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An Investigation Study on the Factors Influencing the Effectiveness of Container Management and Logistics Operations in Construction Projects

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Abstract

Construction industry is the backbone of India's economic development. Therefore this study looks into the factors influencing the effectiveness of container management and logistics operations in construction projects. This study aims to identify the respondents' facts and opinions to determine the factors influencing supply chain logistic management in the construction industry. The sample size was determined to be 130, and respondents were selected through the random sampling method. A well-structured survey questionnaire was prepared. Around 129 respondents participated from Tamil Nadu and provided their responses. Methods deployed for analysis, such as simple percentage, standard deviation, average value, mean, and relative importance index for ranking the factors. Regression and analysis of variance, used to interpret the relationships and predictions. The key statistics has been analysed and interpreted to provide more insights on the study topics. Further, the results revealed that if an upsurge in AI & IoT based SCM practice by 1, the rate of problem reductions in SCM increases by 0.9967. Adopting the IoT-based supply chain management practices may improve the efficiency of container management in logistics and also improve the performance of the construction industry. The results of this study also pointed out the same clearly. The future scope for research in this topic may extend to various regions of India to explore the change in the factors analysed in this study. However, the results are limited to the region of the study carried out and may be changed from time to time and province to province accordingly.

Key Words: *Supply Chain, Logistics, Construction Projects, Container Management.*

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1. INTRODUCTION

Over time, supply networks for building materials have changed to base decisions about production & resources management on demand data from the supply chain's immediate downstream node. As distinct upstream nodes try to predict and deliver orders, this narrow perspective causes demand signals to be amplified. The high degree of demand uncertainty between the supply houses and contractors further exacerbates this demand distortion. Based on ongoing research, another study explores a novel business model for Internet-enabled pooled procurement in building supply chains. Pooled procurement reduces transaction costs, lowers material costs for owners and contractors, and increases production and distribution efficiency by integrating procurement data globally across several projects (Taylor, J., & Bjornsson, H., 1999).

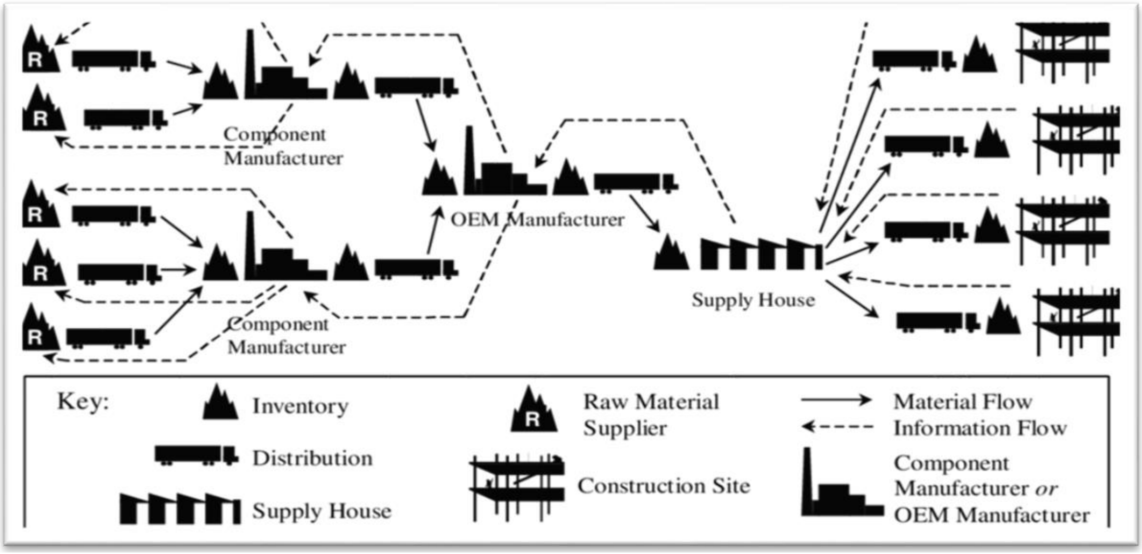


Figure 1: Overview of logistics and material flow
Source: (Taylor, J., & Bjornsson, H. et al 1999)

As businesses realise how important it is to have integrated relationships with their suppliers, consumers, & involved parties, supply chain management (SCM) is becoming a significant issue in many sectors. By lowering uncertainty and increasing customer service, SCM has emerged as a means of boosting competitiveness. Value chain (VCM) management is a concept that is increasingly being used in industry. Despite its widespread use, the literature shows no indication of associated theory development. Research that lacks focus and may be irrelevant results from the inability to identify precise hypotheses and propositions that can be tested in the absence of theory development (Al-Mudimigh, A. S., Zairi, M., & Ahmed, A. M. M., 2004).

