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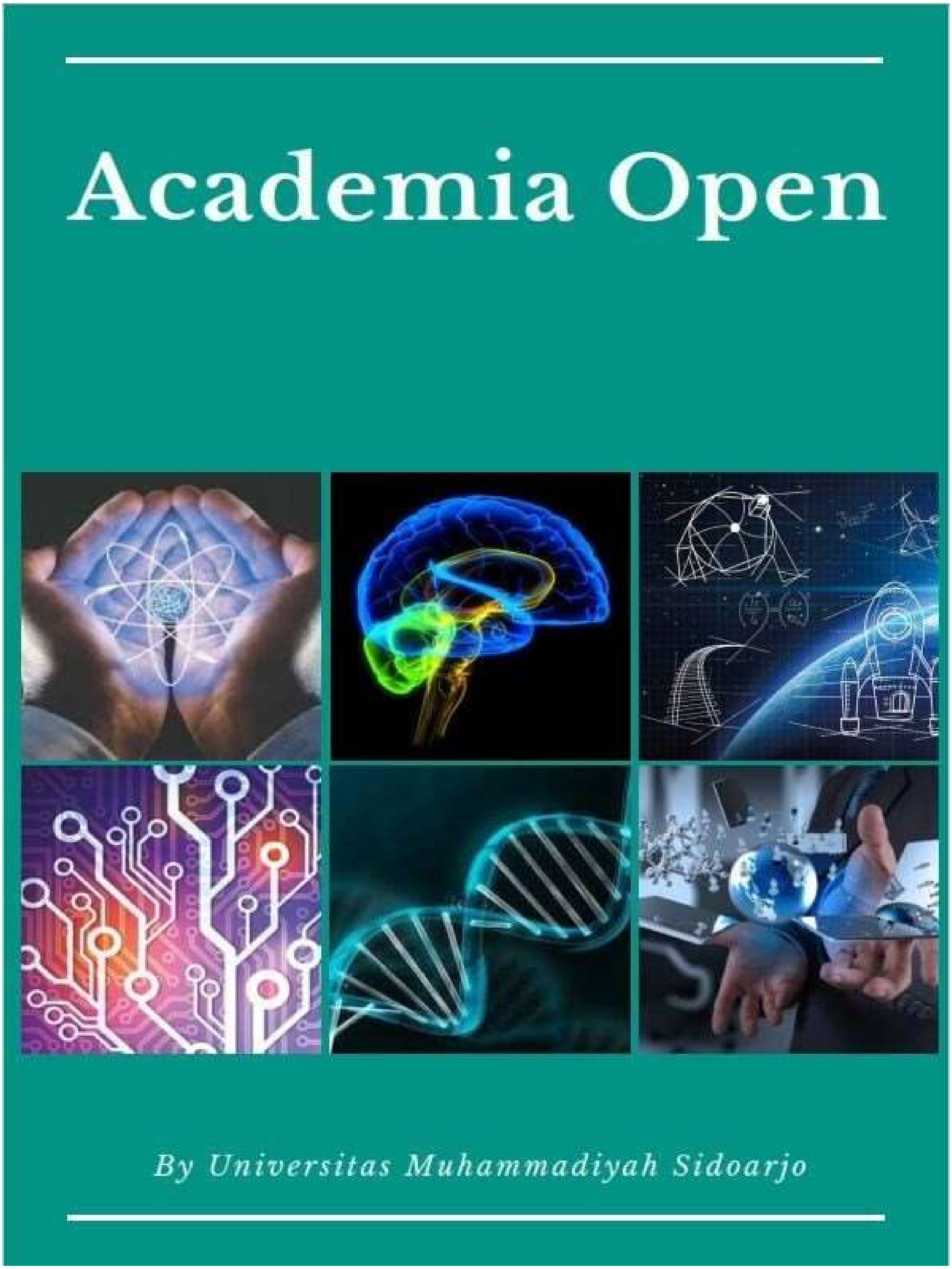

