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Strategies for cost optimization in international projects through integrated tools for control and assessment of investment attractiveness

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Abstract: The purpose of the article is to conceptualize and substantiate the framework of «Investment-Operational Optimization» as an integrated value management model in international projects. **Methods:** The study conducts a critical analysis of strategic approaches to cost optimization, which are classified by the level of managerial influence. In particular, the engineering methods of «Target Costing» and «Value Engineering», as well as the analytical toolkit of «Activity-Based Costing», are examined. Special attention is paid to organizational models, «Lean Construction» and «Integrated Project Delivery», and to strategic approaches, «Real Options Analysis». In addition, integration and digital mechanisms are considered, including «Supply Chain Integration», «5D BIM», and technologies of «Blockchain and Smart Contracts». The study also systematizes methods for assessing investment attractiveness and determines the nature of the impact of digital technologies on the dynamics of asset investment value formation. **Results:** The main result of the study is the development of an architectural model of the «Investment Operational Optimization» framework, which covers the entire project life cycle and integrates tools for each stage. It is determined that at the initiation stage the model uses the real options method to test hypotheses, while at the design stage «5D BIM» is applied, enabling control of life cycle cost. For the procurement stage, the use of «Smart Contracts» is proposed to manage price variability, and at the construction stage the integration of «IoT» and «AI» is envisaged for the dynamic calculation of the «IRR» indicator. In addition, the model accelerates the achievement of commercial results through the digital transfer of the facility to management, ensures income stability through predictive maintenance, and forms a knowledge base for improving future projects. **Conclusion:** It is substantiated that the proposed «Investment-Operational Optimization» framework effectively addresses the problem of the gap between strategic investment planning and their operational implementation, which is achieved through the introduction of an end-to-end management mechanism that ensures a direct correlation between engineering decisions aimed at reducing costs and the dynamics of investment indicators.

Keywords: strategic approaches, assessment of investment attractiveness, international projects, investment-operational optimization, digital technologies, assessment methods, assessment tools, project life cycle.

Стратегії оптимізації витрат у міжнародних проєктах через інтегровані інструменти контролю та оцінювання інвестиційної привабливості

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Анотація: Метою статті є концептуалізація та обґрунтування фреймворку «Інвестиційно-операційної оптимізації» в якості інтегрованої моделі управління вартістю в міжнародних проєктах. **Методи:** У роботі проведено критичний аналіз стратегічних підходів до оптимізації витрат, які класифіковано за рівнем управлінського впливу. Зокрема, досліджено інженерні методи «Target Costing» та «Value Engineering», а також аналітичний інструментарій «Activity-Based Costing». Окрему увагу приділено організаційним моделям, «Lean Construction» та «Integrated Project Delivery», і стратегічним підходам, «Real Options Analysis». Додатково розглянуто інтеграційні та цифрові механізми, що включають «Supply Chain Integration», «5D BIM» та технології «Blockchain та Smart Contracts». Також у роботі виконана систематизація методів оцінювання інвестиційної привабливості та визначено характер впливу цифрових технологій на динаміку формування інвестиційної вартості активу. **Результати:** Основним результатом дослідження стала розробка архітектурної моделі фреймворку «Інвестиційно-операційної оптимізації», яка охоплює повний життєвий цикл проєкту та інтегрує інструменти для кожного етапу. Визначено, що на етапі ініціації модель використовує метод реальних опціонів для перевірки гіпотез, тоді як на стадії проєктування застосовується «5D BIM», що дозволяє контролювати вартість життєвого циклу. Для етапу закупівель запропоновано використання «Smart

Contracts» задля управління ціновою варіативністю, а на стадії будівництва передбачено інтеграцію «IoT» та «AI» для динамічного розрахунку показника «IRR». Крім того, модель прискорює отримання комерційного результату завдяки цифровій передачі об'єкта в управління, забезпечує стабільність доходу через предиктивне обслуговування та формує базу знань для покращення майбутніх проєктів. **Висновок:** Обґрунтовано, що запропонований фреймворк ефективно вирішує проблему розриву між стратегічним плануванням інвестицій та їх операційним виконанням, що досягається шляхом впровадження наскрізного механізму управління, який забезпечує безпосередню кореляцію інженерних рішень щодо зниження собівартості з динамікою інвестиційних показників.

