Research on the Strategic Performance Evaluation System for Mining Companies Based on the Integration of BSC and EVA: A Perspective Integrating Safety, Environmental Sustainability, and Economic Benefits

Qian Liu*

Hainan Vocational University of Science and Technology, Haikou, 570100, China
**Corresponding author: 18940023005@163.com*

Abstract: *In confronting multiple strategic objectives, the traditional financial performance evaluation model of mining companies, due to its short-term focus and lagging nature, proves inadequate in effectively translating long-cycle and complex strategies. This often results in a disconnection between long-term value drivers, such as safety and environmental sustainability, and short-term decision-making. To address this, this study constructs a strategic performance evaluation system that integrates the Balanced Scorecard and Economic Value Added. It elucidates the complementary logic of the two frameworks, where Economic Value Added serves as the core value metric, while the Balanced Scorecard delineates the strategic pathways. Furthermore, the research designs a multidimensional strategic map that incorporates safety, environmental, and economic performance dimensions, identifying key performance areas and their causal relationships. Finally, it proposes an integrated evaluation model that connects value drivers, quantifies non-financial contributions, and incorporates a dynamic adjustment mechanism. This model aims to provide mining companies with a systematic management tool for achieving strategic synergy and building a sustainable competitive advantage.*

Keywords: *Balanced Scorecard; Economic Value Added; strategic performance evaluation; mining companies; safety performance; green mining*

Introduction

Mining companies operate within a complex system comprising resources, the environment, and society. Their competitive advantage increasingly depends on the integrated capabilities of capital allocation, risk management, and ecological stewardship. Traditional financial-dominant performance evaluation systems, which focus on short-term financial outcomes, prove inadequate in effectively translating the long-cycle, multi-objective composite strategies of enterprises. Such systems not only fail to sufficiently incentivize strategic investments in areas such as safety and environmental sustainability, but may also encourage short-term decision-making, thereby undermining long-term value and the foundation for sustainability. Consequently, constructing an evaluation framework capable of integrating economic and non-economic objectives, while systematically incorporating the latter into the logic of value creation, carries significant theoretical and practical importance. The Balanced Scorecard and Economic Value Added, which respectively emphasize multidimensional strategic description and value-focused measurement, offer the potential for deep integration to address the aforementioned challenges. Through theoretical synthesis and contextualized design, this study aims to develop an integrated strategic performance evaluation system for mining companies that embeds safety and environmental dimensions and is centered on value creation. The objective is to guide corporate management in shifting from partial efficiency to systemic synergy, thereby providing theoretical support and a managerial basis for building sustainable competitive advantage.

1. Theoretical Reflection on the Traditional Performance Evaluation System of Mining Companies and the Necessity for Integration

1.1 Limitations of the Finance-Dominant Evaluation Model in Conveying Mining Corporate Strategy

The core deficiency of the finance-dominant evaluation model lies in its inherent short-term focus and lagging nature, which renders it inadequate for effectively conveying the long-cycle, multi-objective composite strategies essential to mining companies. This model excessively focuses on historical financial outcomes, such as net profit and return on investment, while failing to incorporate into the value assessment framework the critical capitalized expenditures that determine the long-term viability of mining enterprises—such as the depletion of resource endowments, ecological restoration costs, and investments in safety production. As a result, during strategy implementation, adverse selection may occur, whereby the pursuit of short-term financial indicators leads to the crowding out of safety investments and delays in the adoption of green technologies. This creates a disconnect between long-term strategic issues—such as resource extraction planning, community relations maintenance, and environmental risk management—and day-to-day operational decision-making. Moreover, the information feedback of this model concentrates on ex-post financial results, lacking measurement of strategic drivers and leading non-financial performance indicators. Consequently, it cannot provide forward-looking guidance for the dynamic adjustment and effective implementation of strategy, resulting in significant obstruction within the strategic transmission mechanism under this evaluation system.