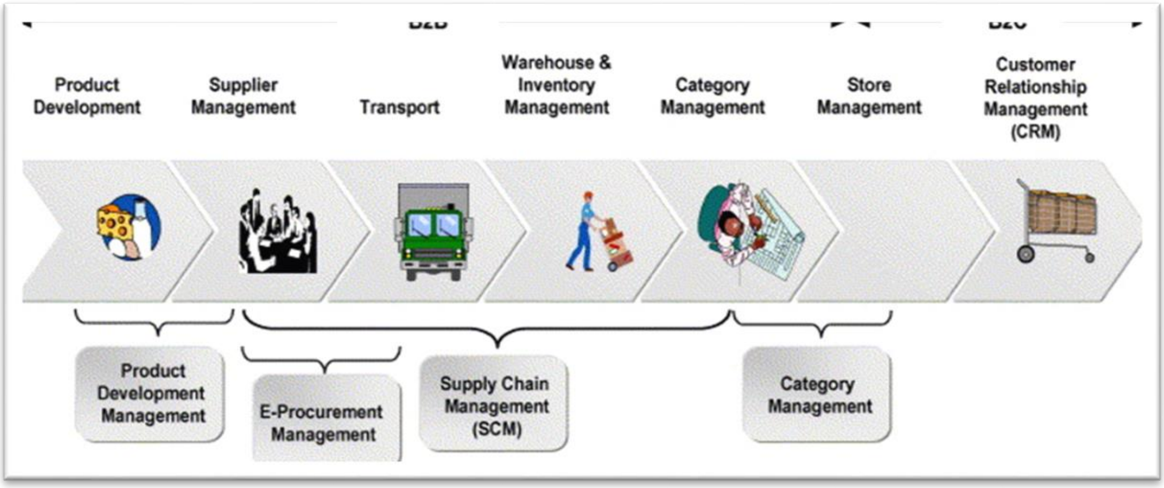


Figure 1: Supply Chain logistics from manufacturer's view
Source: (Al-Mudimigh, A. S., Zairi, M., & Ahmed, A. M. M et al., 2004)

Using a risk management matrix to determine the frequency and severity of CSI risk factors, another study assesses the effect of risk factors from the container security effort on Taiwan's shipping sector and identifies some suitable risk management options. The majority of risk variables have a moderate degree of danger, towards the findings. Risk avoidance, self-retention, and insurance are potential substitute risk management strategies. For every trading nation dealing with security risk challenges, striking a balance between supply chain security and marine logistics efficiency is crucial. In order to support the expansion of the home security industry and provide job opportunities, the government should reassure the private sector to develop and sell security hardware and software (Yang, Y. C., 2010). Planning is necessary for construction supply chain management in order to integrate and coordinate logistics and construction phases, save costs, increase productivity, and create a win-win scenario for all stakeholders. The supply chain operations reference is a standardised operational modelling technique for supply chain process analysis that has been widely used in other sectors. In order to improve communication efficiency and pinpoint issues with materials management, another study used a bridge building project as a case study to ascertain the interactions among supply chain actors. The case study findings show that the suggested hybrid modelling approach greatly enhances SCM recital, assists project managers in locating supply chain bottlenecks, and helps players in the SCM of construction define their responsibilities and communicate more effectively (Pan, N. H., Lin, Y. Y., & Pan, N. F., 2010).The resources used can be linked to the activity that used them and then to a specific cost element using the activity-based costing technique. More significantly, the findings show that the simulation model is capable of determining a logistics solution that will minimise logistical expenses deprived of negotiating the building timeline (Fang, Y., & Ng, S. T., 2011). Furthermore, the manufacturing sector suggests service-oriented architecture as one of the solutions for efficient information gathering and sharing in SCM. Its services allow a heterogeneous system environment of events intricate in the process to interface. However, because the SC process in the project sector is so dynamic owing to frequent changes in the design and planning of building projects, the industry is limited in its ability to contrivance the framework proposed in the manufacturing sector. Thus, creating a smoothly integrated information management architecture that can give project stakeholders logistics data for their decision-making is the aim of another study (Shin, T. H., Chin, S., Yoon, S. W., & Kwon, S. W., 2011). There is a dearth of thorough frameworks and knowledge on how to incorporate environmental efforts and lean methodologies into supply chain activities, despite the rising focus on creating lean and green supply chains. Four challenges—conceptual, technological, operational, and measurement—have mostly caused this. A workable framework for integrating leanness and greenness across the supply chain is created in order to address these issues. The integration of lean and green practices into different supply chain components and operations is emphasised by the green and lean supply chain framework. Value Stream Mapping, both static and dynamic, is suggested as a platform for development and validation. The goal is to use lean and green methods to maximise value across the supply chain. The measures and obstacles to implementing the green lean supply chain are discussed at the conclusion of another study. Assembly schemes are the environment in which the framework is intended for use (Al-Aomar, R., & Weriakat, D., 2012).

