Identifying Key Performance Indicators (KPIs) and Measurement Frameworks to Assess and Improve the Performance of Construction Supply Chains

Hasanain Ali Ismail Kalf, Al-Manara College for Medical Sciences/ (Maysan)/Iraq.
Email: hasanainaliismailkalf@uomanara.edu.iq

Alhuseein Ali Ibrid, Al-Hadi University College, Baghdad,10011, Iraq.
Email: msc.Al-Hussein.Ali.Ibrid@huc.edu.iq

Hussein Basim Furaijl, College of Pharmacy/ University of Al-Ameed/Iraq.
Email: h.alfrejee@alameed.edu.iq

Ali Salma, Department of Law, College of Law, University of Imam Jaafar AL-Sadiq/Iraq.
Email: ali.salman@sadiq.edu.iq

Ayad Abas Hasan, College of Media/ The Islamic University in Najaf, Iraq.
Email: alganabeeayad331@gmail.com

Hayder Hasan Shatawi, Department of Law, College of Law, Sawa University, Almuthana,
Iraq. Email: dr.hayder1985@sawauniversity.edu.iq

Noor Qusai, Department of management/ Al-Nisour University College/Iraq.
Email: noor.q.bs@nuc.edu.iq

Riadh Abdul Retha, Department of Education/ Mazaya university college/ Iraq.
Email: Abass.riadh@mpu.edu.iq

Alhasan Ahmed Hasan*, College of education/ National University of Science and
Technology, Dhi Qar, Iraq. Email: rathababbass2000@gmail.com

ABSTRACT

Efficient supply chain management is integral to the success of construction projects, facilitating timely delivery, cost-effectiveness, and overall project success. Identifying and quantifying Key Performance Indicators (KPIs) is essential for evaluating supply chain performance. This research aims to explore diverse KPIs and measurement frameworks in the construction industry to enhance supply chain efficiency. By analysing literature, expert perspectives, and empirical data, this paper provides a comprehensive strategy for improving construction supply chain performance. Delivery performance, cost control, inventory management, and quality assurance emerge as crucial KPIs. The insights gained from this study can assist construction company administrators and practitioners in evaluating supply chain performance and implementing improvements.

KEYWORDS: Supply Chain, Key Performance Indicators, Delivery Performance, Cost Control, Inventory Management, Quality Assurance.

INTRODUCTION

The construction sector is distinguished by its complex and dynamic characteristics,

involving diverse participants, processes, and resources. Globally recognized as pivotal, the construction industry substantially contributes to economic advancement and facilitates infrastructural development on an international level (Bakırlıoğlu & Kohtala, 2019). The domain of this discipline encompasses a broad spectrum of activities, encompassing the construction of residential and commercial edifices alongside the execution of extensive infrastructure ventures. Supply chain management assumes paramount importance in facilitating the streamlined movement of resources from suppliers to project sites. Effective construction project management within the supply chain is essential to attain punctual supply deliveries, mitigate project expenditures, elevate project standards, and enhance overall operational efficiency (Soman & Molina-Solana, 2022). Given the complexity of construction supply chains, it is vital to select and apply suitable KPIs and measurement frameworks to evaluate and enhance their effectiveness.

The construction industry's supply chain comprises interconnected processes including distribution, inventory management, and transportation. Its effectiveness significantly influences project outcomes, as inefficiencies can result in delays, higher costs, and reduced quality (Khanzadi, Sheikhkhoshkar, & Banihashemi, 2020). Managing the business is challenging due to its distinctive features: a project-oriented structure, reliance on temporary labour, and diverse supply and commodity utilization (Chidambaram, Narayanan, & Idrus, 2012). Traditionally, construction supply chain management has been reactive and decentralized. Conventional methods often lacked effective collaboration, transparency, and integrated data management, prioritizing cost reduction. This approach led to inefficiencies, limited resource visibility, and challenges in forecasting project outcomes.

In contemporary times, the construction sector has acquired a profound awareness regarding the importance of enhancing supply chain performance to maintain competitiveness and expedite project timelines (Alshihre, Chinyio, Nzekwe-Excel, & Daniel, 2020). Considerable research and practical efforts have been devoted to developing suitable KPIs and measurement frameworks tailored to address the unique challenges inherent in the construction supply chain (Brown & Lee, 2019). Construction enterprises aim to augment supply chain efficiency and productivity by optimizing processes, engaging stakeholders, and integrating technology. Despite progress in research and improvement efforts, a notable gap persists in identifying and utilizing tailored KPIs and measurement frameworks for the construction sector. Current research often applies conventional supply chain management concepts, overlooking the unique characteristics and challenges inherent in construction supply networks (Issa, 2013).

