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Optimizing Packing And Logistics Costs: A KPI Study In Cement Industry

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Abstract
The cement industry faces significant challenges in managing packing and logistics costs, which constitute a substantial portion of overall operational expenses. This study examines the optimization of packing and logistics costs through the systematic application of Key Performance Indicators (KPIs) in cement manufacturing and distribution operations. A comprehensive analysis of supply chain operations, distribution network optimization, and cost components was conducted using data from multiple cement industry case studies. The research identifies critical KPIs including total logistics costs, on-time delivery performance, distribution efficiency, inventory management metrics, and packaging optimization indicators. Findings reveal that total logistics costs in cement projects range from 14.60% to 22.56% of total investment costs, with foreign logistics costs and customs clearance representing the largest components at 6.62% and 6.52% respectively. The study demonstrates that implementation of Mixed Integer Linear Programming (MILP) optimization models can reduce supply chain costs by 4-7%, with distribution process efficiency improvements reaching up to 44%. The research establishes a framework for cement industry practitioners to implement strategic KPI-based monitoring systems that enhance cost efficiency, improve delivery performance, and optimize resource utilization across the packing and logistics value chain. This study contributes to the body of knowledge by providing empirical evidence of logistics cost optimization opportunities and establishing benchmarking standards for the cement industry.

Keywords: logistics optimization, packing costs, key performance indicators, supply chain management, distribution network, performance measurement

1. Introduction
The cement industry operates within a highly competitive global market where operational efficiency and cost management directly determine organizational profitability and market sustainability. As one of the most capital-intensive and logistics-dependent manufacturing sectors, cement production and distribution involve complex supply chain networks spanning raw material extraction, manufacturing processes, packaging operations, and multi-modal transportation systems (Subiyanto and Suyoto, 2020). The economic viability of cement operations is particularly sensitive to logistics and packing costs, which represent substantial portions of total operational expenses and significantly impact final product pricing competitiveness.[1][2][3]

Packing and logistics activities in the cement industry encompass diverse operational domains including bulk cement handling, bag packaging systems, warehouse management, inventory control, transportation fleet optimization, and distribution network design. These operations must balance competing objectives of cost minimization, service level maintenance, delivery reliability, and resource utilization efficiency. The complexity of these challenges is amplified in geographically dispersed markets, particularly in archipelagic regions where multi-modal

transportation and transshipment operations introduce additional cost layers and operational uncertainties.[4][5][3]
Recent research has demonstrated the critical importance of systematic performance measurement in achieving supply chain optimization objectives. Key Performance Indicators (KPIs) serve as quantifiable metrics that enable organizations to monitor operational effectiveness, identify improvement opportunities, and implement data-driven decision-making processes. In the cement industry context, KPIs related to logistics costs, delivery performance, inventory turnover, capacity utilization, and distribution efficiency provide essential visibility into operational performance and cost structure dynamics.[6][7][8]

The application of advanced optimization techniques, particularly Mixed Integer Linear Programming (MILP) and linear programming models, has shown considerable promise in addressing cement industry supply chain challenges. Studies have documented cost reduction potentials ranging from 4% to 44% in various supply chain segments through the implementation of mathematical optimization approaches. These methodologies enable simultaneous consideration of multiple decision variables including production allocation, distribution routing, inventory positioning, and transportation mode selection while respecting operational constraints and capacity limitations.[2][5][1][4]
Despite the established importance of logistics cost management and performance measurement, significant gaps remain in the systematic application of KPI frameworks specifically tailored to cement industry packing and logistics operations. Previous research has predominantly focused on isolated aspects such as transportation optimization or production scheduling, without providing integrated approaches that address the comprehensive packing and logistics value chain. Furthermore, empirical benchmarking data for logistics cost components and performance standards remains limited, constraining the ability of industry practitioners to assess their relative performance and identify targeted improvement opportunities.[7][3]

This research addresses these gaps by conducting a comprehensive KPI study focused on optimizing packing and logistics costs in the cement industry. The study objectives include identifying critical performance indicators relevant to cement packing and logistics operations, quantifying typical cost structures and performance benchmarks based on empirical industry data, analyzing optimization opportunities through mathematical modeling approaches, and establishing a practical framework for KPI-based performance management in cement supply chain operations. Through these contributions, this research aims to provide actionable insights that enable cement industry organizations to enhance operational efficiency, reduce logistics costs, and strengthen competitive positioning in increasingly challenging market environments.

