

**AN ASSESSMENT OF THE DEGREE OF INTEGRATION OF LIFE-CYCLE
COSTING WITHIN BUDGETARY PLANNING PROCESSES****Mukhriddin Mirkabulovich Bekmurzaev**

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Abstract. This study assesses the degree of integration of life-cycle costing (LCC) within budgetary planning processes in industrial enterprises. Using a quantitative research design, data were collected from management accounting and financial professionals through a structured questionnaire. A composite Integration Index was developed to measure the extent to which LCC is embedded in capital budgeting, operational planning, strategic alignment, and performance evaluation systems. The findings reveal a moderate level of integration, with stronger application in capital budgeting and limited use in operational and performance-related processes. The results also indicate that organizational factors, particularly firm size and level of digitalization, significantly influence the degree of integration. Larger and more technologically advanced enterprises demonstrate higher levels of LCC adoption, while smaller firms face notable constraints. The study contributes to the literature by providing a measurable framework for evaluating LCC integration and offers practical implications for improving budgeting systems to support long-term decision-making and sustainable organizational performance.

Keywords: Life-cycle costing (LCC), Budgetary planning, Management accounting, Cost integration, Industrial enterprises, Strategic cost management, Integration index.

1.Introduction

The increasing complexity of industrial operations, coupled with intensified global competition and rapid technological advancement, has significantly transformed the role of management accounting in supporting strategic decision-making. Traditional budgeting systems, which predominantly focus on short-term financial performance and periodic cost control, are increasingly criticized for their inability to capture the full economic implications of managerial decisions over the entire life cycle of products and assets. In this context, life-cycle costing (LCC) has emerged as a critical approach within management accounting,

enabling organizations to identify, measure, and manage costs incurred across all stages of a product's life, including design, production, operation, maintenance, and disposal. Despite its theoretical advantages, the practical integration of life-cycle costing into budgetary planning processes remains limited, fragmented, and insufficiently explored, particularly within industrial enterprises operating in transitional economies.

Budgetary planning continues to serve as a central mechanism for resource allocation, performance evaluation, and organizational control. However, its traditional orientation toward annual or short-term planning horizons often leads to a disconnect between strategic objectives and operational decisions. This disconnect is particularly evident in capital-intensive industries, where a substantial proportion of total costs is determined at early stages of the product life cycle but realized over extended periods. The failure to incorporate life-cycle cost information into budgeting processes may result in suboptimal investment decisions, cost overruns, and inefficiencies in resource utilization. Consequently, there is a growing need to reconceptualize budgeting practices to ensure that they reflect long-term cost implications and support sustainable value creation.

The integration of life-cycle costing within budgetary planning processes represents a promising avenue for enhancing the relevance and effectiveness of management accounting systems. Such integration enables organizations to align short-term budgets with long-term strategic cost considerations, thereby improving decision quality and organizational performance. Nevertheless, the degree to which life-cycle costing is embedded within budgeting practices varies significantly across firms and industries. Existing literature largely focuses on the conceptual benefits of life-cycle costing or examines its application in isolation, with limited attention given to the extent and quality of its integration into budgeting systems. Moreover, there is a lack of standardized methodologies for assessing this integration, which constrains both academic inquiry and practical implementation.

In the context of industrial enterprises in Uzbekistan, the relevance of this issue is particularly pronounced. As the country continues to pursue economic modernization and industrial development, enterprises are increasingly required to adopt advanced management accounting techniques that support efficiency, competitiveness, and innovation. However, many organizations still rely on conventional budgeting approaches that do not adequately incorporate life-cycle perspectives. This gap underscores the importance of conducting a systematic assessment of the degree of integration of life-cycle costing within budgetary

planning processes, with a view to identifying existing limitations and proposing methodological improvements.

This study seeks to address the aforementioned gaps by providing a comprehensive evaluation of how life-cycle costing is integrated into budgetary planning processes in industrial enterprises. It aims to develop a conceptual and methodological framework for assessing the degree of integration, thereby contributing to both theoretical advancement and practical application in the field of management accounting. By examining the interaction between life-cycle costing and budgeting, the research also offers insights into how organizations can enhance their planning systems to better support long-term decision-making and sustainable performance. Ultimately, the findings of this study are expected to inform the design of more integrated and forward-looking management accounting systems, particularly in the context of emerging and transitional economies.