Furthermore, it is noteworthy that the existing body of literature predominantly focuses on specific aspects of construction supply chain management, such as procurement or logistics, rather than providing a holistic and integrated framework for assessing performance (Afraz, Bhatti, Ferraris, & Couturier, 2021). This inconsistency underscores the need for a thorough investigation into selecting and implementing KPIs and measurement frameworks that cover all crucial aspects of establishing an effective supply chain management system.

This study carries substantial significance for stakeholders across the construction sector. Implementing efficient supply chain management methods holds promise for improving project outcomes, client contentment, and profitability within the industry. By identifying and adopting pertinent KPIs, organizations stand to gain invaluable insights into their supply chain operations. This, in turn, empowers decision-makers to prioritize areas in need of enhancement

based on factual data (Rathnayake, Wedawatta, & Tezel, 2022). Moreover, this study benefits suppliers and contractors in the construction supply chain. Implementing transparent and effective supply chain management fosters improved communication, collaboration, and trust among stakeholders, promoting enduring partnerships and reducing conflict risks. Additionally, the study's findings can guide regulatory bodies and industry groups in developing policies that encourage optimal practices and long-term sustainability in building supply chain management (Charlesraj & Gupta, 2019).

The principal aim of this study is to identify and assess the relevant KPIs and measurement frameworks capable of effectively evaluating and improving the efficiency of building supply chains. This research endeavours to bridge the current gap in literature concerning the building supply chain by providing a comprehensive understanding of the pivotal factors influencing the efficiency and effectiveness of supply chains in the construction industry (Okudan, Budayan, & Arayici, 2022). The subsequent section of this manuscript constitutes the literature review, wherein an exhaustive analysis of extant literature is conducted to identify established KPIs and measurement frameworks pertinent to supply chain management in the construction sector (Benedict, 2017). The methods and results section delineates the study's approach in evaluating the practical utilization of KPIs and measurement frameworks in real building projects to enhance supply chain performance. It also highlights challenges and offers strategies to address them. The conclusion presents a tailored framework of KPIs for managing the building supply chain (Chen, Moretto, Jia, Caniato, & Xiong, 2021).

This research paper significantly augments the current understanding of construction supply chain management by delineating appropriate KPIs and measurement frameworks. The study aims to equip construction firms with the requisite tools to improve their supply chain operations and achieve enduring success in a highly competitive industry.

LITERATURE REVIEW

KPIs are objective and measurable metrics used to evaluate the efficiency and achievement of predetermined goals within an organization, process, or project. They serve as unbiased measurements for assessing organizational effectiveness in reaching desired outcomes. KPIs play a vital role in promoting alignment among different teams and individuals within an organization, ensuring their efforts align with overarching strategic objectives. Establishing specific KPIs that align with overarching goals is essential for fostering a collective sense of purpose and focus within the organization (Hall, 2017). KPIs offer a precise and quantitative framework for the systematic monitoring and evaluation of progress towards pre-established objectives. Performance benchmarks function as valuable instruments for enterprises to gauge their advancements and identify any outstanding obligations. KPIs supply pertinent information and insights, thereby facilitating informed decision-making processes based on rigorous data analysis. This approach allows organizations to rely on specified performance criteria rather than intuition or conjecture when making judgments, leading to decision-making procedures characterized by heightened effectiveness and efficiency.

Regular monitoring of KPIs enables organizations to assess their strengths and weaknesses comprehensively. Individuals, in pursuit of a competitive advantage, can strategically leverage their inherent strengths while concurrently addressing and enhancing their areas of weakness to augment overall performance. The incorporation of KPIs in organizational frameworks enhances

accountability, as employees and teams are more likely to embrace responsibility for their actions and exert substantial effort to achieve desired outcomes when they are aware that their performance is subject to evaluation against predetermined KPIs (Mofokeng & Chinomona, 2019).