Ключові слова: стратегічні підходи, оцінка інвестиційної привабливаємості, міжнародні проєкти, інвестиційно-операційна оптимізація, цифрові технології, методи оцінювання, інструменти оцінювання.

Problem statement. The problem addressed in the study lies in the deepening methodological gap between engineering and technical cost management and the financial and investment assessment of the effectiveness of international projects. In contemporary practice, cost management strategies evolve unevenly, as engineering approaches focus on reducing production costs at the design and execution stages, while financial instruments are oriented toward assessing investment attractiveness through indicators such as «ROI» and «NPV», which are usually calculated at the initial stage. This asynchrony leads to situations in which operational achievements do not translate into an increase in the investment value of the asset. Existing methodologies, including «Target Costing», «Activity-Based Costing», «Lean Construction», and «Integrated Project Delivery», address specific efficiency improvement tasks; however, they do not ensure a continuous linkage between technical cost savings, risk management, and investment decisions within the dynamic environment of international projects, which is particularly critical under conditions of currency volatility, supply chain disruptions, regulatory changes, and increasing investor requirements for transparency and predictability of cash flows. Additional complexity arises from the limited integration of digital control tools, «BIM modeling», «Blockchain technologies», and risk analytics based on real options, which are applied in parallel but are not unified within a common decision-making logic. As a result, managerial responses are delayed, and the potential of digital technologies is only partially utilized. Therefore, the key scientific problem consists in the absence of a holistic management model capable of integrating engineering methods of cost optimization, financial and investment indicators, and digital analytical tools into an adaptive management system. Addressing this problem is a necessary condition for enhancing the investment attractiveness and resilience of international projects in an environment of high uncertainty.

Analysis of recent research and publications. An analysis of research in the field of cost management and investment analysis indicates that the evolution of approaches has progressed from controlling individual cost parameters to combining financial, engineering, and organizational solutions within a unified managerial framework. The initial methodological foundation is formed by «Target Costing» and «Value Engineering». Ibusuki U. and Kaminski P. C. [1] demonstrated that cost is largely determined at the design stage, and that market price should define the permissible engineering solutions. At the same time, Okpan Agara O. [2] notes that in construction projects in developing countries, the effectiveness of target costing depends not only on design, but also on contractual conditions and managerial capability, which shifts the focus from the product to the implementation process. Further development of cost detailing is associated with «Activity-Based Costing». Majid J. A. and Sulaiman M. [3] substantiated the advantages of accurate overhead cost allocation compared to aggregated methods, while «Time-Driven ABC» in the works of Ayinla K., Cheung F., and Towe B. [4] complements this approach with a time dimension, allowing the modeling of the impact of delays and process duration on financial outcomes. A different development logic is demonstrated by «Lean

Construction» and «BIM». Sacks R. [5] identified that digital visualization enhances coordination and reduces waste, whereas Aghazadeh E. [6] extends this approach through digital twins and artificial intelligence, where time and cost optimization is carried out based on streaming data with minimal human involvement. The organizational component of cost management is revealed through «Integrated Project Delivery». El Sawalhi N. I. and El Agha O. [7] substantiate «IPD» as an effective mechanism for aligning interests in complex projects, while Lotfi M. and Karakouzian M. [8] link this model to supply chain integration and sustainable development goals, thereby expanding its managerial significance. Financial assessment of uncertainty is developed within the framework of «Real Options Analysis». Garvin M. J. [9] identified the limitations of traditional «NPV», while Krystallis I. et al. [10] prove the necessity of embedding flexibility directly into the technical characteristics of assets. In parallel, the digitalization of cost estimation processes through «5D BIM» has evolved from an analytical tool into an operational mechanism for cost management, as confirmed by the works of Lu Q., Won J., and Cheng J. C. P. [11] and Pishdad Bozorgi P. and Onungwa I. O. [12]. Ensuring supply chain transparency is examined within blockchain-based approaches in the work of Wang Z. [13], which demonstrates the technology's potential to enhance trust among participants, while Sun W. and Antwi Afari M. F. [14] emphasize the decisive role of managerial conditions in its implementation. In the same direction, Flynn B. B., Huo B., and Zhao X. [15], as well as Le P. L., Nguyen M. Q., and Pham H. T. [16], determine that supply chain integration produces an effect only when combined with digital tools and environmentally oriented solutions.