Large-scale construction projects have a substantial impact on the environment because of their intricate logistical processes for moving, processing, and storing materials to, from, and on site. These effects include emissions, waste generation, and land utilisation. Examining the ecological and financial effects of construction logistics on on-site waste management when these logistics are discussed and decided upon in the early planning stages of a renovation project is the driving force for more study. Towards research, putting in place a waste management strategy may lessen its effects on the environment, notably improving the logistics of disposal by around 9%. However, this comes at a greater cost (Tischer, A., Besiou, M., & Graubner, C. A., 2013). Another study's findings suggest 15 service operations from the viewpoint of CT operators and 19 customer requirement qualities from the viewpoint of users. Additionally, towards importance level, the top five customer requirements are: cargo safety; accuracy of dynamic cargo information; consistency of the bill of lading; accuracy of EDI information for container receiving and release; and the professional ability of operators to handle cargo damage (Hsu, W. K. K., 2013). Data analysis revealed that both monetary & non-monetary cost-related aspects influencing construction logistics were not quantified and were mainly disregarded, particularly the potential social and/or environmental effects of truck movement. At the location under observation, factors connected to the service industry were not adequately controlled. The comprehension and application of construction SCM are the primary causes of ineffective construction logistics. It is observed that insufficient awareness and logistical efficiency are mostly caused by a lack of operational skills and managerial commitment (Ying, F., Tookey, J., & Roberti, J., 2014)

2. LITERATURE REVIEW

Investigating the utilisation of freight containers to store relief supplies rather than running a permanent warehouse structure is the aim of another article. To explore the feasibility of employing goods containers for storage, a mathematical model is created to calculate the kind and quantity of relief supplies to store, as well as the position and number of containers. Data on earthquake risk, population estimates at risk, and city-to-city distances are used to evaluate the model. The study's findings suggest the ideal places for containers based on the potential regions' seismic risk. Beneficiaries were able to be efficiently and quickly accessed because to the concept of employing containers as storage facilities (Şahin, A., Alp Ertem, M., & Emür, E., 2014). Another paper aims to improve the decision-making process in choosing the best option by presenting an integrated decision analysis outline for the asset reasoning of applying substitute evidence and communication technology-based logistics systems in the building industry. In order to estimate the expected cost of each alternative with respect to each selection attribute, the probabilities of providing benefits vary among the alternatives. These likelihoods will swap the uncertainties surrounding the impacts of the substitute systems in addressing the acknowledged construction logistics problems with chance events (Fadiya, O., Georgakis, P., Chinyio, E., & Nwagboso, C., 2015). The innovation process has been the main focus of empirical research on logistics innovations, mostly ignoring the inventive item or solution design itself. By presenting the generative processes of logistics innovation adoption—that is, the mechanisms by which the solution design facilitates its adoption—and concentrating on the artifact and solution design in a case study add to the developing theory of logistics innovations. Towards a different study, the adoption of logistics innovation at temporary building sites is largely facilitated by standard and effective solution setup. Implementation in the triad is facilitated by communication and operational guidelines, while interior and exterior integration promote implementation by establishing connections between the creative logistics solution and other endeavours. Lastly, the connection triad's congruent technical frameworks and trilateral cooperation support implementation over time (Tanskanen, K., Holmström, J., & Öhman, M., 2015). Recycling and waste reduction are cornerstones of the recently popularized sustainable development idea worldwide. Waste is produced in large quantities during the manufacture of items and during the construction and usage structures. Being an outcome, the project industry is implementing the concept of waste management and reverse logistics. Another study's major goal is to define the term "reverse logistics" in connection to the project industry and investigate the variables that encourage and condition the usage of this strategy in building projects while producing the desired outcomes. The physical movement of things and raw materials throughout the building life cycle has been investigated. Another study investigates how reverse logistics activities are distributed among investment process participants, making it a lucrative and profitable segment for construction firms that also benefits the environment. Issues that need to be considered in order to effectively manage waste and raw materials in construction have also been highlighted (Sobotka, A., & Czaja, J., 2015).