2. Literature Review

2.1 Supply Chain Cost Structures in Cement Industry

The cement industry's supply chain cost structure comprises multiple interconnected components that collectively determine total operational expenses and product competitiveness. Subiyanto and Suyoto (2020) conducted extensive empirical research examining logistics costs across eight cement projects in Indonesia spanning 2010-2018, revealing that total logistics costs constitute approximately 14.6% of total investment costs. Their detailed decomposition identified five primary cost categories: insurance costs (0.11%), customs clearance costs (6.52%), foreign logistics costs (6.62%), domestic manufacture costs (0.47%), and domestic logistics costs (0.89%). This cost structure framework provides essential benchmarking data for understanding relative cost distributions and identifying high-impact optimization opportunities within cement supply chains.[3]

Research on cement supply chain optimization has increasingly employed mathematical programming approaches to minimize distribution costs and improve operational efficiency. A study on supply chain network optimization in the Indonesian cement industry demonstrated that application of MILP methods using specialized software could reduce total supply chain costs by 4%, equivalent to approximately 451 billion rupiah, through production cost efficiency gains of 3% and distribution improvements of 7%. The highest efficiency improvements were recorded in the distribution process from cement plants to packing plants, reaching 44% cost reduction potential. These findings underscore the substantial financial impact achievable through systematic optimization of cement distribution networks.[1]

The integration of production and distribution planning represents another critical dimension of cement supply chain cost management. Research by Sundari et al. (2021) on multi-site cement plant operations proposed integrated production-distribution planning models that simultaneously optimize production allocation and distribution routing decisions. Their MILP-based approach considered raw material fulfillment through multi-supplier schemes, production capacity constraints, demand requirements, supply limitations, and the combined impact of production costs, logistics costs, and product revenue on overall profitability. This integrated perspective addresses the interdependencies between production decisions and downstream logistics costs that traditional sequential planning approaches often overlook.[4]

Maritime transportation costs represent particularly significant challenges for cement companies operating in archipelagic regions. Christianto et al. (2020) examined maritime inventory routing problems in the Indonesian cement industry, where sea transportation costs contribute substantially to overall expenses due to cement's heavy weight, low price point, and geographically dispersed packing plant locations. Their MILP optimization model for multi-product cement carriers using undedicated ship compartments achieved a global optimum solution with total transportation costs of approximately IDR 3.69 billion for a two-week planning period while maintaining required inventory availability levels. This research highlights the importance of specialized optimization approaches tailored to the unique characteristics of cement maritime logistics.[5]

2.2 Key Performance Indicators in Logistics and Manufacturing

The systematic measurement of supply chain and logistics performance through Key Performance Indicators has emerged as a fundamental management practice enabling operational visibility, continuous improvement, and strategic alignment. Research has established that effective KPI systems should encompass multiple performance dimensions including cost efficiency, operational effectiveness, service quality, resource utilization, and strategic alignment with organizational objectives.[9][10]

A comprehensive study on economic sustainability KPIs in the cement industry conducted in Pakistan identified 14 critical indicators through literature review and expert consultation, ultimately ranking them using Taguchi signal-to-noise ratio methodology. The research findings indicated that increase in market share, development of new export markets, and operating cost optimization represented the most significant KPIs from cement industry experts' perspectives. This ranking provides valuable insights into the relative priorities that practitioners assign to different performance dimensions when pursuing economic sustainability objectives.[7]

The concept of Lean Logistics 4.0 has introduced new perspectives on logistics performance measurement by integrating lean manufacturing principles with Industry 4.0 technologies. Research employing the Analytic Hierarchy Process (AHP) methodology with 15 logistics experts identified eight priority KPIs: investment and innovations in automation and new equipment, handling and transportation waste reduction, workforce flexibility, lead time minimization, predictive and prescriptive capacity enhancement, punctuality and completeness of delivery, total logistics cost management, and setup reduction. These indicators reflect the evolving nature of logistics performance measurement in technologically advanced operational environments.[8]

Hierarchical structures of KPIs have been proposed to address the relationships and dependencies between different performance metrics in manufacturing operations. Research by Li et al. (2018) developed a hierarchical KPI framework distinguishing between outcome metrics, supporting metrics, and their interconnections. This structural approach enables manufacturing engineers and managers to understand how operational improvements in supporting metrics cascade through the system to influence ultimate outcome performance indicators. Such hierarchical perspectives are particularly valuable for identifying leverage points where targeted interventions can generate disproportionate performance improvements.[10]

The application of balanced scorecard methodologies to supply chain performance measurement has gained considerable traction in academic research and industry practice. Studies have demonstrated that integrating financial indicators with assessments of customer relationships, internal processes, and innovation capabilities provides more comprehensive performance visibility than traditional financially-focused approaches. This multi-dimensional perspective enables organizations to monitor both short-term operational performance and long-term strategic positioning simultaneously.[9]

2.3 Optimization Approaches for Packing and Distribution

Mathematical optimization methodologies have demonstrated substantial potential for improving packing and distribution efficiency in manufacturing industries including cement production. Mixed Integer Linear Programming represents the most commonly employed optimization technique for cement distribution network problems due to its ability to handle discrete decision variables such as facility selection, route assignment, and shipment scheduling while maintaining computational tractability.[2][5][4]

Research on cement distribution optimization in Java and Bali markets developed comprehensive MILP models incorporating 2 cement plants, 5 packing plants, 6 virtual distribution centers, and 128 market areas with multiple transportation modes including ships and trucks. The optimization model's implementation resulted in potential supply chain cost savings of up to Rp49.6 billion compared to existing allocation patterns, while also identifying packing plant operations with low production utility that could be economically discontinued. These findings demonstrate the financial magnitude of optimization opportunities available through systematic mathematical modeling approaches.[2]

