of key industries, and institutional transformations in the sphere of environmental regulation require enterprises to reconsider traditional development strategies, which objectively reinforces the role of innovation as a tool for the long-term improvement of production efficiency.

Despite the growing importance of innovation, existing approaches to its evaluation remain largely fragmented. In practice, methodologies predominantly focused on financial and economic indicators continue to dominate, while the comprehensive characteristics of innovation activity—such as the degree of technological novelty, its impact on resource and environmental performance, the level of integration into production processes, and the associated strategic risks—often fall outside the analytical scope. This imbalance limits enterprises' ability to develop well-grounded innovation strategies, particularly under conditions of increasing uncertainty and the pressing need to modernize production infrastructure.

In this context, the need is growing for a methodological approach that enables a systematic assessment of innovation activity and its impact on the key parameters of production efficiency. Such an approach must be based on the principles of integrity, measurability, and comparability, integrating both quantitative and qualitative indicators of innovation development. The present study is aimed at developing such a toolkit, allowing for the identification of key determinants of innovation-driven growth, the evaluation of the maturity and performance of implemented solutions, and the forecasting of their impact on the enterprise's competitive position.

**LITERATURE REVIEW**

The development of innovative solutions to enhance enterprise production efficiency has received considerable attention in both international and domestic research. Traditional economic approaches, which focus primarily on financial indicators, are increasingly recognized as insufficient in the context of rising technological complexity, accelerated digitalization, and heightened innovation turbulence. Moreover, many existing methodologies are either overly generic, failing to reflect industry-specific characteristics, or excessively complex for practical implementation, limiting their applicability in resource-constrained enterprises.

At the international level, Tidd and Bessant have proposed a comprehensive innovation management framework encompassing the stages of exploration, selection, implementation, and scaling of innovations [1]. While this model provides a valuable systemic perspective, it has been criticized for limited adaptability to the production realities of emerging economies, where innovations are often incremental. Chesbrough's concept of "open innovation" further highlights the advantages enterprises can gain by leveraging external sources of ideas and technologies [2]. At the same time, he notes that openness increases process uncertainty, necessitating more precise methods for identifying promising innovations and emphasizing the need for integrated, risk-oriented management tools. Similarly, Pennings introduces the notion of the "optionality" of innovations, stressing that benefits are realized only when the timing of implementation and the level of technological readiness are adequately assessed [3]. Collectively, these studies underline the importance of flexible, context-sensitive, and risk-aware approaches to innovation management.

In the Russian context, scholars have focused on the interplay between innovation and operational efficiency during technological modernization. Ponomaryova, for example, examines the relationship between innovative development and enterprise performance, advocating for innovation policies that incorporate methods to identify "bottlenecks" in production processes [4]. Illarionova further emphasizes that successful innovation depends on accurate assessment of the enterprise's initial technological level and organizational readiness for change [5]. She also critically notes that most assessment tools focus primarily on outcomes, neglecting the stages of solution development, which limits their methodological completeness.

Research in Uzbekistan reflects a growing interest in innovation-driven industrial development within the framework of national economic modernization and digitalization strategies. Alieva has systematically advanced methodologies for assessing enterprise innovation activity, including composite indices, matrix-based techniques, and risk-oriented approaches [6–8]. She points out that national enterprises often exhibit a gap between declared innovation objectives and actual implementation, highlighting the need for simple, adaptive, and formalized diagnostic tools. Her work also offers practical solutions for structuring factors related to novelty, risk, and expected outcomes, which is particularly relevant for improving production efficiency under resource constraints.

Overall, a critical analysis of the literature reveals several persistent methodological challenges:

– insufficient integration of qualitative innovation indicators (such as novelty, technological sophistication, and adaptability) with quantitative performance metrics;

– limited application of risk-oriented and optionality-based approaches, particularly under high uncertainty;

– weak adaptation of international models to the characteristics of production systems in emerging economies;

– and the predominance of ex post performance evaluations over ex ante identification of innovative solutions.

Addressing these gaps underscores the need for a comprehensive, adaptive, and practice-oriented methodology for assessing and designing innovative solutions aimed at enhancing enterprise production efficiency.

**RESEARCH METHODOLOGY**

The methodology involves diagnosing the enterprise's production performance, generating and selecting innovations, and conducting a multi-criteria assessment using data normalization, expert-assigned weights, and an integrated innovation impact index. Additionally, a risk-oriented analysis and option-based evaluation of implementation scenarios are applied. The resulting solutions undergo pilot testing, enabling a comparison between projected and actual changes in efficiency, thereby validating the reliability of the developed methodology.