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Improving The Methodology of Managing Construction Materials Manufacturing Enterprises

Achilov Ilmurad Nematovich, ilmurodachilov1987@gmail.com,(1)
Dean Of the Faculty of Social Sciences, Shahrisabz State Pedagogical Institute, Phd, Uzbekistan

(1) Corresponding author

Abstract

General Background: The construction materials manufacturing industry plays a decisive role in national economic development, infrastructure modernization, and housing provision, requiring efficient enterprise management systems to meet growing demand while optimizing costs and ensuring quality. **Specific Background:** Construction materials enterprises face specific challenges including production process continuity, high energy and raw material intensity, significant logistics costs, and complex technological processes, yet management systems remain predominantly reactive with insufficient strategic planning and weak integration between strategic and operational levels. **Knowledge Gap:** Despite extensive international literature on strategic management tools (Porter's competitive advantage, Balanced Scorecard, Lean, Theory of Constraints, ISO 9001) and domestic studies highlighting sectoral problems in Uzbekistan, a comprehensive integrated methodology systematically linking strategy, KPIs, process-based management, supply chain optimization, and quality systems adapted to construction materials manufacturing specifics remains underdeveloped. **Aims:** This study examines improving the management system methodology of construction materials manufacturing enterprises through scientific-theoretical and practical perspectives, analyzing production dynamics, import dependency, and growth stability using economic-mathematical methods. **Results:** Analysis of Uzbekistan's cement sector (2020-2024) revealed unstable growth patterns (CAGR 6.2%, coefficient of variation 14.32%, instability index 18.10%) with sharp fluctuations indicating reactive decision-making, energy supply disruptions, and insufficient supply chain coordination despite declining import dependency from 16.6% to 8.6%. **Novelty:** The research scientifically substantiates integrating KPIs/Balanced Scorecard, Theory of Constraints, Lean approaches, and ISO 9001 quality management within a unified comprehensive management methodology specifically adapted to construction materials sector characteristics. **Implications:** The proposed comprehensive approach provides a scientific foundation for modernizing management practices, enhancing resource efficiency, ensuring production sustainability, and strengthening competitiveness through systematic linkage of strategic objectives with operational execution and digital technology integration.

Keywords : Construction Materials Management, Enterprise Performance Optimization, Strategic KPI Systems, Lean TOC Integration, Production Stability Analysis

Highlight :

- Production volatility reveals reactive decision-making rather than strategic planning and forecasting mechanisms.
- Integration of KPIs, Balanced Scorecard, Lean, and Theory of Constraints creates comprehensive methodology.
- Import dependency declined from 16.6% to 8.6% between 2020 and 2024.

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Introduction

The construction materials manufacturing industry is one of the key sectors of the national economy, and its stable operation plays a decisive role in the development of the construction sector, the implementation of infrastructure projects, the construction of industrial and social facilities, and the provision of housing for the population. Since demand for construction materials is closely linked to almost all sectors of the economy, the efficiency of enterprises operating in this field has a direct impact on the country's socio-economic development.

In recent years, the rapid development of the construction sector, the increase in public and private investment projects, and the intensification of urbanization processes have required a significant expansion of construction materials production volumes. However, alongside the growth of production capacities, issues such as cost optimization, maintaining consistent product quality, rational use of resources, and compliance with environmental requirements are becoming increasingly critical. Under these conditions, the effective management of enterprise operations requires new scientific and practical solutions.

Construction materials manufacturing enterprises have specific characteristics, including the continuity of production processes, high energy and raw material intensity, a significant share of logistics costs, and the complexity of technological processes. Under such conditions, managerial decision-making should not rely solely on experience or intuition, but must be based on precise calculations, analyses, and a systematic approach.

Practice shows that in many construction materials manufacturing enterprises, the management system is formed within functional departments, and there is insufficient integration between strategic and operational levels. This leads to imbalances in planning, control, and analysis processes, as well as a decline in the effectiveness of decision-making. Therefore, revising the management system and improving it on the basis of modern management methodologies is becoming an objective necessity.

