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A Methodological Approach to Assessing the Effectiveness of Investment Risk Management in Construction Materials Enterprises

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Abstract: The purpose of this study is to develop an improved method for assessing the effectiveness of investment risk management in construction materials enterprises. The proposed methodology integrates risk identification, normalization of risk indicators, calculation of the Integral Risk Index (IRI), and econometric assessment of the relationship between investment risk and financial performance. Based on this approach, the Risk Management Effectiveness (RME) coefficient is introduced as a new indicator reflecting the relationship between enterprise profitability and the level of investment risk. In addition, interpretation scales for both the IRI and RME coefficients are developed to facilitate practical risk classification and managerial decision-making. The proposed method allows investment risk to be evaluated not only in quantitative terms but also from the perspective of management effectiveness. Unlike conventional assessment approaches, it considers the functional relationship between investment risk and enterprise performance, making it possible to compare enterprises according to their risk-adjusted performance and to identify the effectiveness of existing risk management mechanisms.

Keywords: investment risk, risk management, construction materials enterprises, Integral Risk Index, Risk Management Effectiveness, econometric modeling, investment project, enterprise performance.

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1. Introduction

The construction materials industry is widely recognized as one of the key pillars of national economic development, playing a fundamental role in infrastructure expansion, housing construction, and the modernization of industrial sectors. The sustainable development of this industry largely depends on the effective implementation of investment projects and the scientifically grounded management of the risks associated with them. Empirical evidence indicates that investment projects in construction materials enterprises are characterized by high capital intensity, long payback periods, and significant dependence on technological capabilities and raw material supplies [1], [2]. These characteristics substantially increase the level of investment risk, making effective risk management an essential prerequisite for improving project performance and ensuring the long-term competitiveness of enterprises.

Under the current conditions of uncertainty, the approaches used to assess and manage investment risks are primarily limited to risk identification and classification, without providing a comprehensive assessment of the effectiveness of risk management [3], [4]. In particular, risk indicators are often analyzed separately in practice, while their

quantitative impact on the financial performance of investment projects is not sufficiently evaluated. As a result, it becomes difficult for enterprises to adequately incorporate the actual effects of risk factors into the investment decision-making process.

Furthermore, the construction materials industry is increasingly exposed to technological disruptions, uncertainties in energy supply, fluctuations in raw material prices, and the insufficient development of institutional and managerial mechanisms, all of which contribute to the growing complexity of investment risks. However, the existing assessment methods are not capable of comprehensively capturing such a multifaceted risk environment.

From this perspective, developing an improved method for assessing investment risks in construction materials enterprises not only in terms of their magnitude but also from the standpoint of risk management effectiveness is of considerable scientific and practical importance [5]. Such an approach makes it possible to examine investment risks not as static phenomena but as dynamic components closely linked to the economic outcomes of the investment process. In particular, establishing the relationship between the level of investment risk and financial performance indicators through econometric models contributes to more scientifically grounded investment decision-making.

Therefore, improving the method for assessing the effectiveness of investment risk management represents a relevant scientific and methodological approach to enhancing the efficiency of investment resource utilization, mitigating the impact of investment risks, and ensuring the long-term sustainable development of construction materials enterprises [6], [7].

Based on the above considerations and the findings of this study, this paper proposes an integrated econometric approach that not only assesses investment risk but also measures the effectiveness of risk management through an original assessment method.

2. Materials and Methods

This study proposes an integrated methodology for assessing the effectiveness of investment risk management in construction materials enterprises. The methodological framework consists of three consecutive stages: (i) classification of investment risks, (ii) calculation of the Integral Risk Index (IRI), and (iii) econometric assessment of the relationship between investment risk and enterprise performance.

3. Result

The conceptual framework of the proposed assessment method consists of the following three stages:

- a. Identification of investment risk components.
- b. Calculation of the Integral Risk Index (IRI).
- c. Econometric assessment of the impact of investment risk on project performance.

This approach enables investment risk to be assessed not as a static phenomenon but as a dynamic process closely linked to economic performance.

Stage 1. Classification of Investment Risks.