1.2 Theoretical Complementarity and Integration Logic of the Balanced Scorecard and Economic Value Added

The Balanced Scorecard and Economic Value Added exhibit structurally complementary characteristics in the logic of corporate value creation. The Balanced Scorecard provides a multidimensional framework for strategic description and management. Through the cause-and-effect chain across the four perspectives—financial, customer, internal processes, and learning and growth—it systematically reveals the non-financial drivers of value creation and long-term strategic pathways. It is particularly adept at translating abstract strategic objectives, such as safety and environmental sustainability, into concrete actionable indicators. However, its set of financial metrics may potentially lead to internal coordination conflicts due to the lack of a unified value measurement standard.

Economic Value Added, on the other hand, offers a single, core, ultimate financial performance metric by adjusting accounting profit to reflect the true cost of equity capital. It emphasizes value creation over accounting profit and can effectively curb capital misuse and short-term behavior.

The logic for integrating the two lies in employing Economic Value Added as the unified core and ultimate goal for measuring long-term financial success. Simultaneously, the strategic mapping tool of the Balanced Scorecard is utilized to clearly delineate how improvements in non-financial dimensions—such as safety performance enhancement, green technology innovation, and process optimization—drive capital efficiency gains and are ultimately translated into Economic Value Added growth. This achieves a deep coupling between strategic measurement and financial outcomes.

1.3 Motivation for Constructing an Integrated Evaluation Framework Aimed at Sustainable Competitive Advantage

The fundamental motivation for constructing an integrated evaluation framework stems from the intrinsic need for mining companies to acquire and maintain sustainable competitive advantage. The competitive advantage of mining companies has expanded from singular resource possession to encompass competition in integrated capabilities, including efficient resource utilization, excellent safety management, green ecological practices, and a strong social license to operate. Traditional discrete and functionally siloed evaluation systems cannot meet the demands of this systemic competition. A framework that integrates the strategic perspective of the Balanced Scorecard and the value benchmark of Economic Value Added can systematically incorporate non-economic factors—such as safety compliance, ecological restoration, and community relations—into the strategic core, and quantitatively analyze their contribution to or consumption of the firm's long-term economic value. By establishing a coherent cause-and-effect chain from the management of social and environmental capital to the optimization of internal processes, and ultimately to the creation of financial value, this framework guides enterprises to regard various capital investments as necessary for value creation rather than merely as costs. Consequently, it enables the dynamic balance and synergistic evolution of economic benefits, safety stability, and ecological environmental protection at the strategic level. This serves as the rational foundation for building an inimitable sustainable competitive advantage[1].

2. Construction of a Multidimensional Strategic Map Integrating Safety, Environmental Sustainability, and Economic Benefits

2.1 Defining Strategic Themes and Objectives Centered on Long-Term Value Creation

2.1.1 Anchoring Value Objectives in Economic Value Added

The objective of long-term value creation must transcend accounting profit and be anchored in Economic Value Added. This implies that the selection of strategic themes must directly or indirectly affect the difference between Net Operating Profit After Tax and Capital Cost, thereby guiding management decisions to focus on genuine economic profit and capital efficiency. The ultimate effectiveness of any strategic theme must be validated through the Economic Value Added metric, thereby ensuring a high degree of alignment between strategy and the corporation's ultimate financial objectives.

2.1.2 Derivation and Connotation of Core Strategic Themes

Proceeding from the drivers of Economic Value Added, mining companies need to derive three core strategic themes: optimization of capital allocation and operational efficiency, management of systemic risks and building of operational resilience, and maintenance of ecological capital and sustainable resource management. The first theme focuses on improving asset turnover, optimizing extraction sequences, and promoting technological innovation to reduce costs and enhance efficiency. The second theme expands the scope of safety from controlling personnel casualties to minimizing holistic risks that ensure production continuity, protect critical assets, and maintain the operating license. The third theme internalizes ecological and environmental factors from external constraints into key strategic assets that influence the company's long-term costs and social capital.