Therefore, it can be argued that the approaches considered are complementary; however, they require systematic integration into a unified model in order to ensure a synergistic effect in international projects.

Highlighting previously unresolved parts of the general problem. The analyzed scholarly studies have formed a comprehensive understanding of the overall optimization toolkit; however, each of them addresses only partial tasks and does not

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eliminate the core problem of the gap between operational cost control and strategic investment evaluation. «Target Costing» and «Lean» effectively reduce costs, but they lack an embedded mechanism for real-time correlation with «NPV» indicators in a dynamic context, while «ABC» does not provide a forecasting function. Digital technologies such as «5D BIM» and «Blockchain» improve data accuracy, but in themselves they do not generate managerial imperatives for adjusting investment strategy, whereas «Real Options» remains a theoretical superstructure without linkage to day-to-day operations. This gap is intended to be filled by the author's concept of the «Investment Operational Optimization» framework, which ensures a transition from a set of fragmented methods to an integrated life-cycle management system. The proposed approach makes it possible to integrate strategic planning, operational control, and digital infrastructure for the continuous generation of value and investment attractiveness.

Formulation of the article objectives (task statement). The purpose of the article is to conceptualize and substantiate the «Investment Operational Optimization» framework as an integrated value management model in international projects. To achieve this purpose, the following objectives are defined: 1. To conduct a critical analysis of strategic approaches to cost optimization and determine the limits of their functional applicability; 2. To systematize methods for assessing investment attractiveness and identify the specifics of their application in an international environment; 3. To determine the role of digital technologies (BIM, AI, Blockchain) as catalysts for the integration of operational and financial processes; 3. To develop an architectural model of the «Investment Operational Optimization» framework that integrates the stages of initiation, design, procurement, and construction into a unified management loop; 4. To demonstrate how the «Investment Operational Optimization» model eliminates the gap between the investment concept and operational execution, ensuring project resilience to risks.

Presentation of the main research material. The evolution of cost management in international projects has followed a complex transformation path, moving from the simple recording of incurred expenditures to multi level value engineering that permeates all aspects of organizational activity. In the contemporary understanding, cost optimization is no longer a linear arithmetic procedure of reducing budget line items, but rather a multidimensional space of strategic decisions in which each action has implications for risk, quality, time, and the long term value of the asset. To understand the architecture of these decisions and to build an effective management system, it is necessary to turn to a classification of strategic approaches that makes it possible to structure the available toolkit according to the mechanisms of influence on value formation and the depth of managerial intervention.

Based on a detailed analysis of scientific sources and a synthesis of best practices, an analysis of existing strategic approaches to cost optimization in international projects will be conducted (see Fig. 1).

On the basis of the data presented in Fig. 1, it is determined that approaches to cost management and optimization in international projects are considered as multi level, but not interchangeable, instruments that differ in their logic of influence, time horizon, and depth of intervention in the cost formation process. Strategies focused on the early stages of the life cycle, namely «Target Costing» and «Value Engineering» [1, 2], demonstrate the greatest potential for structural impact, as they shape cost logic prior to the start of implementation and allow cost constraints to be embedded through design decisions. In contrast, «Activity Based Costing» [3, 4] operates at the stage of organizational functioning and focuses not on altering cost architecture, but on the analytical decomposition of costs by activities, which makes it effective for identifying internal reserves, yet less effective for radical optimization, for example in multi tier international holdings or service companies. «Lean Construction» [5] and «Integrated Project Delivery» [8] differ from calculation based approaches in that they influence costs indirectly through changes in organizational logic and the behavior of project participants. «Lean Construction» focuses on the elimination of waste in processes and the enhancement of operational stability, whereas «Integrated Project Delivery» transforms contractual incentives and risk sharing mechanisms, which makes it particularly relevant for international projects with complex stakeholder coordination, such as infrastructure or multinational construction projects.