The bin packing problem and its variants have particular relevance to logistics optimization in manufacturing contexts. Recent research on last-mile delivery optimization adapted the Variable Cost and Size Bin Packing Problem with Time Dependent Costs (VCSBPP-TD) to address delivery efficiency challenges. While originally developed for non-perishable parcel deliveries, the model demonstrated applicability to various distribution contexts by optimizing vehicle usage and resource allocation. The fundamental principles of bin packing optimization maximizing container utilization while minimizing total costs directly apply to cement bag loading, truck capacity utilization, and warehouse space optimization challenges.[11]

Dynamic optimization approaches for real-time logistics planning have emerged as important complements to traditional static optimization models. Research on precast concrete component transportation and storage developed dynamic optimization methods based on real-time scheduling extracted from 4D Building Information Models (BIM). The real-time position tracking of components throughout the transportation process enabled adaptive optimization that responds to actual operational conditions rather than static planning assumptions. These dynamic optimization concepts offer potential applications in cement logistics where delivery schedules, truck availability, and customer demand patterns exhibit significant variability.[12]

Construction material supply chain optimization research provides additional relevant insights applicable to cement distribution challenges. A study on delivery planning for construction material stores employed MILP mathematical models to calculate minimum delivery costs while adhering to operational constraints. The optimization approach systematically addressed vehicle routing, load consolidation, delivery timing, and capacity utilization decisions to achieve measurable cost reductions. Given the structural similarities between construction material distribution and cement logistics, these methodological approaches offer transferable optimization strategies.[13]

3. Research Methodology

3.1 Research Framework and Design

This research employs a mixed-methods approach combining quantitative analysis of empirical logistics cost data with qualitative assessment of Key Performance Indicator frameworks relevant to cement industry packing and logistics operations. The research framework is structured around three primary components: systematic literature review and KPI identification, empirical cost data analysis from cement industry case studies, and optimization modeling for cost reduction opportunity assessment. This comprehensive methodology enables both descriptive analysis of current industry performance benchmarks and prescriptive recommendations for optimization strategies.

The research adopts an exploratory-descriptive design appropriate for investigating relatively under-researched phenomena while establishing baseline performance metrics and cost structures. Data collection encompasses secondary data from published cement industry case studies, academic research documenting logistics optimization implementations, and industry reports on supply chain performance metrics. The triangulation of multiple data sources enhances the validity and generalizability of research findings while enabling cross-validation of cost structure patterns and performance benchmarks across different operational contexts.

3.2 Data Collection and Sources

Primary empirical data for logistics cost analysis derives from comprehensive cement project documentation covering eight major cement plant construction and operational projects executed in Indonesia between 2010 and 2018 (Subiyanto and Suyoto, 2020). These projects represent diverse geographical contexts including Java, Sumatra, Sulawesi, and Kalimantan islands, providing variation in infrastructure availability, transportation distances, and multi-modal logistics requirements. Cost data was collected on a quarterly basis throughout project execution periods and carefully categorized according to specific logistics cost components including insurance, customs clearance, foreign logistics, domestic manufacturing delivery, and domestic logistics operations.[3]

Supplementary data sources include published case studies of supply chain optimization implementations in the cement industry, particularly focusing on Indonesian and Southeast Asian contexts. These sources provide documented evidence of cost reduction achievements, optimization methodology applications, and performance improvement outcomes from MILP model implementations. Additional data on KPI frameworks and performance measurement systems derives from academic literature spanning logistics management, supply chain optimization, and manufacturing performance measurement domains.[5][1][2]

The reliability and validity of cost data is ensured through multiple verification mechanisms. All project cost data underwent daily verification during collection, quarterly consolidation and review processes, and final audit validation procedures. Costs were attributed to specific logistics categories based on expert judgment from project management professionals with direct operational experience. This rigorous data collection and verification approach provides confidence in the accuracy of reported cost structures and performance metrics.[3]

3.3 Key Performance Indicator Selection Framework

The identification and selection of relevant KPIs for cement packing and logistics operations follows a systematic framework based on established performance measurement principles. The KPI selection process integrates multiple criteria including strategic relevance to organizational objectives, measurability and data availability, actionability for management decision-making, and benchmarkability for performance comparison. This multi-criteria approach ensures that selected KPIs provide practical value for operational management while enabling meaningful performance assessment.

KPI categories for cement packing and logistics are structured according to five primary performance dimensions: cost efficiency metrics measuring total logistics costs and cost per unit delivered; operational efficiency indicators assessing resource utilization and productivity; service quality metrics evaluating delivery reliability and order fulfillment; inventory management indicators monitoring stock levels and turnover rates; and sustainability metrics addressing environmental impact and resource consumption. This dimensional structure provides comprehensive coverage of relevant performance aspects while facilitating balanced assessment across multiple organizational priorities.

The final KPI framework incorporates both outcome indicators that measure ultimate performance results and process indicators that monitor intermediate operational characteristics influencing outcomes. This hierarchical structure enables organizations to trace performance gaps from outcome deficiencies back to specific process inefficiencies requiring corrective action. The framework also distinguishes between leading indicators providing early warning of potential performance issues and lagging indicators confirming historical performance achievement.