2.1.3 Translating Strategic Objectives into Measurable Forms

Each strategic theme must be translated into a series of specific, forward-looking strategic objectives. For instance, "operational efficiency optimization" can be specified as "achieving an increase in the intelligent automation rate of key process flows to X%". The objective for "risk management" can be set as "establishing a digital safety risk early-warning platform covering the entire lifecycle". "Ecological capital maintenance" can be quantified as "forming a self-sustaining ecosystem before mine closure". These objectives collectively form a bridge connecting long-term value with short-term actions.

2.2 Identification of Key Performance Areas in the Dimensions of Safe Operations and Green Mining

2.2.1 Key Performance Areas for Proactive Risk Management in Safe Operations

Key performance areas must shift from lagging incident statistics to leading risk indicators. These areas include, but are not limited to: the completeness and frequency of dynamic updates to risk identification and assessment systems; the investment intensity and speed of achieving closure in major hazard control; the safety culture assessment index and the compliance rate of employee safety behavior observations; as well as the drill intensity and resource support level of the emergency response system. These areas measure the enterprise's ability to prevent losses, not merely the losses themselves[2].

2.2.2 Key Performance Areas for Whole-Process Ecological Governance in Green Mining

Performance areas within this dimension should encompass the entire lifecycle from planning and production to mine closure. Core areas include: resource comprehensive utilization efficiency based on ecological footprint analysis (e.g., recovery rate of associated resources, resource utilization rate of solid waste); energy and resource intensity management with core indicators such as comprehensive energy consumption and water consumption per unit product; ecological disturbance control technology and land reclamation quality (e.g., soil reconstruction index, vegetation community restoration level); as well as the formulation and effectiveness evaluation of biodiversity impact mitigation measures.

2.2.3 Establishing Quantitative Benchmarks and Thresholds for Performance Areas

After identifying the performance areas, it is necessary to establish scientific quantitative benchmarks and performance thresholds for each area. These benchmarks should reference industry best practices, international standards (such as the principles of the International Council on Mining and Metals), and scientific studies on carrying capacity, rather than merely complying with statutory minimum requirements. For example, one might define an industry-leading benchmark for water recycling rates or set minimum thresholds for soil health at different stages of reclamation, thereby steering management towards continuous improvement.

2.3 Designing the Interconnectedness of Multidimensional Strategic Indicators Based on Cause-and-Effect Chains

2.3.1 The Driving Logic from Learning and Growth to Internal Processes

At the base of the cause-and-effect chain lies the learning and growth perspective. Its driving effect on internal processes manifests in how investments in employee skills and information technology concretely enhance the effectiveness of safety monitoring and ecological management processes. For instance, an increase in the "coverage rate of digital skills training" drives improvements in process indicators such as the "alarm accuracy rate of intelligent safety monitoring systems" and the "automatic data collection rate for real-time environmental monitoring."

2.3.2 The Transformation of Internal Process Outcomes into Value for Customers and Stakeholders

Improved internal processes yield tangible outcomes, which are then transformed into value at the customer and stakeholder level. A more efficient closed-loop hazard management system will reduce accident frequency, reflected in an increase in the "Community Safety Perception Index." The application of advanced ecological restoration technologies will enhance the environmental conditions of the mining area, reflected in a strengthening of the "Stakeholder Environmental Trust Index." These soft indicators are crucial for maintaining the enterprise's social license to operate and reducing non-market risks.

2.3.3 The Final Value Translation into the Financial Dimension and Economic Value Added

Positive changes at the stakeholder level ultimately translate into the financial dimension. Improved community relations may reduce the risk of production stoppages and additional compensation costs caused by community incidents; a strong environmental reputation may lead to preferential green credit terms, thereby lowering the cost of capital; and efficient resource utilization directly reduces operating costs and capital expenditures. All these impacts—the reduction of risk-related costs, the optimization of capital costs, and the enhancement of operational efficiency—will be comprehensively reflected in the improvement of core financial metrics such as Economic Value Added. Through this rigorous design of cause-and-effect chains, safety and environmental performance are no longer reported as isolated cost centers but become an organic part of the core narrative of the enterprise's overall value creation.

