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ANALYSIS OF FACTORS AFFECTING SUPPLY CHAIN MANAGEMENT IN THE CONSTRUCTION INDUSTRY

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***ABSTRACT*:**

The construction industry faces unique challenges that significantly impact supply chain management (SCM). This research examines the factors affecting supply chain management (SCM) in the construction industry through a structured approach involving data collection, validation, and analysis using the Relative Importance Index (RII) method and one-way analysis of variance (ANOVA). A questionnaire survey was distributed to professionals in the construction sector, including project managers, contractors, and suppliers, to gather relevant data. After validating the responses for accuracy, the RII method was applied to rank the significance of each factor influencing SCM. Subsequently, one-way ANOVA was used to assess statistical differences in responses across various stakeholder groups. The findings highlight the most significant factors affecting SCM in the construction industry and reveal notable differences in perceptions based on the roles of respondents. The study provides insights for improving supply chain efficiency and performance, offering practical recommendations for addressing the challenges faced by stakeholders in the construction sector.

***Keywords**: Supply Chain Management, Anova Analysis, Rii Method, Construction Management, Critical Influencing Factors.*

1. INTRODUCTION

Supply chain management (SCM) is essential in construction as it directly affects project quality and schedule. Due to the complexity of construction projects, as well as fluctuating materials demand and coordination among various parties, an effective system is required for smooth and efficient deliveries [2][4]. However, the construction sector is usually plagued by fragmented supply chains, with different independent players, such as project managers, contractors, and suppliers, collaborating towards a similar objective but at times facing coordination and information issues [1]. Several parameters affect SCM in construction, including procurement methods, delivery of materials on time, workforce management, and technology utilization [2][4]. Inability to manage these factors properly may result in delay, cost overruns, and non-optimally executed projects [1][2]. These factors being crucial, however, little work exists on examining these factors systematically and comparatively, and comparative contribution towards SCM efficiency and effectiveness in the construction sector [2][4]. The present research intends to bridge this gap by investigating the pertinent factors affecting SCM in the construction sector. The nature of construction projects due to their magnitude, technicality, and multiple environmental and regulatory factors adds another level of complexity to SCM [4][11]. Coordinating delivery, procurement, having the right inventory levels, and having proper communication among all the stakeholders requires proper planning and implementation [2]. With new technologies such as Building Information Modelling (BIM), drones, and project management software beginning to surface, there are new opportunities to improve SCM in the construction sector [5]. The technologies, however, are not easily adoptable by companies, and incorporating them into current supply chain operations might be challenging, especially for small companies or those that lack a sufficient technological infrastructure [5]. There has been an increasing interest over the past few years to optimize SCM processes in the construction industry to counteract such problems [4]. The current study attempts to bridge this knowledge gap by investigating the most influential factors affecting SCM in the construction industry. Data will be collected from construction practitioners, including project managers, contractors, and suppliers, through a well-structured questionnaire survey. The Relative Importance Index (RII) method would be used in ranking the factors in terms of their perceived importance, and one-way analysis of variance (ANOVA) would be used to establish the

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statistically significant differences in the responses among the various stakeholders. Through the identification and analysis of such factors, this study aims to provide actionable insights for improving SCM practices in the construction industry, ensuring more efficient project delivery, and fostering better coordination among all stakeholders involved in the construction process.

Objective

The aim of this research is to identify and classify the key elements influencing Supply Chain Management (SCM) in construction projects, with a particular focus on procurement, material handling, and project coordination. The study intends to collect expert insights and industry data to verify these elements and confirm their relevance and correctness. Furthermore, the research will employ ANOVA analysis to evaluate the effects of these elements on SCM practices among various stakeholders. Based on the results, the study will offer practical recommendations to improve SCM practices, boost efficiency, and promote enhanced collaboration within the construction sector.

2. LITERATURE REVIEW

This section reviews academic research on supply chain management in construction and examines the key factors that influence its effectiveness within the construction industry.

2.1 The role of Supply Chain Management

The construction supply chain encounters considerable inefficiencies and waste, mainly due to outdated management practices and discrepancies in problem recognition throughout the supply chain [1]. To tackle these issues, four essential roles for Supply Chain Management (SCM) are outlined, focusing on the specific requirements of the construction sector [1]. An integrated strategy is recommended to strengthen the link between site operations and supply chains, improve performance through focused initiatives, incorporate on-site actions into the supply chain, and adopt a comprehensive management viewpoint. By implementing contemporary SCM principles, significant enhancements in construction project delivery can be realized, motivating industry participants to adopt innovative management strategies to address ongoing challenges [1].