3.4 Analytical Approach

The analytical methodology employs descriptive statistical analysis to characterize logistics cost structures, identify central tendencies and variability in performance metrics, and establish industry benchmarks. Cost component distributions are analyzed using percentage contribution analysis to quantify the relative significance of different logistics cost categories. Comparative analysis across geographical regions and project characteristics reveals the impact of infrastructure availability, transportation distances, and operational scale on logistics cost structures.

Optimization potential assessment utilizes documented case study results from MILP model implementations in cement distribution networks. Cost reduction percentages achieved through optimization are analyzed in relation to baseline cost structures to estimate absolute financial impact magnitudes. The analysis examines which supply chain segments production-to-packing plant distribution, packing plant-to-market distribution, or integrated network optimization yield the highest cost reduction potentials. This segment-specific analysis provides guidance for prioritizing optimization investment decisions.

Performance benchmarking methodology compares observed logistics costs and operational performance metrics against identified best practices and optimization-achieved performance levels. Gap analysis quantifies the difference between current performance and benchmark standards, establishing the magnitude of improvement opportunities available. The benchmarking approach enables cement industry organizations to assess their relative performance positioning and identify specific dimensions requiring targeted improvement initiatives.

4. Results and Discussion

4.1 Logistics Cost Structure Analysis

The empirical analysis of cement industry logistics costs reveals a complex cost structure with significant variation across different operational contexts and geographical regions. Based on comprehensive data from eight major cement projects in Indonesia, the average total logistics costs constitute 14.60% of total investment costs, with individual project variations ranging from 13.53% to 22.56% (Subiyanto and Suyoto, 2020). This substantial range demonstrates the significant impact that geographical location, infrastructure availability, and operational design decisions exert on logistics cost efficiency.[3]

The decomposition of total logistics costs into constituent components provides critical insights for identifying optimization priorities. Foreign logistics costs represent the largest single component at 6.62% of total investment costs, closely followed by customs clearance costs at 6.52%. These two international logistics components collectively account for approximately 90% of total logistics expenses, highlighting the disproportionate cost impact of cross-border supply chain activities. Domestic logistics costs comprise 0.89% of total investment, domestic manufacture delivery costs account for 0.47%, and insurance costs represent 0.11% of total investment. This cost structure pattern reflects the capital-intensive nature of cement manufacturing equipment procurement and the dependence on international suppliers for specialized machinery and technology.[3]

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Regional analysis reveals systematic patterns in logistics cost efficiency correlated with infrastructure development and geographical characteristics. Table 1 presents the detailed logistics cost breakdown across the eight analyzed cement projects, demonstrating clear performance differentiation between projects located in different Indonesian islands.

Table 1: Logistics Cost Components by Project (Percentage of Total Investment)

Project Name	**Location**	**Insurance**	**Domestic Manufacture**	**Domestic Logistics**	**Customs Clearance**	**Foreign Logistics**	**Total Logistics Cost**
Rembang	Java	0.09%	0.49%	1.73%	5.25%	5.97%	13.53%
Indarung	Sumatra	0.15%	0.54%	0.49%	8.49%	8.66%	18.33%
P14	Java	0.12%	0.60%	0.46%	8.02%	7.97%	17.17%
Tuban#2	Java	0.16%	0.46%	0.39%	9.41%	9.03%	19.45%
Bayah	Java	0.10%	0.37%	1.10%	6.52%	6.34%	14.44%
Banyumas	Java	0.13%	0.45%	1.76%	8.35%	7.87%	18.55%
Maros	Sulawesi	0.12%	0.80%	1.30%	7.39%	8.24%	17.85%
Train#1	Kalimantan	0.16%	1.00%	0.93%	10.10%	10.37%	22.56%
National Average	**Indonesia**	**0.11%**	**0.47%**	**0.89%**	**6.52%**	**6.62%**	**14.60%**

Source: Adapted from Subiyanto and Suyoto (2020)