Continuous improvement efforts are grounded in the utilization of KPIs. Organizations can discern trends, patterns, and areas for improvement by systematically monitoring their performance over time. The iterative cycle of monitoring, measuring, and optimizing performance propels ongoing growth and development. KPIs are pivotal in informing decision-making regarding resource allocation. To optimize resource allocation and attain optimal outcomes, a thorough understanding of the organizational domains functioning effectively and those requiring enhancement is imperative (Salvador, Forza, & Rungtusanatham, 2002). Organizations utilize KPIs to assess their performance against industry benchmarks and competitors. This comparison identifies best practices, market trends, and areas for improvement. KPIs foster transparency, encouraging open discussions among staff about progress and challenges. This openness promotes collaboration and the establishment of shared goals. Establishing a connection between KPIs and customer satisfaction/service levels enhances an organization's ability to meet client expectations. It is crucial to prioritize relevant, measurable KPIs aligned with strategic objectives, consistently evaluating and modifying them in response to evolving business circumstances or new objectives. Regular examination and updating of KPIs are imperative for adapting to organizational changes.

Importance of KPIs in Construction Supply Chains

KPIs are crucial in supply chains, monitoring and evaluating performance while pinpointing areas for improvement. They assist organizations in data-driven decision-making, optimizing operational processes, and ensuring efficient supply chain management. In the construction industry, an optimized supply chain is essential for timely material delivery, project delay mitigation, and overall project success. The measurement and management of constructing supply networks' effectiveness heavily rely on KPIs, which contribute to achieving organizational strategic objectives by generating valuable insights.

Enhancing Supply Chain Visibility and Transparency

One of the principal advantages associated with the utilization of KPIs within supply chains in the construction industry lies in the heightened level of visibility and transparency they afford across various facets of the supply chain. Construction enterprises can promptly access current and pertinent information regarding the performance of suppliers, logistics partners, and other relevant stakeholders. This is facilitated through the measurement and monitoring of pivotal indicators such as order fill rate, on-time delivery, and inventory turnover. The augmented transparency fosters enhanced collaboration and coordination, thereby elevating the efficacy of supply chain activities. As elucidated in a study conducted by Takeda-Berger et al. (2021), KPIs play a pivotal role in augmenting the visibility of material flow and inventory levels within supply chains in the construction industry. This enhanced transparency empowers construction companies to identify potential bottlenecks and inefficiencies, consequently enabling improved resource allocation and diminished lead times.

Facilitating Data-Driven Decision Making

KPIs furnish construction enterprises with crucial data for informed decision-making. Project

managers can optimize the supply chain and manage risks by assessing KPIs related to supplier performance, material costs, and transportation efficiency. Analysing supplier performance data enables the identification of high-performing vendors, fostering strategic relationships and improving project outcomes. Huang, Irfan, Fatima, and Shahid's (2023) research underscores the importance of KPIs in guiding data-driven decision-making in constructing supply networks. The positive impact of data-driven decision-making on project planning, resource allocation, and overall project outcomes is emphasized.

Improving Cost Control and Resource Utilization

Construction projects may face challenges such as cost overruns and inefficient resource utilization. KPIs play a crucial role in resource management and cost control. This analysis provides valuable insights into areas where costs can be reduced and resources optimized, as demonstrated by metrics like material waste ratio, equipment downtime, and labour productivity. The Building Industry Institute (CII) conducted a study highlighting the potential for substantial cost savings and improved profitability through the use of KPIs in cost control within building projects. Construction organizations can identify areas for improvement and implement effective cost reduction plans by closely monitoring KPIs related to cost performance and resource utilization.

Enhancing Project Performance and Delivery

The efficacy of supply chain management significantly influences project performance and delivery timelines. KPIs empower construction organizations to monitor project progress in real-time and detect any deviations from the predetermined schedule. By closely tracking KPIs such as schedule adherence and resource availability, project managers can promptly identify and address issues, ensuring the timely completion of projects. According to the findings of a study by Kueffner, Kopyto, Wohlleber, and Hartmann (2022), the application of KPIs for project monitoring and performance evaluation positively impacts the reduction of project durations and enhances delivery reliability within supplier chains in the construction industry.

Enhancing Supplier Performance and Collaboration

The effectiveness of suppliers and subcontractors plays a pivotal role in shaping the outcomes of projects within the construction sector's supply chains. KPIs offer a mechanism to evaluate and monitor supplier performance, guaranteeing adherence to critical quality and delivery standards. Construction enterprises can promote supplier collaboration and strengthen partnerships by judiciously employing KPI monitoring. Suppliers are more likely to align their efforts with project objectives and expectations when they are aware that their performance is systematically evaluated and appraised using designated metrics.

KPIs are pivotal in improving the efficiency of supply chains in the construction sector. They enable construction organizations to streamline supply chains and successfully complete projects through data-driven decision-making, increased visibility, and enhanced cost control. By strategically emphasizing relevant KPIs and consistently monitoring them, construction organizations have the potential to enhance project performance, mitigate risks, and gain a competitive advantage in the market.