At the first stage, investment risks specific to construction materials enterprises are classified into the following five categories:

- a. Financial risks (R_1);
- b. Technological risks (R_2);
- c. Raw material and energy risks (R_3);
- d. Market risks (R_4);
- e. Institutional and managerial risks (R_5).

Each risk category is assessed using standardized indicators:

$$R_j = \frac{X_i - X_{\min}}{X_{\max} - X_{\min}} \quad (1)$$

where X is the original (non-standardized) value of a specific, measurable indicator representing investment risk.

The standardized indicators (X) are proposed to be structured for each risk category as presented in Table 1.

Table 1. Risk Categories and Their Constituent Indicators

No	Risk Categories	Constituent Indicators
1	Financial risks	- Debt-to-equity ratio
		- Debt-to-assets ratio
		- Interest coverage ratio
		- Current ratio
		- Debt service coverage ratio (DSCR)
		- Cash conversion cycle (CCC)
		- Capacity utilization rate
2	Technological risks	- Defect rate
		- Degree of depreciation of production equipment
		- Production downtime duration
		- Energy intensity per unit of output
		- Maintenance schedule compliance rate
3	Raw material and energy risks	- Raw material price volatility (%)
		- Energy supply interruptions (hours/month)
		- Share of imported raw materials (%)
		- Delivery delay (days)
		- Inventory coverage (days/month)
		- Dependence on water and gas supply limits (number of interruptions)
4	Market risks	- Sales volume volatility (%)
		- Price variability (inflation impact)
		- Export share and foreign exchange risk exposure
		- Market share decline
		- Accounts receivable turnover (days)
5	Institutional and managerial risks	- Number of contract cancellations
		- Project schedule delay (days)
		- Cost overrun (%)
		- Number of tender or contract violations
		- Employee turnover rate (%)
		- Number of internal control deficiencies

The indicators included in each of the risk categories presented in Table 1 are normalized as follows:

$$z_{k,it} = \frac{x_{k,it} - \min(x_k)}{\max(x_k) - \min(x_k)} \quad (2)$$

where $z_{k,it}$ - is the normalized value of the indicator k , reflecting the relative level of investment risk, with 0 representing the lowest level of risk and 1 representing the highest level of risk,

$x_{k,it}$ - the actual value of indicator k for enterprise i in period t ,

x_k - the set of observations for the indicator k across all enterprises and time periods.

The risk indicator for each category (R_i) is obtained by aggregating the weighted normalized values of the corresponding indicators (k) into a single integrated risk measure.

$$R_{j,it} = \sum_{k=1}^{m_j} \omega_k \cdot z_{k,it} \quad (3)$$

where, ω_k - the weight assigned to indicator k ,

m_j - the total number of indicators included in risk category R_j .

The weights are typically determined through expert judgment, subject to the constraint that their sum equals 1.

$$\sum_{k=1}^{m_j} \omega_k = 1$$

Stage 2. Calculation of the Integral Risk Index (IRI).

$$IRI_i = \sum_{j=1}^5 \omega_j \cdot R_{ij} \quad (4)$$

where, R_{ij} - the integrated risk indicator for risk category j for enterprise i .

The interpretation of integrated indicators is an important methodological issue in the assessment of investment risks[8]. From this perspective, this study develops an interpretation scale for the proposed Integral Risk Index (IRI), enabling the qualitative classification of investment risk levels (Table 2).

Table 2. Interpretation Scale for the Integral Risk Index (IRI)

№	IRI Range	Risk Level (Criteria)
1	0,00 - 0,20	Low (Stable)
2	0,21 - 0,40	Acceptable
3	0,41 - 0,60	Moderate
4	0,61 - 0,80	High
5	0,81 - 1,00	Critical (Crisis)

The proposed methodological approach is based on the principle that, following the normalization of risk indicators, the values of the Integral Risk Index (IRI) are distributed over a continuous interval ranging from 0 to 1. To reflect the gradual changes in investment risk, this interval is divided into several qualitatively distinct threshold ranges. The threshold values were determined by considering the increasing impact of investment risk on economic performance, the progressive limitations of risk management capabilities, and the critical conditions that arise during investment decision-making.