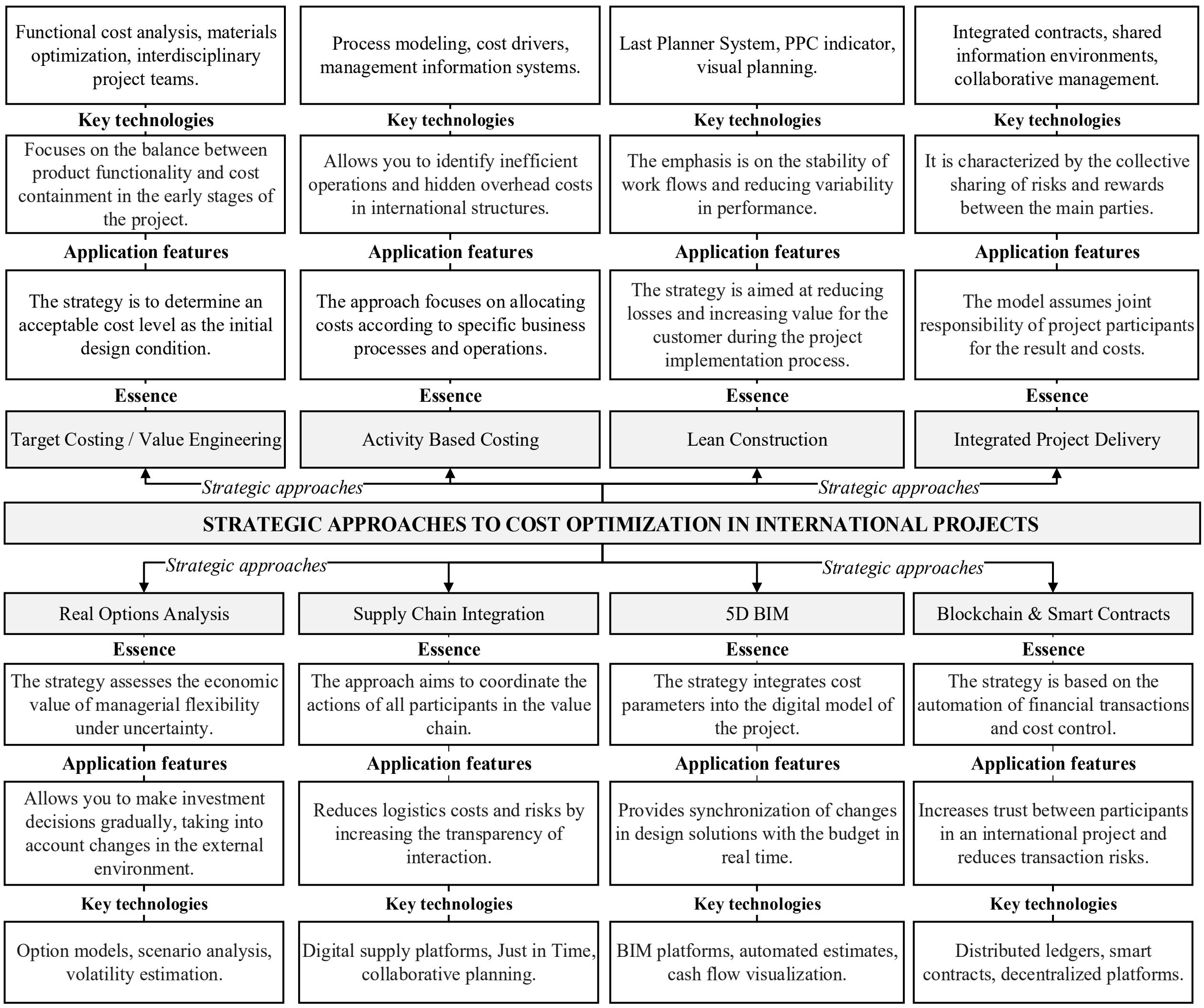

Fig. 1. Strategic approaches to cost optimization in international projects

Source: formed by the author based on [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16]