2.2. Factors Involved in implementing supply chain practices

A significant factor affecting Supply Chain Management (SCM) in the construction sector is the accessibility of materials. Construction initiatives tend to be intricate, necessitating supplies from various vendors and careful oversight of their delivery. Aspects such as price variations, lead times, and the dependability of suppliers are vital in influencing the effectiveness of SCM [2]. Vrijhoef and Koskela (2000) [1] note that issues related to purchasing frequently result in delays in projects, mismanagement of funds, and shortages of materials. This challenge entails managing relationships with suppliers, ensuring deliveries are timely, and keeping suitable inventory levels [2].

2.3 Effective communication and coordination

Effective coordination and communication between the stakeholders are the keys to the success of SCM in the construction sector. Miscommunication between the suppliers, the contractors, and other stakeholders is bound to lead to misunderstanding, delay, and inefficiency [4]. A lack of communication during the process of information flow and the absence of a consolidated project management system contribute further to the problem, where it is impossible to coordinate the different phases of the construction process [4]. Many of the studies advocate the use of additional channels of communication, especially between the on-site crews and the suppliers, to facilitate the flow of resources and materials [8].

2.4 Workforce management.

Workforce skills and availability are vital aspects influencing supply chain management (SCM) in the construction sector. A lack of skilled labor, especially in specialized fields, can lead to delays in projects and increased costs [3]. The construction industry frequently depends on temporary workers, resulting in workforce instability and difficulties in maintaining steady productivity. Furthermore, labor-related challenges can hinder the effectiveness of supply chains, as delays in on-site activities can create cascading impacts throughout the entire supply chain. To minimize these disruptions, effective labor planning, training, and workforce management are crucial [3].

2.5 Project scope and scale

The magnitude and complexity of construction projects can greatly impact SCM. Larger and more complex projects involve numerous subcontractors, suppliers, and stakeholders, and coordinating the flow of information, materials, and labor is challenging [11]. The longer the duration of the project, the higher the likelihood of delay and logistics.

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O'Brien and Derry (2000) determined in their research that large projects are more likely to be plagued by supply chain inefficiencies, particularly when integration among varying supply chain functions is poor. Besides that, high uncertainty and variability in project requirements could lead to SCM management complexity [9].

External factors such as economic conditions, government policies, and market conditions have a significant impact on SCM in the construction sector. Raw material price fluctuation, government policy regarding environmental matters, and economic recession can impact material price and availability, and hence can cause supply chain disruption [14]. For instance, fluctuation in international commodity prices in the market or supply chain disruption due to geopolitical factors can lead to cost escalation and delays in construction projects [11].

2.6 Risk Management

The inherent risks and uncertainties associated with construction projects introduce an additional layer of complexity to supply chain management (SCM). These risks encompass unpredictable weather, shortages of materials, and changes to the project scope [7]. Some studies highlight the significance of incorporating risk management tactics into the SCM process to tackle these uncertainties. By efficiently managing risks, it becomes possible to foresee potential disruptions, formulate contingency plans, and maintain supply chain resilience amid unexpected events [7].

The construction sector faces numerous difficulties in effectively managing its supply chains. Aspects such as procurement, coordination, technological integration, workforce management, project complexity, and external market factors significantly influence the performance of construction SCM. To address these challenges, construction industry stakeholders need to embrace integrated strategies, improve communication and coordination, utilize emerging technologies, and adopt methods to manage risks and uncertainties. As the industry progresses, the implementation of innovative supply chain practices will be crucial for enhancing efficiency, reducing costs, and achieving improved project results.

3. METHODOLOGY

3.1 Research Design

This study uses a systematic research approach to examine the most influential factors in supply chain management (SCM) in the construction industry [2][3][4][11]. Thirty key factors, identified through an extensive literature review, are examined through a quantitative questionnaire [2][3][4]. Statistical factor significance is identified through one-way ANOVA testing, and Relative Importance Index (RII) is used to rank the factors in accordance with the extent of influence [3][9]. The results are very informative and can be used to improve SCM practices, eliminate supply chain inefficiencies, reduce delays, maximize material handling, and enable more cost-effective and efficient construction management practices.