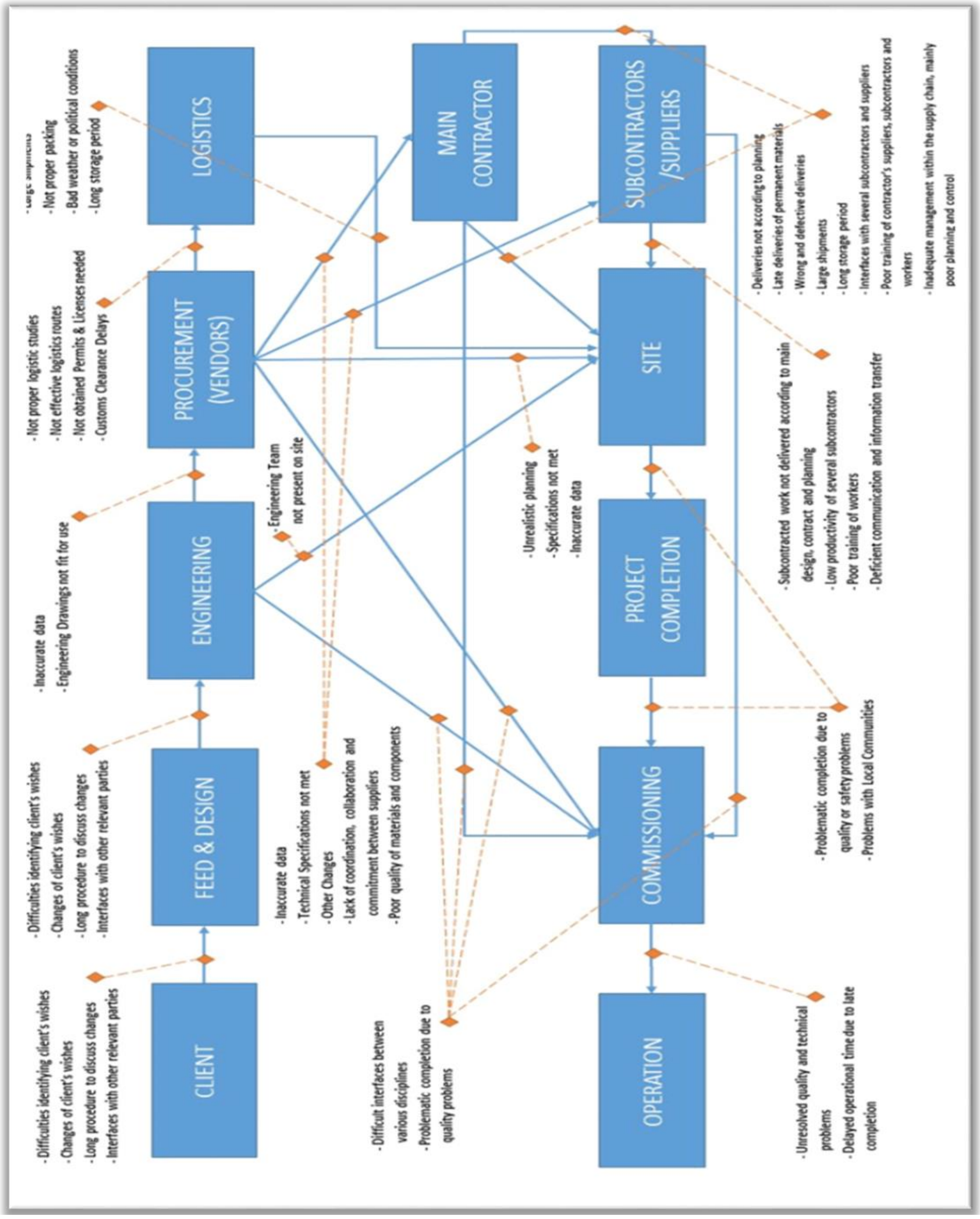


Figure 3: Overview of logistics from project owner's perspective
Source: (Papadopoulos, G. A., Zamer, N., Gayialis, S. P., & Tatsiopoulos, I. P. et al 2016)