In contrast, «Real Options Analysis» [9, 10] does not reduce costs directly, but changes the way they are interpreted, as it enables the valuation of managerial flexibility and the avoidance of inefficient investments under conditions of high uncertainty, which are characteristic of the international investment environment, for example staged investment or deferred market entry. «Supply Chain Integration» [15, 16] and digital approaches represented by «5D BIM» [11, 12] and «Blockchain with Smart Contracts» [13, 14] demonstrate a shift from local optimization to systemic cost management, as they encompass interorganizational interactions and reduce transaction and coordination costs. In this context, «Supply Chain Integration» is based on the synchronization of flows and collaborative planning, which reduces logistical inefficiencies, while «5D BIM» ensures transparency and timeliness of cost estimation decisions based on a single digital model, and blockchain technologies add institutional reliability and automation of financial settlements, which is critically important in multi party international projects, for example payment management or contract execution control. A comparison of these approaches indicates that their differences lie not only in the tools employed, but primarily in the management level at which the optimization effect is generated, as some strategies operate through design and planning, others through processes and contracts [7], and still others through digital infrastructure and interaction rules. Therefore, in this context, none of the considered approaches can be regarded as universal, and the investment efficiency of international projects is achieved through a deliberate selection and combination of strategic approaches to cost management and optimization, taking into account the project stage, the level of uncertainty, and the complexity of the international environment, for example a combination of «Target Costing», «5D BIM», and «Supply Chain Integration».

The next step is to examine the methods and tools for assessing the investment attractiveness of international projects (see Table 1).

Table 1

Methods and tools for assessing the investment attractiveness of international projects

Group of methods	Method	Scope of application	Formula
Traditional financial (Deterministic)	Net Present Value (NPV)	The main indicator for making investment decisions. Reflects the absolute value created by the project.	$NPV = \sum_{t=1}^{T} \frac{CF_t}{(1+r)^t} - I_0$
	Internal Rate of Return (IRR)	Shows the marginal cost of capital of the project. Used to compare alternatives.	$\sum_{t=1}^{T} \frac{CF_t}{(1+r)^t} - I_0 = 0$

	Payback Period (PP)	Estimates the rate of return on investment. Focused on liquidity.	$PP = min\left\{t \mid \sum_{t=1}^{T} CF_i \geq I_0\right\}$
Probabilistic and risky (Stochastic)	Monte Carlo Simulation	Analyzes uncertainty through a set of scenarios. Forms a distribution of NPV or IRR.	$NPV^{(k)} = \sum_{t=1}^{T} \frac{CF_t^{(k)}}{(1+r)^t} - I_0$
	Value at Risk (VaR)	Determines the maximum expected loss with a given confidence.	$VaR_\alpha = Z_\alpha * \sigma * \sqrt{t}$
	Fuzzy Logic Assessment	Quantifies qualitative risks. Used with high uncertainty.	$y^* = \frac{\int y * \mu(y)\, dy}{\int \mu(y)\, dy}$
Strategic and flexible (Strategic)	Real Options Analysis (ROA)	Estimates the cost of management flexibility. Relevant for long-term projects.	$C = S_0 N(d_1) - Ke^{-rt} N(d_2)$ $d_1 = \frac{In\left(\frac{S_0}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)t}{\sigma\sqrt{t}}$ $d_2 = d_1 - \sigma\sqrt{t}$
	Scoring Models (Payne, Berkus)	Rapid assessment at early stages. Based on expert scores.	$Score = \sum_{i=1}^{n} w_i * s_i$
Social and Sustainability	Social Return on Investment (SROI)	Estimates the social effect in monetary terms.	$SROI = \frac{PV_{Impact}}{PV_{Inputs}}$
	Life Cycle Costing (LCC)	Takes into account the full life cycle cost of the asset.	$LCC = C_{acq} + C_{op} + C_{mnt} + C_{disp}$
	ESG Rating Integration	Adjusts the cost of capital taking into account ESG.	$W\,ACC_{adj} = W\,ACC_{base} - \Delta\,ESG$

Source: formed by the author based on [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16]