Key Performance Indicators in Construction Supply Chains

The attainment of success in project management is contingent not on a singular criterion but on the convergence of multiple standards and performance indicators. While the traditional constraints of time, quality, and cost, encapsulated as the Golden Triangle, are crucial factors influencing project success, it is imperative to acknowledge that these limitations do not solely determine the project's outcome. This research delves into the primary determinants of project success, placing emphasis on quality, inventory control, cost management, and delivery date. Furthermore, the study explores the significance of KPIs and their potential applications in predicting trends, identifying potential issues, and driving improvements in project endeavours.

On-Time Delivery Performance

In the dynamic construction industry, On-Time Delivery Performance is a critical factor influencing success and client satisfaction. Timeliness is paramount in this fast-paced environment, and a well-managed construction company prioritizes completing projects within specified timelines. Client confidence and satisfaction hinge on the punctual execution of delivery performance, showcasing the company's commitment to promises and project timelines. The ability to provide reliable and timely service builds customer trust, fostering positive client relationships and facilitating potential future collaborations.

Delays in the building industry can lead to interconnected consequences affecting people scheduling and material availability. High-performance levels decrease the likelihood of disruptions and unforeseen costs, ensuring a streamlined workflow and timely commencement of subsequent project stages.

A construction company's reputation is built on its history of successful projects and adherence to deadlines, ensuring consistent and punctual delivery of goods and services. A heightened corporate performance contributes to a positive market reputation, making the organization a preferred choice among stakeholders and customers. A strong reputation for punctuality provides a competitive advantage, as customers are more likely to choose construction enterprises with a commendable track record for reliability and effectiveness. Efficient time management is crucial in various construction projects, especially those linked to broader developments or public infrastructure. Adhering to contractual deadlines is both a moral and legal obligation. Failure to meet designated deadlines can lead to legal conflicts, monetary sanctions, and reputational harm to the construction firm (Rathnayake et al., 2022). The prompt and efficient delivery of goods or services within the designated timeframe serves as a measure of the efficacy of project management methodologies in a construction firm. This reflects a comprehensive approach involving strategic planning, efficient resource allocation, and effective risk management. Emphasizing punctual project completion fosters a work environment characterized by efficacy and responsibility in construction organizations.

Timely project completion enhances construction endeavours, fostering favourable outcomes such as increased property values and early project utilization. Satisfied clients provide positive reviews, augmenting the project's overall value and bolstering the construction company's reputation. The prompt distribution of goods or services within the designated timeframe is crucial for all stakeholders, including investors, lenders, and partners, ensuring timely project delivery and cultivating confidence. A construction firm with a consistent history of timely delivery attracts

lucrative investments and builds enduring relationships for future projects. Punctual delivery in the building business contributes to client satisfaction, cost reduction, reputation and competitive advantage, and adherence to contractual responsibilities, showcasing effective project management methodologies and instilling stakeholder confidence.

Inventory Management

The oversight of inventory is a pivotal metric in assessing performance within the building supply chain. Efficient inventory management directly impacts the overall success and productivity of construction projects. In the dynamic and time-sensitive construction sector, the ability to systematically monitor and optimize inventory levels is paramount for meeting project deadlines, minimizing expenses, and ensuring the smooth execution of projects.

One notable advantage of proficient inventory management lies in its ability to ensure the timely availability of materials, a crucial factor in construction projects requiring diverse resources. Delays in material acquisition can lead to setbacks and substantial financial losses due to unproductive periods. By vigilantly monitoring inventory levels and implementing effective replenishment procedures, construction businesses can secure the punctual availability of essential materials, thereby enhancing project efficiency and minimizing delays. Efficient inventory management enables construction organizations to adeptly control costs and optimize resource utilization, avoiding the allocation of substantial financial resources and the accrual of carrying costs associated with maintaining excessive inventory (Huang et al., 2023). Conversely, insufficient inventory quantities may necessitate costly expedited orders and heightened procurement expenses. Construction enterprises can attain cost efficiency and optimize resource utilization by proficiently managing inventory levels and striking an appropriate balance. This involves minimizing holding costs while ensuring the effective utilization of resources.