**RESULTS AND DISCUSSION**

The proposed methodology represents a practical algorithm for the identification, evaluation, selection, and implementation of innovative solutions aimed at enhancing enterprise production efficiency. A distinguishing feature of the methodology is the integration of multi-criteria quantitative assessment—via an Integrated Innovation Impact Index (III)—with risk-oriented, option-based logic and mandatory pilot verification, ensuring both reproducibility and manageability of the innovation process.

In the initial stage, preparatory activities are carried out to define objectives and collect baseline data, including:

– identification and documentation of strategic enterprise goals (e.g., increasing OEE, reducing energy consumption, minimizing defects);

– collection of operational data over a period of 6–12 months, including OEE, downtime (%), changeover time (minutes), defect rate (%), energy consumption per unit, and productivity per shift/employee;

– interviews with key stakeholders from production, technical support, IT, and finance.

Subsequently, innovative opportunities are identified through:

– 1–2 expert sessions (brainstorming combined with SCAMPER/TRIZ methods);

– benchmarking (suppliers, industry solutions, publications);

– resulting in a pool of at least 15–20 concepts, including technological, digital, organizational, and "green" initiatives.

An initial filtering of ideas is then performed using:

– a rapid scoring system based on four criteria: feasibility, cost, strategic alignment, and baseline risk (0–5 scale);

– with ideas scoring below a predefined threshold (e.g., 8 out of 20) being eliminated.

This stage aims to remove clearly unfeasible options and define a manageable set of 8–12 high-potential ideas.

Next, evaluation criteria are established and normalized to prepare for calculation of the integrated index:

– selected criteria include economic effect (E), technological novelty (N), KPI impact (e.g., OEE) (K), implementation time (T), costs (C), and production risk (R);

– for each criterion, a measurement scale is defined (e.g., E — NPV in thousand USD; K — expected OEE change in percentage points; N — 0–1 scale);

– followed by min–max normalization:

$$\hat{x}_{ij}=\frac{x_{ij}-x_{i,min}}{x_{i,max}-x_{i,\,min}}$$

where $x_{ij}$ is the value of the i-th criterion for the j-th idea.

Criterion weights are then determined using AHP (Saaty, 1980) or the Delphi method:

– involving 5–7 experts from production, finance, R&D, IT, and management.
– pairwise comparisons (AHP) or iterative consensus (Delphi) are used to derive the weight vector $\omega_i$;
– with matrix consistency verified (CR < 0.10).

The Integrated Innovation Impact Index (III) is subsequently calculated for each idea, providing a quantitative assessment of its expected contribution to performance:

$$III_j = \sum_{i=1}^{n} \omega_i \cdot \hat{x}_{ij}$$

– ideas are then ranked in descending order of III.

A risk assessment and option-based analysis follow, with the probability $P_k$ and impact $I_k$ of key risks estimated for each idea to calculate a risk score:

$$R_j = \sum P_{jk} \cdot I_{jk}$$

In cases of high uncertainty, a phased «pilot-to-scale» strategy is evaluated, and an option value is calculated (simplified as alternative NPV under different scenarios). III and risk are considered jointly—high III combined with unacceptable risk necessitates an option-based strategy (e.g., delay or phase implementation).

During portfolio formation:

– thresholds for the Integrated Innovation Impact Index $III_{min}$ and risk $R_{max}$ are established (e.g., $III_{min}$=0.5, $R_{max}$ to be determined by agreement);
– selecting projects that satisfy $III_j \geq III_{min}$ and $R_j \leq R_{max}$;
– budget constraints are handled using a knapsack-type optimization, applying portfolio rules to diversify innovation types (technological, digital, organizational).

In the final stage, pilot implementation, before-and-after data collection, and model validation are conducted:

– a pilot is implemented on a limited site (line or unit);
– KPI data are collected before and after implementation (ideally over a period of 3–6 months);
– actual changes are compared with the projected III values, and the correlation between III and the observed effect (e.g., ΔOEE) is calculated.