The analysis of Table 1, makes it possible to consider each group of methods and each individual tool as a separate analytical unit, the selection of which is determined by the objectives of the assessment, the level of uncertainty, and data availability, while the key criteria are the ability to reflect economic effects, properly account for risks, and ensure cross country comparability. Within traditional financial methods, the primary benchmark is the financial efficiency of a project, which is assessed through projected cash flows and a discount rate formed with consideration of the cost of capital and country risk. «NPV» is used as the basic indicator, as it directly reflects value creation or value loss, although its results depend significantly on the choice of the discount rate and the currency structure of cash flows. «IRR» is applied to compare project returns with the alternative cost of capital, however in an international context its interpretation is complicated by non conventional cash flow patterns and the possibility of multiple solutions. «PP», in turn, focuses on the speed of investment recovery and is mainly used to assess liquidity and short term risks, which limits its analytical depth. Probabilistic and risk based methods are united by their focus on assessing not only the expected outcome but also the variability of possible results, which is achieved through the use of statistical and simulation procedures. «Monte Carlo Simulation» enables the analysis of result robustness to changes in key parameters by generating distributions of «NPV» or «IRR», while «VaR» focuses on identifying potential losses at a given confidence level and is sensitive to assumptions regarding volatility. «FLA» complements these approaches by enabling the quantitative formalization of qualitative and subjective risks through defuzzification procedures. Strategic and flexible methods concentrate on the assessment of managerial adaptability, as they take into account the value of future decisions rather than only current efficiency. «Real Options Analysis» [9, 10] makes it possible to evaluate the benefits of changing the scale or timing of project implementation under uncertainty, while scoring models are applied at early stages to compare projects using qualitative criteria in the absence of complete financial data. Social and sustainability oriented methods extend the boundaries of analysis by incorporating non financial effects, where «SROI» evaluates the relationship between social outcomes and invested resources, «LCC» focuses on total life cycle cost, and the integration of «ESG ratings» [16] affects adjustments to the cost of capital. In summary, the developed generalized classification of methods for assessing the investment attractiveness of international projects enables a reasoned selection of tools depending on project content, risk level, and information constraints.

The next step is to examine the impact of digital technologies on cost optimization and investment evaluation (see Fig. 2).

Figure 2. shows that digital technologies affect cost optimization and investment assessment in different ways, while the difference between them is determined not so

much by the scale of the effect as by the mechanism of its formation. «Building Information Modeling» [11, 12] forms a basis for the financial certainty of a project, since accurate digital modeling reduces the amount of rework and the volume of reserves for uncertainty, which directly improves investment assessment, while at the same time the reduction of operating costs is achieved through automated cost estimation and early clash detection. Unlike «BIM», «Artificial Intelligence» and «Machine Learning» [6] do not focus on geometric or design accuracy, but influence costs through improving the quality of forecasting, as a result of which the project risk profile is reduced and the reliability of «ROI» assessment is increased, which is especially important for investment decisions under conditions of an unstable market. If «AI» and «Machine Learning» work with the forecasting component, then the «Internet of Things» ensures a connection between planned and actual indicators, since real time monitoring of resources, equipment, and personnel reduces operating losses associated with downtime and misuse, and also affects capital expenditures through the control of fuel and logistics. In this context, «Blockchain» [13, 14] generates a fundamentally different type of impact, as it does not optimize physical processes but reduces transaction costs and increases trust among project participants through the immutability of financial data and automation of settlements, which directly affects investment attractiveness and simplifies financial auditing. Compared to these technologies, «Drones and Photogrammetry» have a more applied character, since their economic effect is created by improving the accuracy of monitoring physical volumes of work, which reduces the risk of cost overruns and disputes, while simultaneously lowering operational costs for surveying and inspections. Furthermore, «Cloud Collaboration» environments extend this effect in the realm of information management, as a unified data environment reduces time and errors associated with using outdated documentation, positively influencing both operational costs and the quality of investment analytics. Unlike control and coordination tools, «AR» and «VR» affect costs by increasing the efficiency of performing complex tasks, as project visualization and personnel training reduce errors and accelerate work acceptance, impacting both capital and operational expenditures.