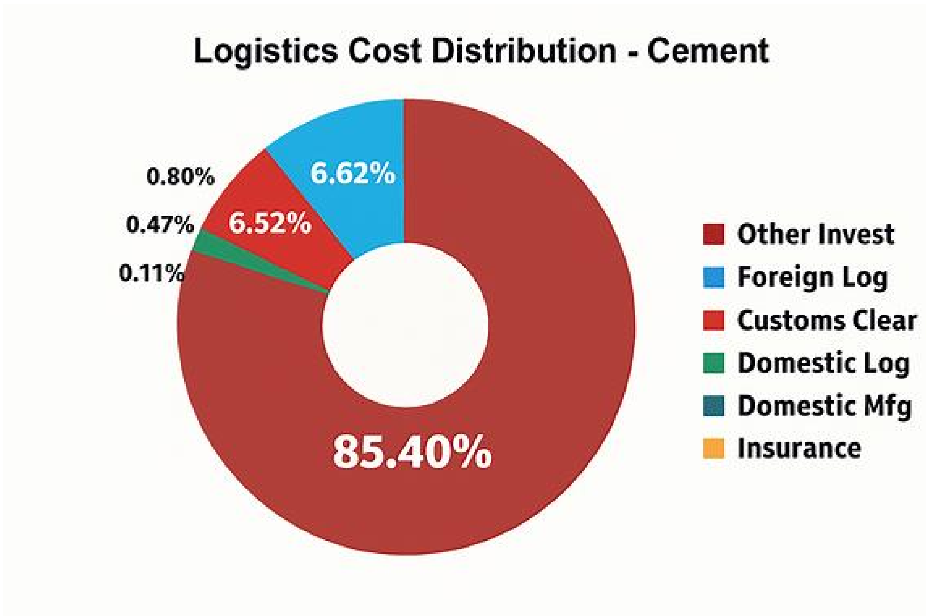

Figure 1: Logistics Cost Components Distribution in Cement Industry Operations
Source: Based on empirical data from Subiyanto and Suyoto (2020) - eight cement projects in Indonesia (2010-2018)

This colorful donut chart effectively visualizes the relative proportions of different logistics cost components, making it immediately apparent that foreign logistics and customs clearance dominate the cost structure. The professional color scheme uses distinct colors for easy differentiation, while the clean typography ensures excellent readability.

The decomposition of total logistics costs into constituent components provides critical insights for identifying optimization priorities. Foreign logistics costs represent the largest single component at 6.62% of total investment costs, closely followed by customs clearance costs at 6.52%. These two international logistics components collectively account for approximately 90% of total logistics expenses, highlighting the disproportionate cost impact of cross-border supply chain activities.

The data reveals that projects in Java Island, which possesses Indonesia's most developed infrastructure network, generally achieve lower logistics costs than projects in outer islands. The Rembang project represents the most cost-efficient case at 13.53% total logistics costs, benefiting from proximity to major international seaports, extensive road networks, and abundant logistics service providers. Conversely, the Train#1 project in Kalimantan experienced the highest logistics costs at 22.56%, reflecting infrastructure limitations, absence of local international seaports requiring additional transshipment, and constrained availability of specialized logistics equipment.[3]

Regional aggregation of logistics costs further clarifies the infrastructure impact on cost efficiency. Table 2 presents logistics cost averages by major Indonesian islands, demonstrating systematic cost differentials attributable to regional infrastructure development levels.

Table 2: Regional Logistics Cost Comparison by Island

Island/Regio	Insuranc	Domestic	Domesti	Customs	Foreign	Total

n	e	Manufactur e	c Logistics	Clearanc e	Logistic s	Logistic s Cost
Java	0.12%	0.48%	1.09%	7.51%	7.44%	16.63%
Sumatra	0.15%	0.54%	0.49%	8.49%	8.66%	18.33%
Sulawesi	0.12%	0.80%	1.30%	7.39%	8.24%	17.85%
Kalimantan	0.16%	1.00%	0.93%	10.10%	10.37%	22.56%
National Average	**0.11%**	**0.47%**	**0.89%**	**6.52%**	**6.62%**	**14.60%**

Source: Adapted from Subiyanto and Suyoto (2020)
The regional comparison demonstrates that Java Island achieves approximately 35% lower total logistics costs compared to Kalimantan Island, despite being only 14% above the national average. This cost advantage derives primarily from Java's superior port infrastructure with two major international seaports enabling direct vessel access, extensive highway networks reducing domestic transportation distances and costs, and abundant availability of specialized logistics equipment including multi-axle trailers and mobile cranes. These infrastructure advantages reduce the necessity for multiple transshipment operations and enable more efficient direct delivery routes from international ports to project sites.[3]

4.2 Supply Chain Optimization Potential

The application of mathematical optimization techniques to cement supply chain networks has demonstrated substantial cost reduction potential across multiple operational segments. Research on Indonesian cement distribution networks employing MILP optimization methods documented total supply chain cost reductions of 4%, equivalent to approximately 451 billion rupiah annually. This cost reduction derived from two primary sources: production cost efficiency improvements of 3% through optimized production load redistribution among facilities, and distribution cost reductions of 7% through enhanced routing and facility utilization.[1]

The distribution segment optimization yielded particularly impressive results, with the highest efficiency improvements occurring in the cement plant to packing plant distribution process, reaching 44% cost reduction. This substantial improvement opportunity reflects the complexity of multi-echelon distribution decisions involving facility location selection, production allocation, inventory positioning, and transportation mode choices. The optimization model enabled more even redistribution of production loads between facilities, increased capacity utilization at previously underutilized packing plants, and systematic elimination of inefficient transportation routes.[1]

Analysis of optimal versus existing allocation patterns in cement distribution networks revealed cost saving potential of up to Rp49.6 billion through systematic reallocation of production and distribution flows. The optimization also identified specific packing plants operating with low production utility that could be economically shut down without compromising market service levels, generating additional cost savings through fixed cost elimination. These findings demonstrate that many cement companies operate with suboptimal facility and distribution network configurations that systematically generate excess costs without corresponding service benefits.[2]