Effective SCM has become crucial in the construction industry, which is a highly competitive and complicated sector with demands for the delivery of high-quality projects at extremely competitive costs. A very promising strategy for effectively integrating the many chain disciplines—such as inner and outer suppliers, designers, vendors, contractors, subcontractors, and inner and outer clients—is construction SCM. Large, global construction firms have conducted in-depth studies and created computer-based platforms to test out the newest ideas in SCM. The application of the same principles to the project industry demonstrates that issues in construction supply chains are widespread and enduring, despite the fact that the manufacturing business has seen substantial study and development on the subject. An examination of these issues has revealed that a significant portion of them stem from the complex structure of the building environment and the interfaces between different disciplines or roles. Another study's goal is to offer a series of recommendations for enhancing the management of the construction supply chain, including benchmarking, enhancing the performance of suppliers and subcontractors, removing waste, training, and information exchange among supply chain participants. Lastly, the research makes recommendations for better supply and demand management that are founded on cooperation, integration, trust, and information sharing (Papadopoulos, G. A., Zamer, N., Gayialis, S. P., & Tatsiopoulos, I. P., 2016). Another research aims to use structural equation modeling to determine optimal practices for the efficient management of materials in an urban, constrained building site. The best practices for managing materials in a constrained urban site setting include proactive spatial monitoring and control, effective communication and delivery, implementation of site safety management plans, and consultation and review of the project program (Spillane, J. P., & Oyedele, L. O., 2017). Investigating models and techniques for controlling supply chain risks and delays in building projects is the aim of additional research. The study demonstrates the advantages of using the dynamic modeling approach in a building project. It was discovered through event-based modeling that construction delays affect the likelihood and the extent of disturbance. Because the strategy takes time into account, it adds to the theoretical underpinnings of risk management practices. The technique is a complement to the time-independent Monte Carlo statistical simulation approach. In order to reduce risks in the construction supply chain, the study suggests boosting the safety stock of building supplies at the distribution center using empirical analysis (Panova, Y., & Hilletofth, P., 2018). The goal of another research is to determine and investigate the possessions of various logistics and transportation arrangements on construction efficiency. Decentralized coordinated, on-site coordinated, and supply network coordinated are the three specific transport and logistics setups that are investigated in the study. The study also finds that expanding the scope of coordination beyond the specific building site offers opportunities to improve efficiency on all three levels of analysis (Dubois, A., Hulthén, K., & Sundquist, V., 2019).The risk identification procedure, a list of 215 distinct hazards, and a related risk breakdown structure are presented in another work for the design and construction stages of a shipping port and related container terminal. A 3,500-meter breakwater, 80 hectares of reclaimed land, a 1,000-meter quay wall, port machinery, and buildings are all included in the case study project scope for the study. Risks related to breakwater, reclaimed land, entry canal and basin, quay wall, container yard and buildings, power supply and project management office are all included in the checklist, which is organised in accordance with the project work breakdown structure. The study findings, which were created by subject matter experts during a real project, can be used to particular activities, such as building quay walls in accordance with the project scope requirements, or as a wholeness check after risk documentation on related projects. A list of hazards that are particularly related to marine building is also included in the study (Joubert, F. J., & Pretorius, L., 2020). Kuwait's advantageous position has made it possible for the nation to rely mostly on marine trade for its economic growth. Shuwaikh Port, Kuwait's principal commercial port, is now beset by several issues. Among these issues are traffic jams on the internal and external roadways that prolong the time it takes for trucks carrying cargo to arrive at the port and for empty containers to return. Furthermore, the lack of adequate container storage at Shuwaikh port has resulted in a notable decline in ship traffic in recent years. Establishing a logistics city that supports and enhances the port of Shuwaikh was the goal of another project. In totalling to managing truck traffic, the logistics city offers a cohesive environment that supports other nearby businesses. By building dedicated truck routes, cutting down on handling time, and creating an international logistics