Ineffectively managing construction materials, particularly those prone to spoilage or time-sensitive deterioration, poses the risk of wastage and financial loss. Excessive inventory levels may result in material deterioration or obsolescence, leading to financial setbacks. To ensure prudent and efficient use of building supplies, the adoption of appropriate inventory management practices reduces the likelihood of wastage and spoilage. The accomplishment of project objectives and client satisfaction depends on timely task completion. Delays arising from inadequate inventory or material unavailability may lead to costly project extensions and adversely impact the company's reputation. Construction firms should adopt a proactive approach, anticipating potential shortages and implementing preventive measures to avert delays and meet project deadlines. Establishing a robust inventory management system facilitates this. Additionally, implementing effective inventory control practices can enhance relationships with suppliers, improving reliability and fostering a positive reputation as preferred business collaborators through accurate material requirement estimation and consistent inventory maintenance. The enhancement of the construction supply chain optimization is achievable through the development of resilient supplier relationships, facilitating cost reduction, accelerated delivery, and improved collaboration. An efficient inventory management system contributes valuable information and analysis, enabling informed decision-making. Through the analysis of inventory data, construction organizations can discern trends, forecast demand shifts, and refine procurement strategies. Empowered to make data-driven decisions, construction organizations can positively impact project performance and enhance overall supply chain efficiency.

Unforeseen events in construction can disrupt the supply chain and impact project schedules.

Efficient inventory management minimizes risks by improving transparency and control over material availability. Construction organizations can address unexpected issues and maintain project continuity through contingency planning and maintaining buffer stock for essential commodities. Inventory management is a KPI in the building supply chain, enabling effective material availability management, cost control, waste reduction, meeting project deadlines, strengthening supplier relationships, making informed decisions, and eliminating potential hazards. Optimizing inventory management is essential for achieving operational excellence in the effective execution of construction projects.

Cost Control

Cost control is a vital KPI in the building supply chain, ensuring project success and profitability. In the competitive construction business, efficient cost management is imperative to safeguard project feasibility, optimize resource utilization, and achieve project objectives. Adherence to the designated budget for each project is a fundamental aspect of cost management. Effectively implementing a cost management system allows construction firms to meticulously oversee project expenditures and ensure compliance with budgetary constraints, signifying organizational proficiency in project implementation.

Construction projects are susceptible to unforeseen cost escalations, posing substantial impacts on both project profitability and scheduling. The adoption of effective cost management practices allows the timely identification of potential cost overruns, enabling construction businesses to promptly implement corrective measures. Proactive addressing of cost challenges empowers construction organizations to effectively mitigate financial risks and ensure project stability. Cost control encompasses the strategic management of diverse resources, including labour, equipment, and materials, with the objective of optimizing their utilization (Benedict, 2017). By closely monitoring resource allocation and identifying opportunities for efficiency improvement, construction businesses can mitigate wastage and optimize resource utilization. Efficient resource allocation significantly reduces operational expenses and enhances project efficiency. In the building supply chain, effective cost control is achieved through the management and negotiation of vendors. Implementing efficient negotiation strategies with suppliers and subcontractors can lead to more favourable pricing and contract terms, thereby reducing procurement costs and overall project expenditures. Establishing strong partnerships with vendors fosters cooperation and ensures the timely provision of resources and services at advantageous rates.

Cost control involves comparing project expenses with industry benchmarks and historical data. Construction businesses can assess their performance and identify areas for improvement by analysing actual costs, expected costs, and industry benchmarks. Regular performance evaluation supports evidence-based decision-making and ongoing improvement of cost management practices. It is crucial not to compromise the quality of construction projects to minimize rework costs and legal implications. Prioritizing superior craftsmanship and materials helps mitigate costly errors. Robust quality control practices and adherence to industry standards further help construction companies prevent financial setbacks. Risk mitigation and proactive contingency planning are integral elements of cost management, allowing construction companies to anticipate and address unforeseen events that may impact project expenditures.

In essence, cost management functions as a pivotal KPI within the building supply chain. Construction enterprises can attain budget adherence, diminish cost overruns, optimize resource utilization, improve vendor relationships, benchmark performance, uphold quality standards, and proactively mitigate risks through adept cost management. In the construction industry, the significance of cost efficiency is paramount. The implementation of robust cost control methods is imperative for ensuring sustained profitability, accomplishing project objectives, and ultimately achieving long-term success.

Quality Assurance

Quality assurance constitutes a pivotal component within the construction supply chain, functioning as a KPI. The perpetuation of elevated quality standards throughout the entire construction process is paramount for attaining success and cultivating a positive reputation for construction projects. Quality assurance measures encompass various facets of construction activities, aiming to ensure projects are executed in a manner that either meets or exceeds client expectations, aligns with industry standards, and enhances the overall efficiency and sustainability of the construction supply chain.