Improving the methodology of the management system refers to the development of principles, methods, tools, and mechanisms for enterprise management within a unified conceptual framework. This process encompasses the clear formulation of strategic objectives, optimization of business processes, implementation of performance indicators, use of digital information systems, and incorporation of innovative approaches into management practice. In particular, the role of management methodology is crucial in ensuring the long-term sustainability of enterprises in a competitive environment.

At the current stage, the construction materials manufacturing industry is considered one of the most dynamically developing sectors of the national economy. Large-scale construction activities, infrastructure modernization, the establishment of industrial zones, and measures aimed at providing the population with high-quality housing are increasing requirements for both the volume and quality of products in this sector. Under these conditions, the operational efficiency of construction materials manufacturing enterprises is acquiring strategic importance.

However, increasing production volume alone is not sufficient. For enterprises to operate sustainably in a competitive environment, they must be able to control costs, use resources efficiently, ensure product quality, and rapidly adapt to market demands. The effective fulfillment of these tasks is determined primarily by the extent to which the management system is scientifically grounded and based on modern methodologies.

Review Of Relevant Literature

The issue of improving the management system of construction materials manufacturing enterprises is, in essence, situated at the intersection of general industrial management, operations management, quality management, supply chain management, and strategic management approaches. Therefore, in the literature review, it is important to compare the theoretical and methodological foundations established in international studies with sector-specific research conducted under the conditions of Uzbekistan, highlighting their strengths and limitations.

In foreign literature, the theory of competitive advantage occupies a central place as a methodological foundation for ensuring enterprise efficiency. M. Porter explains competitive advantage not only through the product itself, but through the coordination of all types of activities within the value chain. This approach makes it possible to systematically analyze cost reduction factors in construction materials manufacturing (energy, logistics, supply, technological downtime) and differentiation factors (quality consistency, certification, service). However, a limitation of Porter's approach is that it primarily explains *how to compete* but does not sufficiently address the issue of how to design and manage industry-specific operational architecture, such as real-time process control, digital monitoring, and the stability of technological regimes [1].

In domestic studies, the topic of strategic management is mainly discussed in connection with growth, sectoral development, and enterprise performance in the construction materials industry. For example, M. A. Ubaydullaev analyzes the formation of strategy and management factors in construction materials industry enterprises and substantiates the importance of a strategic approach. However, in many works within this area, descriptive presentations of strategy and the listing of general factors tend to prevail, while insufficient attention is paid to systematically linking strategy with execution mechanisms such as KPIs, process mapping, budgeting, and risk management.

In transforming strategic objectives into an operational management system that actually functions in practice, the Balanced Scorecard (BSC) concept developed by R. Kaplan and D. Norton serves as an important methodological tool. The BSC links strategy with financial and non-financial indicators, thereby creating a chain of objectives–measures–initiatives–control within the enterprise [2]. In construction materials manufacturing, this approach is useful for aligning indicators such as "energy consumption per ton of output," "rework rate," "logistics delay," "equipment OEE," and "on-time in-full (OTIF) delivery" within a unified system of strategic objectives.

At the same time, a critical limitation of the BSC is that, if applied incorrectly, it may turn into a mere "set of indicators." In other words, if industry-specific technological constraints (such as energy consumption, kiln operating regimes, raw material moisture, and clinker/cement quality parameters) are not taken into account, the indicators do not influence real managerial decisions [3]. Therefore, for construction materials enterprises, the BSC is effective only when applied in integration with process-based management and quality management systems.

In the literature on improving operational efficiency, the Lean concept—focused on reducing waste and eliminating activities that do not add value—is widely applied. Womack and Jones present Lean principles in a universal framework, proposing the redesign of enterprise processes from the perspective of customer value [4]. In construction materials manufacturing, Lean practices contribute to optimizing inventory levels, shortening internal logistics routes, reducing downtime, and lowering rework caused by quality defects.