Specifically, the lower threshold values of the scale represent a risk level at which investment risks do not exert a significant adverse impact on enterprise performance, indicating that they are effectively controlled through existing risk management mechanisms[9], [10]. The intermediate threshold values characterize a situation in which risk factors become more pronounced and require additional managerial interventions throughout the investment process. In contrast, the high and critical threshold values indicate that investment risks pose a serious threat to the stability of investment projects and signal the need to reassess the effectiveness of the existing risk management system.

Overall, the proposed scale enables the assessment of investment risks not only from a quantitative perspective but also in terms of the effectiveness of risk management[11], [12]. This approach strengthens the scientific basis for selecting risk-appropriate management strategies during the implementation of investment projects and contributes to the sustainable development of investment activities in construction materials enterprises.

Stage 3. Econometric Assessment of the Impact of Investment Risk on Project Performance[13].

It should be emphasized that the novelty of the proposed method lies in assessing investment risk as a determinant of financial performance through econometric modeling. As a baseline specification, the following econometric model is proposed:

$$ROA_{it} = \beta_0 + \beta_1 IRI_{it} + \beta_2 Inv_{it} + \dots + u_i + \varepsilon_{it} \quad (5)$$

where, ROA_{it} - return on assets of enterprise i in period t ,

u_i - the unobserved enterprise-specific effect (fixed or random effect component),

β_j - the unknown model parameters,

ε_{it} - the random error term.

The estimated coefficient β_1 represents the elasticity of the Integral Risk Index (IRI) and reflects both the direction and the magnitude of the impact of investment risk on the return on assets (ROA) of construction materials enterprises.

If $\beta_1 < 0$, an increase in the Integral Risk Index (IRI) leads to a decrease in the return on assets (ROA).

Assessing the effectiveness of risk management requires not only evaluating the level of investment risk but also considering the economic performance achieved by an enterprise under such risk conditions[14]. From this perspective, this study proposes the Risk Management Effectiveness (RME) coefficient for construction materials enterprises, which measures the effectiveness of investment risk management and is calculated using the following equation:

$$RME_i = \frac{ROA_i}{IRI_i} \quad (6)$$

The Risk Management Effectiveness (RME) coefficient reflects the relationship between an enterprise's financial performance, measured by Return on Assets (ROA), and the level of investment risk, represented by the Integral Risk Index (IRI). This ratio provides an assessment of the quality of financial performance achieved under risk conditions, as well as the practical effectiveness of risk mitigation and risk management mechanisms. Methodologically, a higher RME value indicates that the enterprise achieves greater economic performance relative to the level of investment risk it faces, reflecting more effective investment risk management[15].

Based on the proposed Risk Management Effectiveness (RME) coefficient, the following threshold criteria are established to evaluate the effectiveness of investment risk management (Table 3).

Table 3. Interpretation Scale for the Risk Management Effectiveness (RME) Coefficient

No	RME Range	Performance Level
1	> 1,5	Effective Risk Management
2	1,0 - 1,5	Satisfactory
3	< 1,0	Ineffective Risk Management

4. Discussion

The proposed methodology provides a more comprehensive perspective on investment risk management by combining multidimensional risk measurement with enterprise financial performance. Unlike conventional approaches that evaluate financial, technological, market, operational, and institutional risks separately, the Integral Risk Index (IRI) consolidates these dimensions into a single standardized measure. This integration is particularly relevant for construction materials enterprises because their investment activities are simultaneously influenced by capital intensity, equipment depreciation, fluctuations in raw material and energy prices, market instability, and

project management constraints. Consequently, the IRI enables managers to identify the overall risk position of an enterprise while retaining the possibility of tracing the contribution of each risk category to the aggregate risk level.

The normalization procedure also improves the comparability of risk indicators that are originally expressed in different units of measurement. Financial ratios, production downtime, delivery delays, cost overruns, and employee turnover cannot be directly aggregated without first transforming them into a common scale. By converting these indicators into values ranging from zero to one, the proposed method minimizes measurement inconsistencies and facilitates comparison across enterprises and periods. This approach is consistent with the principle that construction investment risks should be assessed systematically rather than through isolated indicators [4], [6]. Nevertheless, the reliability of the resulting index depends on the quality of the selected indicators, the completeness of enterprise data, and the appropriateness of the weights assigned to each component.