3.2. Data Collection

For the data collection phase, a structured quantitative survey will be disseminated to a selected group of construction professionals, including project managers, procurement specialists, suppliers, and subcontractors who play active roles in supply chain management [2][3][8]. This survey aims to gather responses from 100 participants, ensuring diverse perspectives on the various factors influencing SCM in the construction industry. The survey will consist of questions addressing key SCM factors identified through a comprehensive literature review, such as challenges in procurement, material availability, workforce management, project complexity, and the impact of external elements like regulatory changes and market fluctuations. The responses will be analyzed to assess the statistical significance and relative importance of these factors using one-way ANOVA and the Relative Importance Index (RII) technique.

3.3. Variables

The survey will include questions that focus on critical SCM aspects identified through a thorough literature review, such as challenges in procurement, material availability, workforce management, project complexity, and the effects of external factors like regulatory changes and market fluctuations [3][11]. The responses will be evaluated to determine the statistical significance and relative importance of these factors using one-way ANOVA and the Relative Importance Index (RII) method. The independent variables listed in Table 1, include: Operational Issues, Procurement, Material Availability, Storage and Stock Control, communication and coordination, Technological advancement, Management factors, External and Environment factors, Financial Management, and Cost. These primary factors have been further broken down into 30 sub-factors based on their characteristics.

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3.4. Data Analysis

The data is initially tested for statistical significance using an ANOVA test. If the data is statistically significant [11]. The Relative Importance Index (RII) method is subsequently applied to ascertain the relative importance of ranking of the SCM factors for construction project success [3][9].

Table 1 Factors Affecting Supply Chain Management

Factors	Variables	Sub Factors
Operational Issues (OI)	OI1	Delay in material deliveries
	OI2	Unavailability of materials and equipment
	OI3	Changes in design during construction
	OI4	Change in scope or schedule
	OI5	Work environment
	OI6	Resource capability
	OI7	Transportation costs
	OI8	Inventory management
	OI9	Distances between supplier depots and construction sites
	OI10	Location of delivery areas
	OI11	Mode of transportation
Communication and coordination (CC)	CC1	Buyer-supplier relationships
	CC2	Communication barriers among stakeholders
	CC3	Conflicts and disputes among stakeholders
	CC4	Involvement of many individuals in supply chain management
	CC5	Poor supplier selection can lead to quality loss and a lack of trust
	CC6	Trust
	CC7	Choosing the right partner
Financial Factors (FF)	FF1	Delayed payment
	FF2	Financial failure
	FF3	Price fluctuations
	FF4	Identifying risk factors
Technological advancement (TA)	TA1	Information-sharing technology
	TA2	Lack of IT tools and integration solutions
Management Factors (MF)	MF1	Top management commitment
	MF2	Management support

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	MF3	Lack of awareness of supply chain management
External and Environmental Factors (EEF)	EEF1	Environmental uncertainty
	EEF2	Project timelines
	EEF3	Customer satisfaction

4. RESULT

4.1 ANNOVA ANALYSIS.

The one-way ANOVA analysis will be used to evaluate the statistical significance of 30 independent variables affecting supply chain management (SCM) in the construction industry [11]. By comparing the means of different groups within each factor, this method will help identify which variables have the most significant impact on SCM practices. The analysis will provide insights into how variations in these factors influence key outcomes such as operational efficiency, cost control, and the reduction of delays or waste in construction projects. This approach serves as a valuable tool for determining the relative importance of each factor, aiding in the optimization of supply chain management strategies within the construction sector.

Table 2 ANNOVA Single Factor Analysis

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	633.8979	103	6.154348	15.19123	6.8E-201	1.245354
Within Groups	1179.724	2912	0.405125			
Total	1813.622	3015				

• The calculated F-value stands at 15.19123, which is significantly higher than the F-critical value of 1.245354, suggesting considerable differences among the means of the 34 sub-factors.

• The p-value is 6.8E-201, well below the commonly accepted significance threshold of 0.05, affirming that the differences among the factors are statistically significant.

The results from the one-way ANOVA analysis indicate that the 30 factors affecting supply chain management (SCM) in the construction sector have a statistically significant impact [11]. With an F-value of 15.19, considerably exceeding the critical value of 1.25, and an extremely low p-value of 6.8E-201, the results confirm that the differences among the groups are significant and not merely due to random variation. This underscores that the factors examined play a vital role in SCM practices, reinforcing their influence on essential project outcomes such as efficiency, cost management, and overall success.