However, in some plants Lean may remain limited to the level of “discipline and 5S”; in resource-intensive industries such as cement, gypsum, and ceramics production, the main constraint is often related to bottlenecks and the stability of technological regimes. In this context, E. Goldratt’s Theory of Constraints (TOC) approach becomes particularly important, as it views efficiency from the perspective of the entire system and focuses on identifying the weakest link and increasing its throughput. The key advantage of TOC is that it emphasizes overall system performance rather than local optimization, where “each department performs well on its own,” but does not necessarily contribute to the overall result [5].

A critical issue is that Lean and TOC are often implemented separately; as a result, one primarily influences “discipline” while the other focuses on “capacity,” and a unified methodology that links them with KPIs and financial results is often lacking. Therefore, in construction materials enterprises, the integration of these approaches within a BSC-based and process-oriented management platform allows for the formation of a more comprehensive and coherent methodology [6].

In the construction materials market, quality consistency and compliance with requirements (certification, laboratory control, ISO standards, and national standards) represent important competitive factors. Studies related to ISO 9001 indicate that its implementation can, in certain cases, reduce rework and defect-related costs [7]. For example, B. Neostany and J. Juanzon show that the adoption of ISO 9001 affects the structure of quality-related costs and, although it may increase control and inspection costs in some cases, it can generate economic benefits by reducing overall defects and rework [8].

At the same time, the research itself provides an important indication: in many enterprises, ISO 9001 is often perceived merely as a “marketing certificate” and may not exert a deep influence on actual processes and managerial decision-making. Therefore, in construction materials manufacturing enterprises, improving the ISO 9001 methodology requires integrating standard requirements with technological process control, root-cause analysis, statistical process control (SPC), and KPI systems [9].

In construction materials manufacturing, the management of raw material supply, warehousing, transportation, and dealer networks has a direct impact on overall managerial efficiency. In evaluating logistics and supply chains, the SCOR model (Supply Chain Operations Reference) provides a standardized framework for describing processes and performance indicators [10].

N. X. Pan and co-authors have developed an approach to modeling and optimizing the construction materials supply chain based on the SCOR framework. The advantage of these studies lies in their ability to systematically view supply chain blocks such as “plan–source–make–deliver” [11]. However, a limitation is that many studies do not fully integrate internal technological variables of production (energy consumption, equipment downtime, quality parameters) with supply chain models. For construction materials enterprises, supply chains and in-plant processes must function as a single integrated system.

In Uzbekistan, a number of practice-oriented studies on construction materials industry enterprises have emerged in recent years [12]. K. B. Nizomov, using the example of Namangan region, emphasizes the need to enhance management efficiency, strategic planning, innovative management, and digital transformation of enterprises [13], [14] These studies are valuable in identifying real sectoral problems such as the depreciation of fixed assets, production costs, and resource efficiency. However, from a scientific perspective, the methodological framework (for example, “process mapping → KPI → information system → control cycle”) is often not fully modeled, and proposed solutions sometimes remain at the level of general recommendations.

It is also noted that Sh. X. Ibrogimov set the objective of developing scientifically grounded proposals to improve the management efficiency of construction materials manufacturing enterprises. Such studies confirm the relevance of the sectoral problem; however, in article-format research, there remains a need to reinforce the results with measurable indicators, experimental or pilot implementations, or calculations of economic efficiency [15].

The analysis shows that international literature provides in-depth coverage of strategic positioning (Porter), execution mechanisms (BSC), operational improvement (Lean/TOC), supply chain management (SCOR), and quality management (ISO 9001). Domestic studies, in turn, effectively highlight sector-specific problems and local conditions. However, for construction materials manufacturing enterprises, what is critically needed is the integration of these approaches into a single comprehensive methodology: strategy → KPIs (BSC) → process-based management → supply chain (SCOR) → quality management (ISO) → continuous improvement based on Lean/TOC. The scientific novelty of the article may therefore be demonstrated by substantiating this integration in a form adapted to sectoral specifics and by developing a mechanism for its practical implementation.