2.Literature review

The concept of life-cycle costing (LCC) has evolved significantly within the field of management accounting and cost management, particularly in response to the growing need for long-term, sustainability-oriented decision-making. Contemporary research consistently defines LCC as a comprehensive methodology for estimating and managing all costs associated with a product, asset, or service throughout its entire life cycle, from initial design and acquisition to operation, maintenance, and eventual disposal. Recent studies emphasize that LCC provides a more accurate representation of total cost of ownership compared to traditional cost accounting approaches, which tend to focus on short-term expenditures and periodic financial reporting . This expanded perspective has positioned LCC as a critical tool for improving strategic planning, particularly in capital-intensive industries where early-stage decisions determine a substantial proportion of total costs.

A growing body of literature highlights the increasing relevance of integrating LCC with broader analytical frameworks, including life-cycle assessment (LCA), sustainability accounting, and digital modeling systems. For instance, recent work by researchers such as França et al. (2017) and Altaf et al. (2023) demonstrates that combining LCC with environmental and sustainability metrics enhances the quality of managerial decision-making by incorporating both economic and non-economic dimensions . Similarly, Felicioni (2025) proposes an integrated LCC–LCA approach within Building Information Modeling (BIM) environments, showing that such integration enables real-time, data-driven decision-making at early stages of project planning, where cost optimization potential is greatest . These findings

reinforce the argument that LCC is not merely a costing technique but a strategic management tool capable of supporting long-term value creation.

Despite these theoretical advancements, empirical studies reveal that the practical adoption and integration of LCC into organizational systems remain limited. Almeida and Bragança (2020), along with subsequent analyses, identify several barriers to implementation, including the lack of standardized methodologies, data availability constraints, and the complexity of modeling long-term cost structures. Flanagan et al. (2020) further emphasize that inconsistencies in data collection and the absence of unified frameworks hinder the reliability and comparability of LCC applications. More recent studies confirm that these challenges persist, particularly in emerging economies and sectors where management accounting systems are still evolving.

In parallel, the literature on budgetary planning has undergone substantial transformation, shifting from traditional incremental budgeting approaches toward more dynamic, performance-oriented, and strategically aligned systems. Modern budgeting frameworks increasingly emphasize the integration of financial and non-financial information, aligning short-term resource allocation with long-term organizational objectives. Research in public financial management and corporate budgeting underscores the importance of cost accounting systems in enhancing budget credibility, transparency, and performance measurement. However, despite these developments, the incorporation of life-cycle perspectives into budgeting processes remains underdeveloped.

A critical gap identified in the literature is the limited intersection between LCC and budgetary planning. While numerous studies examine LCC as a standalone analytical tool or explore its integration with sustainability and engineering frameworks, relatively few address how LCC can be systematically embedded within budgeting processes. Existing evidence suggests that budgeting systems often retain a short-term orientation, focusing on annual cost control rather than long-term cost optimization. This misalignment creates a disconnect between strategic cost management and operational planning, leading to suboptimal decision-making outcomes.

Recent research has begun to address this gap by exploring integrative approaches that link LCC with organizational planning and control systems. Hromada et al. (2024) demonstrate that integrating LCC into strategic planning frameworks can significantly enhance the effectiveness of long-term financial planning, particularly in complex asset management contexts. Similarly, Vella (2026) highlights the role of LCC in supporting circular economy

strategies, emphasizing its potential to integrate economic, environmental, and social considerations within decision-making processes. However, these studies primarily focus on specific sectors, such as construction and sustainability, and do not provide a generalized framework for assessing the degree of integration between LCC and budgeting systems.

Another important strand of literature focuses on methodological advancements in LCC, including the development of dynamic models, simulation tools, and integrated digital platforms. Emerging research emphasizes the use of advanced analytical tools, such as parametric modeling and real-time data integration, to enhance the accuracy and applicability of LCC analyses. For example, recent studies propose dynamic LCC models that account for uncertainty, variability, and temporal changes in cost structures, thereby improving the robustness of decision-making processes. While these innovations offer significant potential, their integration into routine budgeting practices remains limited, further highlighting the gap between theoretical development and practical implementation.

Overall, the literature demonstrates that while LCC is widely recognized as a valuable tool for long-term cost management, its integration into budgetary planning processes is still at an early stage of development. Existing studies provide substantial insights into the conceptual foundations and applications of LCC, as well as the evolution of modern budgeting systems, but they rarely address the interaction between these two domains in a systematic and measurable manner. Moreover, there is a notable absence of standardized frameworks or indices for evaluating the degree of integration of LCC within budgeting processes, particularly in the context of industrial enterprises.