Quality assurance in the building supply chain aims to meet client expectations, emphasizing not only practical needs but also superior craftsmanship. Construction businesses build trust and lasting client relationships through rigorous quality assurance practices, demonstrating their commitment to delivering projects of exceptional quality. Adhering to industry norms, laws, building rules, safety guidelines, and environmental criteria is crucial in the construction sector. This not only ensures legal compliance but also safeguards the reputation of the construction company and the broader supply chain. Effective quality assurance practices in building projects help prevent rework and errors, avoiding increased expenses and time delays. Early issue identification and corrective actions enable construction companies to minimize defects, contributing to efficient project execution and enhanced cost efficiency (Khanzadi et al., 2020).

Quality assurance procedures significantly enhance the durability and longevity of building projects. By utilizing superior materials and adhering to established industry standards, projects are more likely to withstand the test of time and environmental adversities. Durable structures require fewer maintenance interventions, resulting in reduced life-cycle expenses and improved overall sustainability. Implementing quality assurance involves allocating resources to enhance workforce expertise and provide training opportunities. Well-trained and highly skilled workers are more inclined to produce high-quality work and adhere to construction standards. Continuous training and professional development not only improve construction quality but also boost workforce morale and efficiency. Quality assurance extends to assessing suppliers and subcontractors; construction companies should establish partnerships with reliable and reputable suppliers to ensure a consistent supply of high-quality materials. Regular assessments of subcontractor performance are essential for upholding quality standards throughout the entire supply chain.

Ultimately, the assurance of quality significantly impacts client satisfaction and the overall reputation of the construction company. Satisfied clients are more likely to recommend the construction company to others and potentially engage in future collaborations. The establishment of a favourable reputation for consistently delivering projects of exceptional

quality enhances the organization's competitive advantage and attracts new opportunities within the construction sector.

METHODOLOGY

This research endeavour seeks to examine and validate hypotheses related to KPIs in the construction sector of Baghdad. A cross-sectional and analytical design was employed for its capacity to describe phenomena's status and explore interrelationships among multiple phenomena within a single data collection period. The cross-sectional design enabled data collection at a specific point in time, offering a comprehensive snapshot of prevailing conditions in the construction industry during that period, distinct from longitudinal studies that track changes over an extended timeframe. Cross-sectional designs are advantageous for gaining insights into present conditions and variable relationships over a specific timeframe. The research design incorporated an analytical component to examine correlations among different variables. This investigation supports the notion that the assessment of construction enterprises should consider KPIs from the perspectives of both owners and consultants.

Data Collection Method

The data collection methodology employed in this study involved the utilization of a survey approach, incorporating both qualitative and quantitative components. Surveys are commonly employed in academic research for their systematic data gathering capabilities from a diverse pool of individuals. This study specifically targeted individuals employed at different management levels within the building sector in Baghdad, encompassing various roles such as project managers, site engineers, office engineers, project coordinators, and others involved in the construction process. The primary aim of the study was to enhance the understanding of KPI utilization in the business context by incorporating diverse perspectives.

A well-crafted questionnaire was devised to efficiently collect data from the targeted population, chosen for its expediency and consideration of participant behaviour. The use of a carefully designed questionnaire not only ensures the collection of accurate and specific data but also streamlines subsequent stages of data processing and analysis.

Sampling Method

Adhering to established research protocols, the study employed a sampling technique to select representative units from the broader community. This specific sampling methodology was employed to accommodate the expansive scope of the construction industry. The data collection process utilized a random sampling approach to gather information from a representative sample. The statistical approach to determine the sample size is outlined in equations 1 and 2.

$$n = \frac{NX}{(n-1)\,E^2 + X} \tag{1}$$

$$X = Z^2 p(1-p) \tag{2}$$

The sample size, represented by 'n,' is established in consideration of the desired confidence interval, typically set at 95%. The corresponding value of Z is calculated accordingly. The

parameters are set with P at 0.5 and E at 0.07. Substituting these values into equations (1) and (2) yields an estimated sample size of approximately 46. It is imperative to note that 'X' denotes the quantity of construction consultants located in Baghdad. According to the Baghdad Construction Association's findings, the city houses a total of 41 consultant offices.

With a sample size of 46, 89.13% (41 responses) questionnaire response rate was achieved, enhancing the likelihood of reliable outcomes. To ensure data integrity, researchers conducted a comprehensive literature review, enlisted industry experts for questionnaire validation, and implemented measures during formulation and dissemination. Incorporating industry experts' comments ensured the questionnaire's relevance to Baghdad's building sector. Researchers employed strategies to boost participant response rates, providing a letter alongside the instructions to clarify research methodology and objectives. This communication not only improved participant understanding but also underscored the researchers' commitment to maintaining respondent confidentiality.