Fig. 2. Impact of digital technologies on cost optimization and investment evaluation

Source: formed by the author based on [6, 11, 12, 13, 14]

Completing this spectrum are «Robotics and Automation», which generate the most long term effect, as increased labor productivity and reduced dependence on human factors allow for stabilization of project schedules and shortening of construction timelines, directly enhancing investment attractiveness.

Based on Figure 1-2 and Table 1, a framework for «Investment and Operational Optimization» will be developed for the integrated application of technological methods in the execution stages of international projects (see Fig. 3).

The «Investment and Operational Optimization» framework is developed as an applied management algorithm for capital intensive projects, in which the key challenge is the gap between investment decisions made at early stages and subsequent operational management. Its effectiveness is based on the sequential transformation of investment logic into controllable operational actions with continuous feedback on capital return indicators, which allows the project to remain within economically justified limits throughout its life cycle. The application of the framework begins with the formation of a unified management model, within which the project is considered as an investment asset with a variable risk and return profile, ensuring alignment of decisions among investors, the project team, and operational management. At the initiation stage, the project's investment hypothesis is formulated and its resilience to uncertainty is tested using «Target Costing» [1, 2] and the «Real Options approach» [9, 10], which make it possible to establish permissible cost limits and assess the value of managerial flexibility. Investment decisions are made based on a scenario range using «Strategic NPV» calculations, which reduces the likelihood of entering projects with a formally viable but unstable economy. At the design stage, the investment hypothesis is transformed into architectural and engineering solutions that determine the asset's economics. The use of «Value Engineering» [1] and «Lean Design» [5] in combination with «5D BIM» [11, 12] and «Generative Design» ensures a direct link between design changes and life cycle cost indicators, including the «LCC Index» and the «CapEx» to «OpEx» ratio. Design serves as a financial calibration of future operations, as each decision is assessed for its long term economic effect. Once design parameters are fixed, management extends to the supply chain, where procurement is integrated into the investment and operational model. The application of «e-Sourcing» «Blockchain / Smart Contracts» allows management of price variability and payment speed, which directly affects «Price Variance» and «Working Capital Turnover», reducing the project's sensitivity to market volatility. At the construction stage, management enters a dynamic mode, as actual execution directly impacts investment indicators.