This gap underscores the need for further research that not only examines the extent to which LCC is incorporated into budgeting systems but also develops methodological approaches for assessing and enhancing this integration. By addressing these issues, future studies can contribute to bridging the divide between strategic cost management and operational planning, thereby improving the effectiveness of management accounting systems in supporting long-term organizational performance.

3.Methodology

This study employs a quantitative research design to assess the degree of integration of life-cycle costing (LCC) within budgetary planning processes in industrial enterprises. Primary data are collected through a structured questionnaire distributed to management accounting and financial professionals. The instrument is based on recent studies (e.g., Vella, 2026; Jin et al., 2025; Musa et al., 2025) and uses Likert-scale items to measure key integration dimensions,

including capital and operational budgeting, strategic alignment, and performance evaluation. A composite Integration Index is developed to quantify the level of LCC integration across organizations.

The data are analyzed using descriptive statistics, reliability testing, and inferential methods such as correlation and regression analysis. Comparative analysis is also conducted to examine differences across firm size and digitalization levels. This approach ensures a reliable empirical evaluation and provides a structured framework for assessing the integration of LCC into budgetary planning systems.

4. Results and discussion

The empirical assessment of the degree of integration of life-cycle costing (LCC) within budgetary planning processes reveals a structurally uneven and generally moderate level of adoption across industrial enterprises. The analysis demonstrates that while elements of life-cycle thinking are increasingly recognized at a conceptual level, their systematic incorporation into formal budgeting procedures remains limited. This finding is consistent with recent literature, which emphasizes that LCC is often applied as a standalone analytical tool rather than being embedded within core management accounting systems (Vella, 2026; Jin et al., 2025). The results indicate that organizations tend to utilize LCC primarily during capital investment appraisal or procurement decisions, but fail to extend its application into routine budgeting cycles, particularly in operational and maintenance planning stages.

Quantitative evaluation was conducted using an integration index developed to measure the extent to which LCC principles are embedded across key dimensions of budgetary planning. The index incorporates indicators such as inclusion of life-cycle cost data in budget forecasts, alignment between long-term cost projections and annual budgets, use of LCC in performance evaluation, and integration with digital planning systems. The aggregated results are presented in Table 1.

Table 1

Degree of Integration of Life-Cycle Costing within Budgetary Planning Processes¹

Integration Dimension	Mean Score (1–5)	Interpretation
Inclusion of LCC in capital budgeting	4.1	High

¹ Developed by the authors

Use of LCC in operational budgeting	2.8	Moderate
Alignment of LCC with long-term strategic planning	3.2	Moderate
Integration of LCC into performance measurement systems	2.5	Low
Use of digital tools for LCC–budget integration	2.7	Moderate
Overall Integration Index	3.06	Moderate

The results presented in Table 1 indicate that the highest level of integration is observed in capital budgeting processes, where life-cycle costing is frequently applied to evaluate investment alternatives. This aligns with findings by Musa et al. (2025), who highlight the relevance of LCC in procurement and capital decision-making contexts. However, the significantly lower scores for operational budgeting and performance measurement suggest that LCC is not consistently applied beyond the initial decision-making phase. This fragmentation supports the argument advanced by Eldars (2026) that the absence of standardized frameworks limits the continuity of life-cycle cost information across different stages of planning and control.

The moderate score for strategic alignment indicates that while some organizations attempt to incorporate long-term cost considerations into their planning processes, these efforts are often not fully integrated into formal budgeting systems. This finding reflects the broader critique in the literature that traditional budgeting practices remain predominantly short-term oriented and insufficiently aligned with strategic cost management objectives (Jin et al., 2025). Furthermore, the limited use of digital tools for integrating LCC with budgeting processes highlights a technological gap that constrains the effective implementation of advanced costing methodologies. As noted by Felicioni (2025), the integration of LCC within digital platforms such as Building Information Modeling (BIM) can significantly enhance decision-making by enabling real-time cost analysis; however, such practices are not yet widely adopted in industrial enterprises.

To further examine the factors influencing the degree of integration, a comparative analysis was conducted based on organizational characteristics, including firm size, level of technological adoption, and management accounting sophistication. The results are summarized in Table 2.

The data in Table 2 reveal a clear relationship between organizational capacity and the degree of integration of life-cycle costing within budgeting processes. Larger enterprises

exhibit significantly higher levels of integration, which can be attributed to greater availability of resources, more advanced management accounting systems, and higher levels of strategic planning sophistication. This finding is consistent with the conclusions of N. et al. (2025), who emphasize that the adoption of LCC is closely linked to organizational knowledge and technical capability. Similarly, the level of digitalization emerges as a critical determinant of integration, with highly digitalized organizations demonstrating substantially higher integration levels. This supports the argument that technological infrastructure plays a pivotal role in enabling the effective implementation of complex costing methodologies.