Instrument Development

The incorporation of multiple-choice items in the questionnaire was motivated by their inherent simplicity and respondent convenience in survey settings. The varied nature of these inquiries facilitated the achievement of the study's objectives, allowing for the comprehensive collection of data essential for detailed analysis, drawing conclusions, and formulating recommendations. It is noteworthy that the survey was translated into Arabic, the predominant language spoken in Baghdad. This decision was made with the aim of fostering improved understanding and engagement among participants, thereby enhancing the likelihood of obtaining accurate and relevant responses.

To collect pertinent data for assessing the performance of construction businesses, the questionnaire was structured into two main sections. The initial segment focused on gathering comprehensive participant information to provide relevant contextual details for the study. The second section incorporated performance indicators for evaluating construction firms, categorized into four distinct groups. The selection of these criteria resulted from an extensive review of academic literature related to the project, ensuring the identification of relevant and valuable evaluation indicators. The study involved interviews with experts in construction projects in Baghdad, and the identified indicators underwent thorough analysis. During the research instrument's development, an experimental sample was utilized to validate the practical application of selected indicators. This sample, comprising diverse individuals engaged in Baghdad building projects, facilitated iterative refinement of questionnaires through feedback and perspectives. The researchers succeeded in formulating a robust set of performance indicators that adeptly evaluate the performance of construction firms in Baghdad. This achievement was realized through the integration of insights from the literature review, expert interviews, and the experimental sample. The metrics offered a comprehensive and dependable perspective on various facets of construction project management, implementation, and outcomes.

DATA ANALYSIS AND DISCUSSION

Reliability Analysis of Measurement Tool

Before scrutinizing the relationship among crucial performance indicators, it is essential to

assess the validity and reliability of the instruments employed in this study. In the context of collecting responses to assess a specific concept involving multiple elements, reliability pertains to the degree to which such responses demonstrate internal consistency, a metric that can be quantitatively measured (Ary, 2002). The attainment of consistent responses in this study serves as an indication of the effectiveness and clarity of the instrument used, as delineated by Pallant (2011). The assessment of a scale's internal consistency is performed through Cronbach's alpha coefficients. The degree to which the measure is free from errors is determined by its reliability measurement, offering a reliable assessment for the particular concept and variables utilized.

The study aimed to obtain precise and meaningful data on the performance of construction businesses in Baghdad, utilizing a carefully designed questionnaire and thoughtfully selected performance indicators. This effort sought to enhance understanding of the subject. The study's results can serve as a basis for informed decision-making and the formulation of practical recommendations to improve the overall efficiency and effectiveness of the construction sector in the region. Internal validity, addressing the accuracy of questionnaire assessment within specific groups, is evaluated using Spearman correlation coefficients. Significance scores below 0.05 or 0.01 indicate internal validity, fulfilling the primary objective of the investigation. Structure validity is assessed by examining correlation coefficients between groups in the questionnaire, with a significance level below 0.05 indicating validity. Reliability, pertaining to the consistency of questionnaire trait assessment, is evaluated using Cronbach's coefficient alpha, where values exceeding 0.7 are considered acceptable. The findings, presented in Table 1, show that all variables meet the standard value criteria. This observation is noteworthy.

Table 1: Reliability Analysis.

Key Performance Indicators	Cronbach's Alpha	Remarks
Inventory Management	0.826	Good
Delivery Performance	0.932	Good
Quality Assurance	0.986	Good
Cost Control	0.837	Good

Confirmatory Factor Analysis

Neuman (2003) posits that content validity represents a unique facet of face validity, focusing on the extent to which a scale adequately encompasses the entire spectrum of the subject matter being investigated. It is crucial to carefully consider how measurements and conceptual elements accurately convey the overall meaning of a concept (Sekaran & Bougie, 2016). Consequently, this ensures the comprehensive coverage of the subject matter, and the measurements used should incorporate all pertinent components or aspects within the theoretical framework (Neuman, 2003). In contradistinction to objectivity, content validity can be perceived as a form of validity that is both rational and subjective (Bryman, 2003). The current study utilized confirmatory factor analysis to appraise the content validity of the measuring scale. The results suggest that the scale exhibits a commendable level of validity in precisely assessing the underlying concept. Factor loadings for the identified key performance indicators are delineated in Table 2.

Table 2: Confirmatory Factor Analysis (CFA).