Research Methodology

In studying the methodology of the management system of construction materials manufacturing enterprises, a set of scientific methods was applied, including system analysis; the principles of historicism and logical consistency; induction and deduction; analysis and synthesis; comparative and selective research methods; as well as monographic analysis and grouping techniques.

Analysis and Results

In construction materials manufacturing enterprises, management systems have largely been formed on the basis of traditional approaches, which do not fully meet the current requirements of a market economy. The predominance of short-term objectives in managerial decision-making, insufficiently developed strategic planning, and the inefficiency of information support systems give rise to various operational problems [16]. As a result, production costs increase, product cost levels rise, and overall competitiveness declines.

Another important characteristic of the construction materials manufacturing sector is its high resource intensity. The significant share of energy, raw materials, water, and transportation costs requires precise calculations and systematic analysis in enterprise management. At the same time, the tightening of environmental requirements creates the need to reorganize production processes and introduce new approaches to their management. Under these conditions, achieving high economic efficiency without improving the management system is difficult.

Under conditions of the digital economy, the rapid development of information technologies is also placing new demands on management systems. The automation of production processes, real-time monitoring, and the use of analytical and forecasting capabilities create significant opportunities for enterprises. However, to apply these opportunities effectively, they must be integrated into a unified and well-developed

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management methodology.

A. Analysis of Production Volume Dynamics and Growth Rates. In evaluating the performance of construction materials manufacturing enterprises, one of the key indicators is the change in production volume over time. Production dynamics were assessed using the following formula:

Production Growth Rate (T):

$$T_t = \frac{Q_t}{Q_{t-1}} \times 100\%$$

where: (Q_t) – production volume in the current year;

Q_{t-1}– production volume in the previous year.

Table 1. Cement production volume and growth rate in Uzbekistan, 2020–2024

Year	Production volume, thousand tons	Growth rate, %
2020	12537,4	-
2021	14195,0	113,2
2022	11359,5	80,0
2023	11931,3	105
2024	16 007,3	134,2

According to the data presented in the table, production increased by 13.2% in 2021, indicating strong demand in the construction market and active utilization of production capacities (Table 1). In 2022, a sharp decline of nearly 20% was observed, which is associated with constraints in energy supply and logistics problems. In 2024, a growth rate of 34.2% indicates a higher level of capacity utilization at enterprises; however, such abrupt growth also suggests instability in the management system.

B. Analysis of the Compound Annual Growth Rate (CAGR). To assess the long-term stability of production, the **compound annual growth rate (CAGR)** was calculated as follows:

$$CAGR = \left(\frac{Q_{2024}}{Q_{2020}}\right)^{\frac{1}{n}} - 1$$

where $n = 4$years.

$$CAGR = \left(\frac{16\,007{,}3}{12\,537{,}4}\right)^{\frac{1}{4}} - 1 \approx 0{,}062$$

During the period 2020–2024, the compound annual growth rate of cement production amounted to 6.2%. This indicator confirms the presence of growth in the sector; however, the sharp fluctuations observed across individual years indicate that managerial decisions are being made in a predominantly reactive manner. Therefore, a forecasting- and scenario-based management methodology is required.

C. Analysis of the ratio between import volumes and domestic production. The level of import dependency was assessed using the following formula:

$$I_d = \frac{I}{Q + I} \times 100\%$$

where: I– cement imports (million tons); Q– domestic production volume (million tons).

Table 2. Cement imports and the level of import dependency

Year	Domestic Production (million tons)	Imports (million tons)	Import Share, %
2020	12,54	2,49	16,6
2021	14,20	2,70	16,0
2022	11,36	2,10	15,6
2023	11,93	1,85	13,4
2024	16,01	1,50	8,6

According to the data in the table, domestic production amounted to 12.54 million tons in 2020 and increased to 16.01 million tons by

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2024. Import volumes accounted for 2.49 million tons in 2020, while by 2024 they had decreased to 1.50 million tons (Table 2). The share of imports was 16.6 percent in 2020 and declined to 8.6 percent in 2024.