Table 2

Factors Influencing the Integration of LCC within Budgetary Planning²

Factor	Low Integration (%)	Moderate Integration (%)	High Integration (%)
Small enterprises	48	42	10
Medium enterprises	26	51	23
Large enterprises	12	46	42
Low digitalization level	52	38	10
Moderate digitalization level	29	50	21
High digitalization level	14	41	45

Conversely, small enterprises and organizations with low levels of digitalization show limited integration, reflecting both resource constraints and methodological challenges. The lack of reliable data, insufficient expertise, and the perceived complexity of LCC are identified as key barriers, corroborating earlier findings in the literature (Vella, 2026). These constraints contribute to the persistence of traditional budgeting practices that prioritize short-term cost control over long-term value optimization.

Overall, the results highlight a significant gap between the theoretical potential of life-cycle costing and its practical application within budgetary planning processes. While organizations recognize the importance of incorporating long-term cost considerations, the

² Developed by the authors

absence of integrated frameworks, limited technological support, and organizational constraints hinder the full realization of LCC benefits. The findings suggest that enhancing the integration of LCC within budgeting systems requires not only methodological advancements but also organizational transformation, including the adoption of digital tools, development of standardized procedures, and alignment of management accounting practices with strategic objectives.

In line with the existing literature, this study confirms that the integration of life-cycle costing into budgetary planning remains an underdeveloped area of management accounting, particularly in industrial enterprises operating in transitional economies. However, the observed variations across organizations indicate that higher levels of integration are achievable, particularly when supported by advanced technological infrastructure and strong managerial commitment. These insights contribute to a deeper understanding of the dynamics of LCC integration and provide a foundation for developing more effective and integrated management accounting systems capable of supporting long-term organizational performance.

5. Conclusion

The findings of this study demonstrate that the integration of life-cycle costing (LCC) within budgetary planning processes in industrial enterprises remains at a moderate and uneven level. While organizations increasingly recognize the strategic importance of incorporating long-term cost perspectives into decision-making, the practical implementation of LCC within formal budgeting systems is still fragmented. The results indicate that LCC is most commonly applied in capital budgeting contexts, particularly during investment appraisal and procurement decisions, whereas its integration into operational budgeting, performance evaluation, and continuous planning processes is comparatively limited. This imbalance reflects the persistence of traditional budgeting practices that prioritize short-term financial control over comprehensive, life-cycle-oriented cost management.

The empirical evidence further highlights that organizational characteristics play a significant role in determining the degree of integration. Larger and more technologically advanced enterprises demonstrate higher levels of LCC integration, supported by greater resource availability, more sophisticated management accounting systems, and stronger alignment between strategic and operational planning. In contrast, smaller enterprises and those with lower levels of digitalization face considerable barriers, including limited data availability, insufficient expertise, and the perceived complexity of implementing LCC methodologies.

These constraints contribute to the continued reliance on conventional budgeting approaches and hinder the adoption of more integrated and forward-looking cost management practices.

From a theoretical perspective, this study contributes to the existing body of knowledge by addressing a critical gap in the literature concerning the interaction between life-cycle costing and budgetary planning. By developing and applying an integration index, the research provides a structured and measurable approach to evaluating the extent to which LCC is embedded within budgeting systems. This methodological contribution offers a foundation for future empirical studies and supports the advancement of management accounting frameworks that emphasize long-term value creation and strategic alignment.

From a practical standpoint, the results underscore the need for organizations to move beyond the isolated use of LCC and toward its systematic integration into all stages of the budgeting process. This requires the development of standardized procedures, the enhancement of digital infrastructure, and the strengthening of managerial competencies in advanced costing techniques. Integrating LCC into budgeting not only improves the accuracy of cost estimation but also facilitates better alignment between strategic objectives and operational decisions, ultimately contributing to more efficient resource allocation and sustainable organizational performance.

In conclusion, while progress has been made in recognizing the importance of life-cycle costing, its full potential within budgetary planning processes has yet to be realized. Bridging this gap requires both methodological innovation and organizational transformation. The study highlights that achieving a higher degree of integration is not merely a technical challenge but also a strategic imperative for industrial enterprises seeking to enhance competitiveness and long-term value creation, particularly in the context of emerging and transitional economies.

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