hub, this will improve port efficiency; trade mobility; storage capacity; competitiveness; and the amount of traffic on public streets (AlRukaibi, F., AlKheder, S., & AlMashan, N., 2020). Concerns about the economy, society, and environment have grown in the building sector in recent years. There is growing interest in using a sustainability strategy to address these issues. In adding to providing financial benefits, sustainable SCM guarantees socially and ecologically acceptable methods. A sustainable SCM approach that takes into account every stage of the building process is proposed by another research for the Turkish project industry. The triple bottom line sustainability dimensions- economic, social, and environmental are used in the suggested approach, which is based on life cycle assessments of buildings. Using the concepts of the green buildings performance rating system, the study applies the analytical network process methodology to assess the sustainability level of construction sustainable SCM in Turkey. The study's contribution includes a framework to enhance sustainability integration, explanations for inadequate sustainability, and the significance of sustainable SCM components in the construction industry (Kosanoglu, F., & Kus, H. T., 2021). Academic interest in the project logistics industry is sparked by the recent trend of developing renewable energy infrastructure and the idea of modular building. The transportation of large, valuable, and vital goods for infrastructure projects that call for specialist stowage, lifting, and loading and unloading at several ports is known as project logistics. Introducing project logistics to the public sector is the goal of another research. To further explore the specialised issue of project cargo transportation, the researchers employ the descriptive review. The report discusses the project cargo operation flow from the manufacturing yard to the final installation location. Project cargo logistics planning necessitates an integrated planning approach that takes into account: technical safety considerations, integrated international and domestic workflow, transport routing management, variability management, and total delivery cost management, and end-to-end visibility. The best course of action when choosing a fleet should be to consider the damage's overall logistics cost, delivery time, hazards, and repercussions. The research may serve as a roadmap for interdisciplinary studies that take into account the technical, commercial, and safety facets of project logistics (Turbaningsih, O., 2022). Understanding resource usage and increasing operational efficiency are made possible by quantifying greenhouse gas emissions from logistics hubs like warehouses, trans-shipment locations, or ports. Being an outcome, it aids decision-makers in their transition to sustainable logistics hubs and their route to carbon neutrality. An overview of pertinent metrics that may be used to gauge hubs' sustainability performance across their whole life cycle—from construction and operation to refurbishment and end-of-life management—is given by another study. A summary of current methods for measuring operational and embodied carbon is provided. The findings of the global market research on greenhouse gas emissions at hubs and energy efficiency are presented (Dobers, K., Perotti, S., Wilmsmeier, G., Mauer, G., Jarmer, J. P., Spaggiari, L& Skalski, M., 2023). Logistics handles the delivery, storage, and transportation of commodities from the manufacturer to the end user. In today's globalised world, logistics have grown more complicated, necessitating the resolution of issues with data integrity, transparency, and safe storage. Real-time monitoring of products, vehicles, and environmental conditions is made possible by IoT devices in logistics. Nevertheless, this produces enormous volumes of data, making a dependable and secure data management and storage solution necessary. The usage of a blockchain-based solution can resolve the aforementioned problems. Blockchain is a cutting-edge technology with a diversity of uses in industries like healthcare and finance. It runs on a decentralised database system. An IoT-based blockchain model was put up by another study to improve the logistics procedure. The suggested solution made use of the SHA-256 hashing technique to guarantee the anonymity of users' private information and the Interplanetary file system too safely and effectively store logistical data on a distributed and decentralised network. Additionally, the model uses smart contracts to create rules, which boosts efficiency. The suggested model's performance was assessed using security transactions, latency, cost, and throughput as criteria. The performance assessment and experimental findings demonstrate that the suggested model outperforms the current blockchain-based systems in terms of efficiency and security. The suggested methodology also provides real-time tracking of cargo during transportation. The security, storage, and interoperability issues with the IoT logistics system are resolved by the suggested paradigm. Additionally, it offers suggestions for blockchain use by logistics stakeholders (N. A. Ugochukwu, S. B. Goyal, A. S. Rajawat, C. Verma and Z. Illés., 2024).