The calculations presented above make it possible to draw the following scientific and practical conclusions:

1. Production volumes exhibit high volatility, indicating a disconnect between strategic planning and operational management.
2. Growth is present but unstable (CAGR of 6.2%), which means that the management methodology must incorporate scenario-based planning and risk management.
3. The persistence of import share substantiates the need to strengthen Sales and Operations Planning (S&OP) and supply chain management in enterprises.

Based on the data of "Qizilqumsement" JSC, "Ohangaronsement" JSC, "Quvasoysement" JSC, and "Bekabadsement" JSC, which are members of the "O'zsanoatqurilishmateriallari" Association, the following analyses are conducted.

1. **Time Series Analysis: Absolute Change, Chain and Base Indices**
Absolute Change (Chain):

$$\Delta Q_t = Q_t - Q_{t-1}$$

Growth coefficient:

$$K_t = \frac{Q_t}{Q_{t-1}}$$

Chain Growth Rate (percentage):

$$T_t = K_t \times 100\%$$

Base Index (2020 = 100):

$$I_t = \frac{Q_t}{Q_{2020}} \times 100\%$$

Table 3. Dynamics of cement production in 2020–2024

Year	**Production (Q_t) (million tons)**	ΔQ_t, **(million tons)**	T_t, %	**I_t(2020=100), %**
2020	12,54	-	-	100
2021	14,19	+1,66	113,22	113,22
2022	11,36	-2,83	80,02	90,60
2023	11,93	+0,57	105,03	95,17
2024	16,01	+4,07	134,16	127,68

According to the data presented in the table, the sharp decline observed in 2022 (−2,84 mln t; T_{2022} = 80,0%) indicates a high level of risk in the production system related to resource and energy supply, technological continuity, and planning (Table 3). The sharp increase recorded in 2024 (+4,08 mln t; T_{2024} = 134,2%) may be explained by the commissioning of production capacities or the restoration of operating regimes. However, from a management perspective, the sustainability of this growth requires separate assessment, as such abrupt fluctuations often indicate insufficient coordination of KPIs, supply chain management, and energy management systems.

Analysis of average annual absolute growth and CAGR (stability).
Average annual absolute change:

$$\bar{\Delta Q} = \frac{Q_{2024} - Q_{2020}}{4}$$
$$\bar{\Delta Q} = \frac{16{,}0073 - 12{,}5374}{4} = 0{,}8675 \text{ mln t/year}$$

CAGR (Compound Annual Growth Rate):

$$CAGR = \left(\frac{Q_{2024}}{Q_{2020}}\right)^{\frac{1}{4}} - 1 \approx 6{,}2\%$$

Table 4. Average growth indicators for 2020–2024

Indicators	**Value**
Q_{2020} $(mln. tons)$	12,5374

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Q_{2024} (*mln. tons*)	16,0073
Total change, million tons	+3,4699
$\Delta Q mil.tons/year$	+0,8675
CAGR, %/yil	6,2

According to the data presented in the table, a CAGR of 6.2% indicates the presence of overall growth in the sector (Table 4). However, the same data (the decline in 2022 and the sharp increase in 2024) do not allow this "average growth" to be interpreted as stable growth. Therefore, the management methodology should place scenario-based planning, continuous production risk management, energy management, and long-term KPIs at the core of enterprise governance.

Stability (variability) Analysis: the coefficient of variation and the "instability index" were calculated using the following formulas:

Average value:

$$\bar{Q} = \frac{\sum Q_t}{n}$$

Standard deviation:

$$\sigma = \sqrt{\frac{\sum (Q_t - \bar{Q})^2}{n-1}}$$

Coefficient of Variation (CV):

$$CV = \frac{\sigma}{\bar{Q}} \times 100\%$$

Average absolute chain growth deviation (instability index):

$$IA = \frac{1}{n-1} \sum_{t=2021}^{2024} \mid T_t - 100\% \mid$$

Calculation results: $\bar{Q}$ = 13,2061mln t, σ = 1,8912mln t, CV = 14,32%, IA = 18,10%.