4.2. Relative Importance Index (RII)

The Relative Importance Index (RII) approach is employed to evaluate the significance of 30 factors impacting supply chain management (SCM) within the construction sector according to their perceived relevance [3][9]. In this approach, participants in surveys score each factor on a scale usually ranging from 1 to 4, where 1 indicates "not important" and 4 signifies "extremely important." The RII for each factor is computed by taking the sum of the weighted responses and dividing it by the product of the total number of respondents and the maximum possible score. This index aids in pinpointing which factors are most pivotal in shaping SCM practices. Factors that attain the highest RII values are ranked as the most impactful, while those with lower RII values are regarded as less crucial. This ranking offers useful insights for prioritizing initiatives aimed at enhancing SCM in construction projects.

$$(\text{RII}) = \sum w/A*N = \frac{1n1+2n2+3n3+4n4+5n5}{5*N}; \quad (0 \le \text{RII} \le 1)$$

Where the symbols indicate:

- W: weight was given to each affecting factor by the respondent within the range {1, 2, 3, 4,}, multiplied by the number of respondents {n1, n2, n, n4} for each factor;
- n1 = number of respondents who believe that it has very minimal or no impact
- n2 = number of respondents believe that It has neural impact
- n3 =number of respondents believe that it has good impact

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- n4 = number of respondents who believe that it has very huge impact

According to the analysis of the Relative Importance Index (RII), the elements affecting supply chain management (SCM) in the construction industry were arranged in order of their significance [3][9]. The factors with the top RII values are recognized as having the most substantial effect on SCM practices, whereas those with the lowest RII values are viewed as having a minor influence. Utilizing the specified formula, the results gathered from the questionnaire were compiled into Table II, which lists the ranked factors impacting SCM in construction. The "Factors" column details the main elements that affect SCM, and the "RII" column presents the computed values for each factor's relative importance, where higher RII values indicate a more significant effect on SCM efficiency.

FACTORS	RII	RANK
OI2	0.916	1
FF2	0.892	2
OI8	0.880	3
OI10	0.873	4
CC5	0.870	5
MF3	0.868	6
FF4	0.865	7
CC6	0.858	8
EFF2	0.856	9
FF3	0.853	10
MF2	0.851	11
OI7	0.846	12
OI4	0.837	13
FF1	0.829	14
OI3	0.827	15
CC3	0.822	16
MF1	0.820	17
CC4	0.808	18
CC1	0.803	19
TA2	0.784	20
TA1	0.772	21

Table 2 Ranking of Factors Affecting SCM.

Arranging the factors in this way assists in pinpointing the key elements that affect the variables of the study, offering important insights for decision-makers within the construction sector. The integration of ANOVA with the RII method enables a comprehensive analysis that considers both the statistical relevance of the factors and their comparative significance, based on feedback from industry professionals.

5. DISCUSSION

The results of this study present a detailed insight into the drivers of Supply Chain Management (SCM) in the construction sector, presenting insightful information on the key aspects affecting the effectiveness and efficiency of SCM processes. By combining both one-way ANOVA and the Relative Importance Index (RII) approaches, the research brings to the limelight the factors with the greatest influence on SCM, as well as how these factors differ in their importance among various industry stakeholders. The one-way ANOVA outputs validate the statistical significance of the listed factors, which reveals that variations across stakeholder groups are not the result of chance but instead reflect true differences in SCM practice perception. The RII ratings also highlight which factors—material availability, financial considerations, communication—rank as most significant in determining SCM performance. Issues such as the lack of materials (OI2), late payments (FF2), and ineffective

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supplier selection (CC5) were ranked as the most critical areas for improvement. These results indicate that construction professionals need to address enhancing coordination, financial risk management, and material-related issues to maximize SCM. In addition, this study highlights the necessity for enhanced integration of technology, workforce management, and risk management strategies to improve SCM effectiveness in response to complex and dynamic construction projects. Through both statistical significance and perceived importance, the study offers a blueprint for future strategies to mitigate SCM challenges in the construction sector and enhance overall project performance.

6. CONCLUSION

In Conclusion, this research provides important insights into the key elements that affect Supply Chain Management (SCM) in the construction sector, underscoring the significance of material availability, financial oversight, and communication in determining SCM performance. The combination of one-way ANOVA and Relative Importance Index (RII) methodologies highlights notable differences in stakeholder viewpoints, pointing out critical areas for enhancement such as material shortages, late payments, and inadequate supplier selection. These results indicate that construction professionals need to focus on improving coordination, managing financial risks, and optimizing material handling to refine SCM processes. Furthermore, the study emphasizes the necessity for a stronger incorporation of technology, workforce management, and risk management strategies to boost SCM efficiency and tackle the challenges of contemporary construction projects, presenting a clear guide for enhancing overall project success.

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