The Pearson correlation formula is used for the calculations:

$$r = \frac{\Sigma_j \left( III_j - \overline{III} \right) \left( \Delta KPI_j - \overline{\Delta KPI} \right)}{\sqrt{\Sigma \cdot \left( III_j - \overline{\overline{III}} \right)^2 \Sigma \left( \Delta KPI_j - \overline{\Delta KPI} \right)^2}}$$

Statistical significance (p-value) and sample size are considered; r ≥ 0.7 indicates strong predictive capability.

The proposed methodology demonstrates high practical applicability due to its combination of formalized multi-criteria analysis and a risk-oriented approach. Unlike existing models, where innovation evaluation is typically limited to either economic indicators or expert judgment, this methodology integrates the Integrated Innovation Impact Index (III) with risk assessment, creating a unified decision-making procedure. This significantly reduces the likelihood of erroneous project selection and enables more accurate forecasting of their impact on production efficiency.

A key distinguishing feature of the methodology is the requirement for mandatory pilot verification, which allows comparison of projected effects with actual changes in KPIs (e.g., OEE, downtime, defect rate, energy consumption). This approach not only enhances the scientific validity of the assessment but also enables adjustment of weights, criteria, and thresholds, making the methodology adaptive to the specific characteristics of an enterprise. Verification supported by statistical methods (e.g., correlation analysis) confirms the predictive accuracy of the model and prevents decisions based solely on assumptions.

The methodology is highly reproducible due to its step-by-step structure, the use of standardized calculations (min–max normalization, AHP/Delphi, integrated index, risk matrices), and consistent documentation templates. This facilitates its application in enterprises with limited analytical infrastructure and reduces the requirements for expert-level competencies. The hybrid nature of the methodology—combining quantitative methods, expert procedures, and option-based analysis—ensures flexibility and resilience under high uncertainty, which is characteristic of innovation activities.

Furthermore, the focus on operational KPIs, rather than solely on financial indicators, is a critical advantage, as it allows identification of real internal efficiency reserves related to labor time losses, process instability, and energy intensity. The scalability of the methodology enables its adaptation to enterprises of various sizes and industry sectors, while periodic review of weights and criteria maintains its relevance amid changing technological and market conditions.

## CONCLUSIONS

The conducted study demonstrated that innovation is a key factor in improving production efficiency; however, its effectiveness largely depends on the quality of preliminary selection and evaluation. The developed methodology formalizes this process by integrating the diagnosis of production constraints, multi-criteria innovation assessment, and a risk-oriented approach, ensuring a well-founded selection of solutions with the greatest potential impact on production performance.

An important outcome of the study was the confirmation of the practical applicability of the Integrated Innovation Impact Index (III) for forecasting innovation effectiveness. Comparison of projected and actual results from pilot implementations revealed a high degree of correspondence, confirming the reliability of the proposed methodology and its ability to deliver measurable improvements—such as increased OEE, reduced downtime, lower defect rates, and decreased energy consumption.

Thus, the developed methodology is characterized by reproducibility, adaptability, and a focus on operational KPIs, making it applicable across enterprises in various industries. It can serve as an effective tool for building an innovation portfolio and supporting managerial decision-making under conditions of resource constraints and technological uncertainty. Future research may focus on expanding the set of evaluation criteria, implementing digital tools to automate calculations, and testing the methodology across different industrial sectors to refine its industry-specific applicability.

## REFERENCES

1. Tidd, J., & Bessant, J. (2021). Managing Innovation: Integrating Technological, Market and Organizational Change (7th ed.). Hoboken: Wiley.
2. Chesbrough, H. (2003). Open Innovation: The New Imperative for Creating and Profiting from Technology. Boston: Harvard Business School Press.

3. Pennings, E. (2000). Technological innovation and real options. Research Policy, 29(3), 389–408.
4. Ponomaryov, A. N. (2019). Innovative Management [Textbook]. Moscow: INFRA-M.
5. Illarionova, S. V. (2018). Management of innovation activities in industrial enterprises. Economics and Management, 4, 35–42.
6. Alieva, E. (2024). Assessment of enterprise innovation activity. Economic Development and Analysis, 2(7), 240–247.
7. Alieva, E. (2025). Assessment of innovation activity risk. Yashil Iqtisodiyot va Taraqqiyot, 3(4).
8. Alieva, E. (2024). An assessment of innovation activity in enterprises using the matrix method. Scientific and Technical Journal of Namangan Institute of Engineering and Technology, 9(3), 327–334. https://doi.org/10.61151/stjniet.v9i3.465