Maritime logistics optimization for cement distribution in archipelagic regions presents specialized challenges requiring tailored solution approaches. Research on maritime inventory routing for Indonesian cement operations developed MILP models specifically addressing multi-product cement carriers with undedicated compartments, a configuration distinct from specialized chemical tankers requiring dedicated compartments. The optimization achieved global optimum solutions with transportation costs of IDR 3.69 billion for two-week planning periods while maintaining required inventory availability at consumption ports. This specialized optimization approach addresses the unique operational characteristics of bulk cement maritime transportation including flexible compartment allocation, inventory management at destination facilities, and coordinated vessel scheduling across multiple ports.[5]

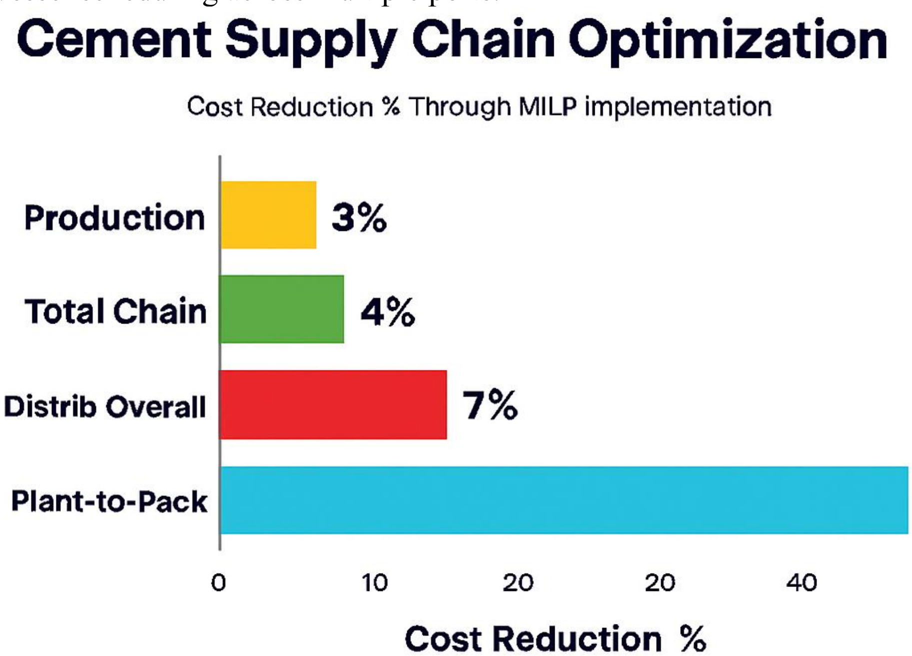

Figure 2: Supply Chain Optimization Potential Through Mathematical Programming in Cement Industry

Sources: Taken from Mubarok et al. (2025)

This vibrant horizontal bar chart dramatically illustrates the varying optimization potential across different supply chain segments. The gradient colors and professional styling make it visually appealing while clearly demonstrating that plant-to-packing distribution offers the most significant improvement opportunity at 44% cost reduction potential.

The distribution segment optimization yielded particularly impressive results, with the highest efficiency improvements occurring in the cement plant to packing plant distribution process, reaching 44% cost reduction. This substantial improvement opportunity reflects the complexity of multi-echelon distribution decisions involving facility location selection, production allocation, inventory positioning, and transportation mode choices.

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4.3 Key Performance Indicators for Cement Packing and Logistics

The systematic measurement and monitoring of cement packing and logistics performance requires a comprehensive framework of Key Performance Indicators spanning multiple operational dimensions. Based on integration of cement industry research and general logistics performance measurement literature, Table 3 presents a structured KPI framework organized by performance category with specific metrics, measurement approaches, and strategic relevance.

Table 3: Comprehensive KPI Framework for Cement Packing and Logistics Operations

Performance Category	**Key Performance Indicator**	**Measurement Formula**	**Strategic Relevance**	**Target Benchmark**
Cost Efficiency	Total Logistics Cost Ratio	(Total Logistics Costs / Total Investment) × 100%	Overall cost efficiency	14.60% (average)
	Foreign Logistics Cost Ratio	(Foreign Logistics Costs / Total Investment) × 100%	International supply chain efficiency	6.62%
	Customs Clearance Cost Ratio	(Customs Costs / Total Investment) × 100%	Import process efficiency	6.52%
	Domestic Logistics Cost Ratio	(Domestic Logistics Costs / Total Investment) × 100%	Domestic distribution efficiency	0.89%
	Cost per Ton Delivered	Total Distribution Costs / Tons Delivered	Unit cost efficiency	Context-dependent
Operational Efficiency	Packing Plant Utilization Rate	(Actual Production / Capacity) × 100%	Asset utilization	>80%
	Distribution Center Efficiency	Orders Processed / Labor Hours	Productivity metric	Industry benchmark
	Vehicle Capacity Utilization	(Actual Load / Vehicle Capacity) × 100%	Transportation efficiency	>85%