3. Design of a BSC and EVA-Integrated Strategic Performance Evaluation Model

3.1 Linking EVA Core Drivers in the Financial Dimension with BSC Non-Financial Dimensions

3.1.1 Strategic Deconstruction and Mapping of EVA Drivers

The construction of the integrated model begins with a strategic deconstruction of the drivers of Economic Value Added. Net Operating Profit After Tax can be attributed to revenue growth, cost efficiency, and asset operation efficiency, while the cost of capital is linked to operational risk and capital market expectations. The model needs to systematically map these financial components to the non-financial dimensions of the Balanced Scorecard. For example, "product premium capability" at the customer level is linked to revenue growth; "ore dressing recovery rate" at the internal process level directly impacts cost and asset efficiency; whereas the "major risk control rate" in the safety dimension and the "environmental compliance rating" in the green dimension act as key leading variables, significantly influencing the level of operational risk and the corresponding cost of capital estimation[3].

3.1.2 The Transmission Mechanism of How Non-Financial Indicators Impact the Cost of Capital

Safety and environmental performance influence the Weighted Average Cost of Capital through risk transmission channels. Excellent safety and environmental management can reduce the company's operational, regulatory, and reputational risks. Within the logic of capital asset pricing, this may manifest as a potential downward adjustment of the equity beta coefficient or in securing more favorable interest rate conditions for debt financing. Therefore, the model must set leading indicators such as "Recordable Incident Frequency" and "Ecological Restoration Index" as risk adjustment factors. By conducting sensitivity analysis or scenario simulations on the cost of capital, their impact is explicitly accounted for within the financial valuation framework.

3.1.3 Weight Assignment for Linkage Points and Consideration of Synergistic Effects

To achieve actionable management guidance, it is necessary to quantify the linkage strength between various non-financial indicators and the drivers of Economic Value Added. This typically involves determining weights or an impact coefficient matrix through methods such as the Analytic Hierarchy Process, the Delphi Method, and historical regression analysis. This process must carefully consider synergistic and trade-off relationships between indicators. For example, excessively pursuing the "equipment uptime rate" may compromise the "preventive maintenance completion rate," ultimately eroding Economic Value Added due to increased safety risks and repair costs from equipment failures. Therefore, the model must have built-in mechanisms to identify and constrain such critical trade-off relationships, thereby ensuring strategic synergy.

3.2 Quantification of Value Contribution and Transformation Pathways for Safety and Environmental Performance

3.2.1 Direct Value Quantification Pathway Based on Cost Avoidance and Loss Prevention

This pathway quantifies the losses avoided due to superior performance through counterfactual inference. For safety performance, the "Potential Loss Estimation Method" can be employed, using historical data and industry benchmarks to calculate the direct accident costs and indirect production stoppage losses avoided by improving the "Safety Culture Maturity." For environmental performance, the direct economic contribution can be monetized by calculating the raw material procurement and disposal costs saved through increasing the "Solid Waste Resource Recovery Rate," or by estimating the future reductions in ecological guarantee deposits and compensation expenditures achieved by meeting "Phased Reclamation Targets."

3.2.2 Indirect Value Transformation Pathway Based on Operational Efficiency Improvement and Asset Value Preservation

Safety and environmental management create indirect contributions by enhancing operational continuity and preserving the long-term value of assets. For instance, strengthening risk pre-control can reduce unplanned downtime, directly improving the "overall effectiveness of the production system." Implementing green mining techniques can improve the working environment, which is linked to a decrease in the "employee health-related absenteeism rate," thereby increasing labor productivity. At the asset level, scientific mine closure planning and ecological reconstruction contribute to maintaining the residual value of mineral rights and land. This portion of value can be quantified through valuation techniques such as discounted cash flow analysis[4].