The interpretation scale developed for the IRI further strengthens the practical usefulness of the method. Enterprises classified within the low or acceptable ranges may maintain their current control mechanisms while continuing regular risk monitoring. In contrast, enterprises located in the moderate range require corrective managerial action, particularly in the risk categories that make the greatest contribution to the overall index. High and critical IRI values indicate that existing risk control mechanisms may no longer be sufficient to protect investment performance. Under these conditions, management should reconsider investment schedules, financing structures, supplier arrangements, technological modernization plans, and internal control procedures. Therefore, the IRI scale functions not only as a measurement instrument but also as an early-warning mechanism that supports risk-based investment decisions in accordance with the general principles of risk management established by ISO 31000 [9]–[11].

An important contribution of the proposed framework is the econometric assessment of the relationship between investment risk and return on assets. The expected negative coefficient of the IRI variable indicates that increasing investment risk is likely to reduce the efficiency with which enterprise assets generate profits. However, the strength of this relationship may differ among enterprises because of variations in managerial competence, production technology, financing policies, market position, and risk mitigation capacity. The use of panel-data models makes it possible to control for unobserved enterprise-specific characteristics and to distinguish the effect of investment risk from other factors affecting financial performance. In practical application, model selection should be supported by appropriate specification tests, while the robustness of the estimated relationship should be examined using alternative financial indicators, lagged risk variables, and additional control variables [13].

The Risk Management Effectiveness (RME) coefficient complements the IRI by showing how successfully an enterprise converts its asset base into financial returns under a given level of investment risk. Two enterprises may have similar IRI values but achieve substantially different profitability levels. In such a case, the enterprise with the higher RME value can be considered more capable of controlling, absorbing, or mitigating the economic consequences of investment risk. This feature makes the RME coefficient useful for benchmarking enterprises, evaluating managerial performance, and prioritizing investment resources. A high RME value suggests that the enterprise generates relatively strong returns despite its exposure to risk, whereas a value below one signals that the financial outcomes achieved are insufficient relative to the risk level encountered.

However, the RME coefficient should not be interpreted independently from the IRI and its components. A high RME value may arise from strong profitability, a low level of measured risk, or a combination of both conditions. Similarly, enterprises with negative or unusually low ROA values may produce RME results that require separate interpretation. The coefficient may also become unstable when the IRI approaches zero. For this reason, the RME should be assessed together with the absolute values of ROA, the overall IRI classification, and the contribution of individual risk categories. Such

combined interpretation prevents misleading conclusions and provides a more balanced assessment of risk-adjusted enterprise performance.

The threshold ranges proposed for the IRI and RME offer a practical initial framework, but they require empirical validation before being applied as universal standards. The boundaries may differ according to enterprise size, production specialization, regional conditions, market structure, and the stage of the investment project. Future empirical research should therefore test the proposed scales using longitudinal data from construction materials enterprises and evaluate their predictive ability in relation to profitability decline, cost overruns, project delays, liquidity difficulties, and investment failure. Sensitivity analysis may also be conducted to determine whether alternative weighting procedures, including expert assessment, entropy weighting, or factor-based methods, produce consistent classifications.

Overall, the integration of the IRI, econometric modeling, and the RME coefficient represents a significant methodological improvement over static risk classification. The framework connects the magnitude of investment risk with the economic outcomes achieved under that risk, thereby supporting a risk–return-based evaluation of managerial effectiveness. Its application can help construction materials enterprises identify vulnerable investment areas, compare performance across business units or periods, allocate mitigation resources more efficiently, and formulate investment decisions based on measurable risk-adjusted performance. Accordingly, the proposed method has the potential to strengthen enterprise resilience and contribute to the sustainable development of the construction materials industry.

5. Conclusion

Unlike conventional static approaches to risk assessment, the proposed RME scale takes into account the functional relationship between the level of investment risk and economic performance. This enables a comprehensive evaluation of investment risk management effectiveness, facilitates comparative analysis of enterprises based on the risk–return relationship, and provides scientifically grounded criteria for investment decision-making.

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