	Loading/Unloading Cycle Time	Average Time per Loading Operation	Process efficiency	Minimize
Service Quality	On-Time Delivery Performance	(On-Time Deliveries / Total Deliveries) × 100%	Reliability metric	>95%
	Order Fill Rate	(Complete Orders / Total Orders) × 100%	Service level	>98%
	Order Accuracy Rate	(Accurate Orders / Total Orders) × 100%	Quality metric	>99%
	Customer Satisfaction Score	Survey-based measurement	Service perception	>4.0/5.0
Inventory Management	Inventory Turnover Ratio	Cost of Goods Sold / Average Inventory	Inventory efficiency	>12 times/year
	Stock-Out Frequency	Number of Stock-Out Events / Period	Availability metric	<1% of SKUs
	Inventory Carrying Cost	(Inventory Value × Carrying Cost %) / Period	Holding cost efficiency	<15% annually
	Days of Inventory	(Average Inventory / Daily Demand)	Inventory level	15-30 days
Sustainability	Carbon Emissions per Ton-Km	CO_2 Emissions / (Tons × Distance)	Environmental impact	Minimize
	Fuel Consumption Efficiency	Fuel Volume / Ton-Kilometers	Energy efficiency	Industry benchmark
	Packaging Material Waste	Waste Volume / Total Packaging Volume	Material efficiency	<2%

Sources: Adapted from multiple sources

The cost efficiency KPIs provide direct measurement of logistics expense levels relative to total investment or revenue, enabling systematic monitoring of cost structure evolution and identification of cost escalation trends. The empirical benchmarks derived from Indonesian cement project data establish industry-relevant targets for total logistics costs (14.60%), foreign logistics costs (6.62%), and customs clearance costs (6.52%) that organizations can use for performance comparison. Organizations achieving costs below these benchmarks demonstrate superior logistics efficiency, while those exceeding benchmarks face opportunities for cost reduction initiatives.[3]

Operational efficiency indicators measure how effectively organizations utilize available resources including production facilities, distribution centers, transportation fleets, and labor. Packing plant utilization rates and vehicle capacity utilization metrics directly impact unit costs through fixed cost allocation effects higher utilization spreads fixed costs across larger production or transportation volumes, reducing per-unit costs. Research has demonstrated that optimization-driven redistribution of production loads can increase facility utilization at previously underutilized plants, contributing to overall cost reduction.[8][1][2]

Service quality KPIs address the customer-facing performance dimensions that determine market competitiveness and customer retention. On-time delivery performance represents a particularly critical metric in cement supply chains where construction project schedules create time-sensitive demand patterns. Industry best practice targets of 95% or higher on-time delivery rates establish minimum service expectations, while leading performers achieve 98% or better performance levels. Order fill rates and accuracy metrics complement delivery timeliness by measuring the completeness and correctness of deliveries, preventing costly construction project delays caused by material shortages or specification errors.[8]

Inventory management KPIs balance the competing objectives of ensuring product availability to meet demand while minimizing the capital costs and storage expenses associated with holding inventory. The inventory turnover ratio provides a comprehensive efficiency measure indicating how many times per year inventory is completely cycled through the system higher turnover rates indicate more efficient inventory management with lower carrying costs. For cement operations, targeting 12 or more inventory turns annually represents an aggressive efficiency standard that requires sophisticated demand forecasting and supply chain coordination.[10][5]

4.4 Implementation Framework for KPI-Based Optimization

The practical implementation of KPI-based logistics optimization in cement industry operations requires a systematic framework encompassing performance measurement system design, data collection infrastructure, analytical processes, and organizational change management. The implementation framework consists of five sequential phases: baseline assessment and KPI selection, data collection system establishment, performance monitoring and reporting, root cause analysis and improvement prioritization, and optimization intervention implementation.[9][10]

The baseline assessment phase establishes current performance levels across selected KPIs, providing the reference point for measuring improvement achievement. Organizations should conduct comprehensive audits of existing logistics costs, operational efficiency metrics, service quality performance, and inventory management practices. This baseline data enables identification of the most significant performance gaps relative to industry benchmarks and strategic targets, supporting prioritization of improvement initiatives based on financial impact potential and strategic importance.[7][3]

Data collection system establishment requires developing infrastructure and processes for systematic, ongoing capture of KPI-relevant data. Modern cement operations should leverage digital technologies including automated weighbridge systems for truck load measurement, GPS tracking for vehicle location and delivery confirmation, warehouse management systems for inventory tracking, and enterprise resource planning systems for financial data consolidation. The integration of these data sources into unified performance dashboards enables real-time visibility into operational performance and early detection of emerging issues requiring management attention.[14][8]

Performance monitoring and reporting processes translate raw operational data into actionable management information through regular KPI reporting cycles. Best practice approaches employ tiered reporting frameworks with daily operational metrics for frontline supervisors, weekly trend reports for middle management, and monthly strategic dashboards for executive leadership. The reporting framework should distinguish between different KPI types outcome metrics that measure ultimate performance results, process metrics that monitor operational characteristics, and leading indicators that provide early warning of potential performance deterioration.[10]