Table 5. Production stability indicators for 2020–2024

Indicators	**Value**	**Notes**
$\bar{Q} = mln.tons$	13,2061	five-year average production
$\sigma = mln.tons$	1,8912	level of fluctuation
CV, %	14,32	significant variability
IA, %	18,10	annual growth rates "fluctuate sharply"

According to the data presented in the table, a CV of 14.3% indicates significant variability in production. An IA of 18.1% shows that year-to-year growth rates are not "smooth" but rather "shock-driven" (Table 5). These results provide a scientific justification for the following measures in improving the management system:

1. -the establishment of a risk management block ensuring continuous production (energy supply, maintenance, spare parts);
2. -linking KPIs with technological constraints (OEE, classification of downtime causes, energy consumption per ton of output);
3. -preparedness for demand and supply fluctuations through S&OP and scenario-based planning.

Conclusion

The study confirms that improving the methodology of the management system of construction materials manufacturing enterprises is an extremely relevant and complex issue under contemporary economic conditions. Analyses conducted on the basis of statistical data for the period 2020–2024 indicate that, despite the presence of an overall growth trend in production volumes, this growth is unstable and characterized by sharp year-to-year fluctuations. This situation demonstrates that managerial decisions in the construction materials industry are often oriented toward responding to short-term challenges, while long-term strategic planning and forecasting mechanisms remain insufficiently developed.

The economic and mathematical methods applied in the study—dynamic time series analysis, growth rate calculations, average annual growth indicators, import dependency assessment, and coefficients reflecting production stability—revealed the existence of systemic problems in the construction materials manufacturing sector. In particular, disruptions in energy supply, difficulties in ensuring the continuity of technological

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processes, low efficiency of equipment utilization, and insufficient coordination within the supply chain were identified as the main factors negatively affecting production performance. These factors scientifically substantiate that enterprise management cannot be limited to a purely functional approach, but instead requires a transition to a process-oriented and systemic management methodology.

The analysis of the ratio between imports and domestic production shows that the share of imports has been decreasing in recent years. This can be assessed as a positive trend; however, the research results indicate that a reduction in import dependency does not automatically lead to higher sectoral efficiency. If production stability is not ensured and energy and resource-related risks are not effectively managed, the import share may increase again under the influence of short-term factors. Therefore, rather than passively restricting imports, it is more appropriate to manage them as a strategic instrument for balancing market demand.

A number of scientific and practical conclusions and recommendations for improving the management system of construction materials manufacturing enterprises have been formulated. First, enterprises should implement a system of performance indicators (KPIs, Balanced Scorecard) that ensures a close linkage between strategic objectives and operational activities. Second, the Theory of Constraints (TOC), aimed at identifying and eliminating key production bottlenecks, and Lean approaches focused on waste reduction should be applied within a unified management methodology. Third, quality management systems (ISO 9001) should be used not as a formal requirement, but as an active managerial tool closely integrated with technological regimes, economic efficiency, and decision-making processes.

At the same time, the study demonstrates the importance of introducing digital technologies in construction materials manufacturing enterprises and integrating them into the management methodology. Real-time data collection, monitoring of production indicators, and the use of analytical and forecasting tools contribute to improving the quality of managerial decisions. This, in turn, enhances enterprises' resilience to external influences and creates a foundation for long-term sustainable development.

Overall, improving the methodology of the management system of construction materials manufacturing enterprises requires a comprehensive approach that encompasses strategic, operational, and tactical levels. The theoretical conclusions and practical recommendations developed in this article provide a scientific basis for modernizing management practices in the sector, increasing the efficiency of resource utilization, and enhancing the competitiveness of the construction materials industry. In future research, it would be appropriate to deepen the analysis using empirical data from specific enterprises or regions, as well as to evaluate the economic effectiveness of the proposed management methodology through precise quantitative assessments.

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