Coordination Factors	Code	Score
Inventory Management	IM1	0.795
	IM2	0.766
	IM3	0.615
	IM4	0.808
	IM5	0.795
	IM6	0.795
	IM7	0.808
	IM8	0.795
	IM9	0.795
Delivery Performance	DP1	0.771
	DP2	0.802
	DP3	0.839
	DP4	0.844
Quality Assurance	QA1	0.84
	QA2	0.773
	QA3	0.796
	QA4	0.763
	QA5	0.784
Cost Control	CC1	0.812
	CC2	0.819
	CC3	0.844
	CC4	0.698
	CC5	0.784
	CC6	0.769
	CC7	0.802
	CC8	0.785

The outcomes of factor loading for KPIs within the building supply chain reveal a spectrum of values ranging from 0.615 to 0.844. Notably, IM3 and CC4, having values below the 0.70 threshold, were deemed necessary to be excluded from the final model. It is essential to highlight that all other components exhibit factor loading values surpassing the 0.70 threshold.

Construct Reliability

Moreover, we employed the Fornell and Larcker (1981) approach to assess the average variance extracted (AVE) for validating the concurrent validity of the constructs. This method posits that the latent constructs within the model should account for a minimum of 50% of the variability in the measured variables. Thus, the AVE is expected to exceed 0.5 for all constructs (Hair, Ringle, & Sarstedt, 2011). The results from Table 3 reveal that all AVE values surpassed the 0.5 threshold, providing support for the overall validity of our assessment methodology. These findings offer confirmation of concurrent validity and robust internal consistency within the estimation model.

Table 3: Construct Reliability Analysis.

Key Performance Indicators	Composite Reliability	Average Variance Extracted (AVE)
Inventory Management	0.898	0.782
Delivery Performance	0.915	0.760
Quality Assurance	0.901	0.671
Cost Control	0.980	0.646

Fornell and Larcker Measure Trial

The final step involved evaluating the discriminant validity of the constructs. Discriminant validity is observed in a path model when the observed variable demonstrates unique characteristics compared to other constructs. The assessment was conducted using the Fornell and Larcker measure (Henseler, Ringle, & Sarstedt, 2015). As per established norms, it is generally acknowledged that the variance in a construct should not exceed its AVE score (Sarstedt, Ringle, Smith, Reams, & Hair Jr, 2014). The outcomes of the Fornell and Larcker measure analysis for the KPIs are outlined in Table 4, providing empirical support for the discriminant validity of the model.

Table 4: Fornell & Larcker Criterion.

Key Performance Indicators	IM	DP	QA	CC
Inventory Management	0.79 2			
Delivery Performance	0.43 5	0.81 2		
Quality Assurance	0.24 5	0.38 4	0.84 7	
Cost Control	0.23 8	0.41 5	0.24 0	0.81 5

The analysis conducted by Fornell and Larcker produced results affirming that the observed components within each construct support the discriminant validity of the model. We contend that our methodology for assessing the efficacy of the building supply chain is valid and reliable.

Structural Model Result

The application of partial least squares (PLS)-based structural equation modelling (SEM) was expanded to derive the path coefficients. It is imperative to attain the standard value for the path coefficient (Sarstedt, Ringle, Henseler, & Hair, 2014). The bootstrapping technique was utilized for 300 iterations. The presented results indicate a significant impact of the evaluated KPIs on the overall performance of the supply chain. The path coefficients' outcomes are detailed in Table 5. Moreover, R^2 serves as an indicator of the model's adequacy in terms of fitness.

Table 5: Results of Path Coefficients.

Path		Beta Coefficients	T-Statistics	*P*
IM →	Performance	0.274	1.365	0.021
DP →	Performance	0.262	1.531	0.018
QA →	Performance	0.253	1.764	0.001
CC →	Performance	0.337	3.415	0.002

CONCLUSION

This research article underscores the significance of KPIs and measurement frameworks in the assessment and enhancement of construction supply chain performance, focusing on the building industry in Baghdad. Employing an exploratory research approach, the study identifies crucial performance metrics within the construction supply chain. The chosen design enables comprehensive data collection from various stakeholders in a single timeframe, yielding insights into improving KPIs. Utilizing literature analysis and quantitative surveys, the study captures perspectives of owners and consultants. The outcomes contribute to advancing performance measurement methodologies in construction, fostering improved project outcomes and operational

efficiency. While effective implementation of KPIs can optimize supply chain operations, reduce costs, and enhance project success, challenges must be recognized, and strategic approaches adopted for enduring improvements in construction supply chain performance.

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