Root cause analysis methodologies systematically investigate the underlying causes of KPI performance shortfalls, moving beyond symptom identification to address fundamental process or system deficiencies. When logistics cost ratios exceed benchmark levels, analysis should examine whether root causes lie in transportation route inefficiency, suboptimal facility location, inadequate carrier contract negotiation, or other specific process failures. This diagnostic approach enables targeted corrective actions addressing actual problems rather than implementing generic improvements with uncertain relevance.[7][3]

Optimization intervention implementation represents the action phase where mathematical optimization models, process redesigns, technology implementations, or organizational changes are deployed to improve KPI performance. For cement distribution networks, MILP optimization models can systematically evaluate alternative facility configurations, production allocations, and transportation routes to identify globally optimal solutions. The documented cost reduction achievements of 4-44% across different supply chain segments demonstrate the financial magnitude of properly implemented optimization interventions.[1][2]

The organizational change management dimension of KPI implementation addresses the human and cultural factors that determine whether performance measurement systems generate sustainable improvements. Research indicates that successful implementation requires executive sponsorship demonstrating leadership commitment, clear accountability assignment linking specific managers to KPI performance, training programs building analytical capabilities, and incentive alignment rewarding KPI achievement. Without addressing these organizational factors, technically sound KPI systems often fail to generate behavioral changes and performance improvements.[14]

5. Conclusion

This research has comprehensively examined the optimization of packing and logistics costs in the cement industry through systematic application of Key Performance Indicator frameworks. The empirical analysis of cement industry logistics cost structures reveals that total logistics costs typically constitute 14.60% of total investment costs, with significant variation from 13.53% to 22.56% depending on geographical location and infrastructure availability. Foreign logistics costs (6.62%) and customs clearance expenses (6.52%) represent the dominant cost components, collectively accounting for approximately 90% of total logistics expenses. These findings establish critical benchmarking standards enabling cement industry organizations to assess their relative cost efficiency and identify improvement priorities.

The research demonstrates substantial optimization potential through application of mathematical programming approaches, particularly Mixed Integer Linear Programming models. Documented case studies reveal achievable cost reductions ranging from 4% in total supply chain costs to 44% in specific distribution segments through systematic optimization of facility utilization, production allocation, and transportation routing. The magnitude of these potential savings quantified at hundreds of billions of rupiah annually in Indonesian cement operations underscores the significant financial impact of rigorous optimization methodologies. Organizations currently operating with suboptimal distribution network configurations and facility allocations systematically incur excess costs that mathematical optimization can eliminate.

The comprehensive KPI framework developed through this research provides cement industry practitioners with structured performance measurement spanning five critical dimensions: cost efficiency, operational efficiency, service quality, inventory management, and sustainability. The framework distinguishes between outcome indicators measuring ultimate performance results and process indicators monitoring intermediate operational characteristics, enabling organizations to trace performance gaps from outcomes back to specific process inefficiencies. The integration of empirical industry benchmarks with each KPI provides actionable targets for performance comparison and improvement goal-setting. Implementation of this KPI framework enables data-driven decision-making, continuous performance monitoring, and systematic identification of optimization opportunities.

The research findings have significant practical implications for cement industry management. First, organizations should conduct comprehensive audits of their current logistics cost structures using the component categories and benchmarks established in this research to identify specific areas of cost excess. Second, companies should prioritize optimization of the cement plant to packing plant distribution segment, where research demonstrates the highest cost reduction potential reaching 44%. Third, infrastructure factors including port access, road network quality, and logistics equipment availability exert dominant influence on logistics costs, suggesting that facility location decisions should systematically evaluate logistics cost implications rather than focusing exclusively on production factors. Fourth, organizations should implement comprehensive KPI monitoring systems spanning all five performance dimensions rather than narrow cost-focused measurement that may inadvertently compromise service quality or sustainability performance.

Several limitations of this research warrant acknowledgment. The empirical cost data derives predominantly from Indonesian cement projects, potentially limiting generalizability to other geographical contexts with different regulatory environments, infrastructure characteristics, and market structures. The optimization potential estimates rely on published case studies rather than controlled experimental designs, introducing potential for selection bias toward successful implementations. The KPI framework development draws primarily on existing literature rather

than empirical validation through industry pilot implementations, suggesting need for practical testing and refinement.
Future research directions should address these limitations while extending the scope of investigation. Comparative analysis of logistics cost structures across multiple countries and regulatory regimes would enhance understanding of how institutional factors influence cost patterns and optimization opportunities. Longitudinal studies tracking organizations through KPI implementation processes would provide empirical evidence of actual performance improvement trajectories and implementation challenges. Integration of emerging technologies including Internet of Things sensors, artificial intelligence-based demand forecasting, and blockchain-enabled supply chain transparency into the KPI and optimization framework would address the digital transformation occurring in cement industry logistics. Investigation of sustainability-focused optimization objectives balancing cost minimization with carbon emissions reduction would align cement logistics practices with global decarbonization imperatives. These research extensions would further advance the theoretical foundations and practical applicability of logistics optimization in the cement industry.

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