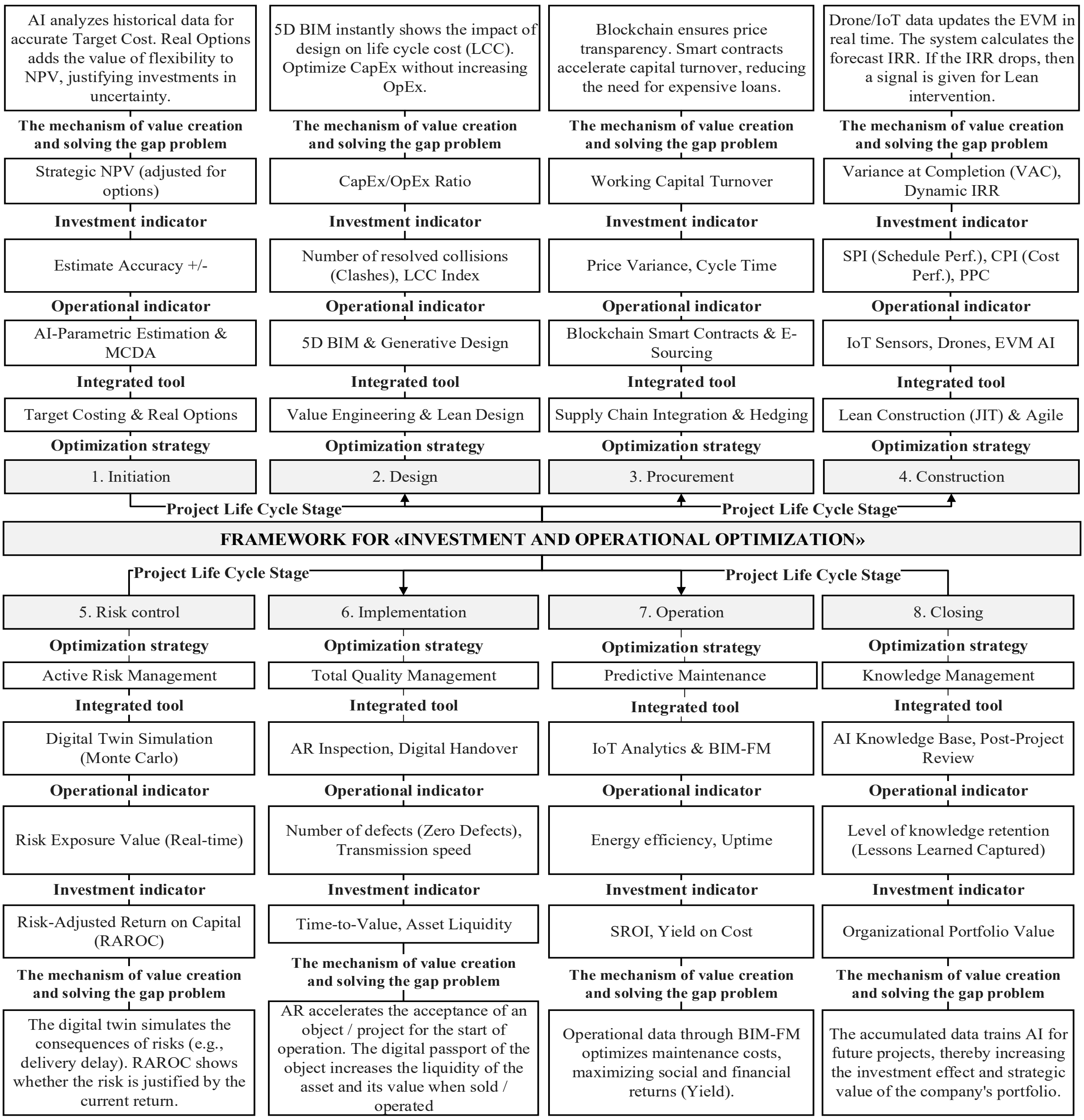

Fig. 3. Framework for «Investment and Operational Optimization»

Source: formed by the author himself

Data from «IoT sensors», drones, and «EVM systems» with «AI analytics» are used to calculate «SPI» and «CPI», followed by recalculation of «VAC» and «Dynamic

IRR», allowing operational deviations to be linked to capital return and enabling timely «Lean» interventions. Risk management is embedded in the overall model through «Digital Twin» and «Monte Carlo Simulation», which provide a quantitative assessment of the impact of events on «Risk Exposure Value» and «Risk Adjusted Return on Capital», supporting the validity of management decisions under changing conditions. After construction is completed, the management focus shifts to the speed of value creation, as commissioning marks the transition to actual result generation. The use of «TQM», «AR Inspection», and «Digital Handover» reduces «Time to Value» and increases asset liquidity. At the operational stage, the quality of prior decisions is confirmed through energy efficiency, reliability, and overall return metrics. «Predictive Maintenance», «IoT Analytics», and «BIM FM» allow management of «Uptime», «Yield on Cost», and «SROI», ensuring stable asset profitability. Project closure signifies the transition from managing an individual asset to managing a portfolio, as accumulated data and results are used for the «AI Knowledge Base» and «Post Project Review», improving the accuracy and economic efficiency of future projects. The practical value of «Investment and Operational Optimization» lies in its ability to systematically transform projects into manageable investment instruments, provided that financial and operational data are integrated and leading indicators are applied in a disciplined manner.

Conclusions. The study confirms that modern cost optimization strategies and digital technologies on their own do not create an integrated performance management system when they remain fragmented across the functions of planning, control, and execution. The analysis demonstrates that international projects face a persistent challenge caused by the absence of an end to end mechanism capable of linking engineering decisions aimed at cost reduction with the dynamics of investment performance indicators. In response, an «Investment and Operational Optimization» framework was developed, which eliminates this gap by establishing a logically integrated model in which each stage of the project life cycle, from «Target Costing» at the Initiation stage to «IoT based monitoring» at the Operation stage, contributes to value maximization. As a result, the framework is expected to ensure a transition from passive accounting to active profitability design and to form a conceptual foundation that enables international companies to build resilient and adaptive project management systems capable of operating effectively under conditions of global uncertainty.

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