3.2.3 Strategic Flexibility Value Assessment from an Option Perspective

Certain proactive investments possess real option characteristics, creating strategic options for the enterprise in uncertain environments. For instance, early investments in carbon emission reduction technologies or closed-loop water systems, while increasing current capital expenditures, grant the enterprise the flexibility and first-mover advantage to comply with more stringent future environmental regulations, thereby avoiding potential transition costs and technology lock-in risks. The value of such "green options" or "safety resilience options" can be estimated using real option pricing models and incorporated into the long-term valuation framework.

3.3 Internal Consistency Testing and Dynamic Adjustment Mechanism of the Evaluation Model

3.3.1 Statistical Verification of Causal Assumptions and Logical Consistency Review

The causal relationship assumptions underpinning the model must undergo continuous testing. By collecting panel data and employing statistical methods such as structural equation modeling, the significance and strength of pathways like "safety training intensity → behavioral compliance rate → reduction in accident rate" can be verified. Simultaneously, a regular expert review mechanism needs to be established to audit the internal logical consistency of the indicator system, preventing incentive conflicts among indicators and ensuring unified strategic direction.

3.3.2 Strategic Environment Scanning and the Dynamic Update Mechanism for Key Performance Indicators

The model should incorporate a strategic environment scanning process. It requires regular analysis of external factors such as technological advancements (e.g., autonomous driving, clean mineral processing technologies), evolving industry standards, and changes in stakeholder expectations. This analysis assesses whether the existing indicator system can still effectively capture the key value drivers. Based on this, a mechanism for the inclusion and removal of key performance indicators should be established. When a specific safety or environmental practice becomes an industry benchmark or a regulatory requirement, its related indicators should be transferred from the "strategic differentiation indicators" pool to the "operational compliance indicators" pool. Consequently, their weights or positions on the strategic map should be adjusted or replaced accordingly.

3.3.3 Model Parameter Calibration and Iterative Optimization Based on Feedback Learning

The model parameters must be periodically calibrated based on actual outcomes, establishing a closed-loop learning system. Through correlation analysis and retrospective studies comparing improvements in non-financial performance with subsequent changes in actual Economic Value Added, the most effective value-driving indicators can be identified. The parameters such as weights and impact coefficients should then be calibrated accordingly. This data-driven iterative optimization process enables the model to adapt autonomously to internal and external changes within the enterprise, continuously enhancing its predictive validity and managerial relevance. Ultimately, it evolves into a learning-capable central hub for strategic management.

Conclusion

This study systematically constructs a strategic performance evaluation system for mining companies that integrates the Balanced Scorecard and Economic Value Added. The research analyzes the limitations of the traditional financial model in strategic translation and clarifies the integration logic wherein the two frameworks complement each other through value focus and strategic multidimensionality. Building on this foundation, the study designs a multidimensional strategic map centered on long-term Economic Value Added, defines strategic themes encompassing operational efficiency, risk management, and ecological stewardship, and identifies key performance areas within the safety and environmental dimensions along with their causal chains. This integrates non-economic objectives into a unified strategic framework. At the model level, the research specifies the linkage mechanisms between Economic Value Added drivers and non-financial dimensions, proposes value quantification pathways based on cost avoidance, efficiency improvement, and a real options perspective, and establishes a model maintenance mechanism comprising statistical verification, dynamic updating, and parameter calibration. This system guides enterprises to view safety and environmental factors as strategic investments, promoting synergy among economic benefits, safety assurance, and ecological responsibility. Future research could focus on adapting the model to different mining contexts, refining the calibration of causal assumptions and coefficients using empirical data, and exploring the deep application of big data and artificial intelligence technologies in the dynamic collection of indicators and the self-optimization of the model, thereby enhancing the system's intelligence and predictive efficacy.

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