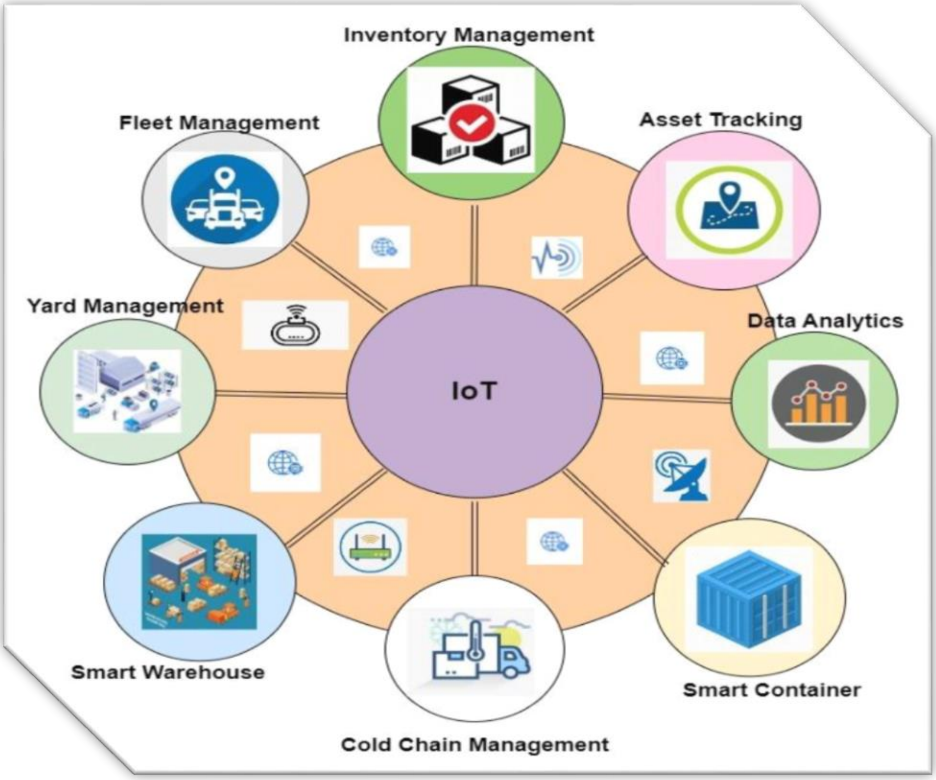


Figure 4: IoT applications in Supply chain and logistics
Source: (N. A. Ugochukwu, S. B. Goyal, A. S. Rajawat, C. Verma and Z. Illés et al 2024)

The installation of an automated control system can greatly increase the effectiveness of sewage treatment. The construction of a PLC-based automated control system to satisfy the specifications for the sophisticated treatment of wastewater containing arsenic at a business's sewage treatment plant is the subject of another study. The research also describes the hardware design, PLC programming, control mode, control system interface, and system construction. In totalling to introducing fuzzy PID control technology, the paper highlights the special features of the sewage treatment process, including non-linearity, substantial inertia, time delays, and the difficulty of developing accurate mathematical models. This technique is used to improve the sewage treatment system's stability, especially when it comes to regulating the wastewater's pH level (Zhao, Q., Li, L., & Bian, H., 2024).

3. THE STUDY OBJECTIVES & RESEARCH METHODOLOGY

The learning intentions to recognise the respondents' facts and opinions to determine the factors swaying supply chain logistic controlling in the construction industry. The sample size was determined to be 130, and respondents were selected through the random sampling method. A well-structured survey questionnaire was prepared, and a detailed survey was performed.

Around 129 respondents participated from Tamil Nadu and provided their responses. Methods deployed for analysis, such as simple percentage, standard deviation, average value, mean, and relative importance index for ranking the factors. Regression and analysis of variance, used to interpret the relationships and predictions.

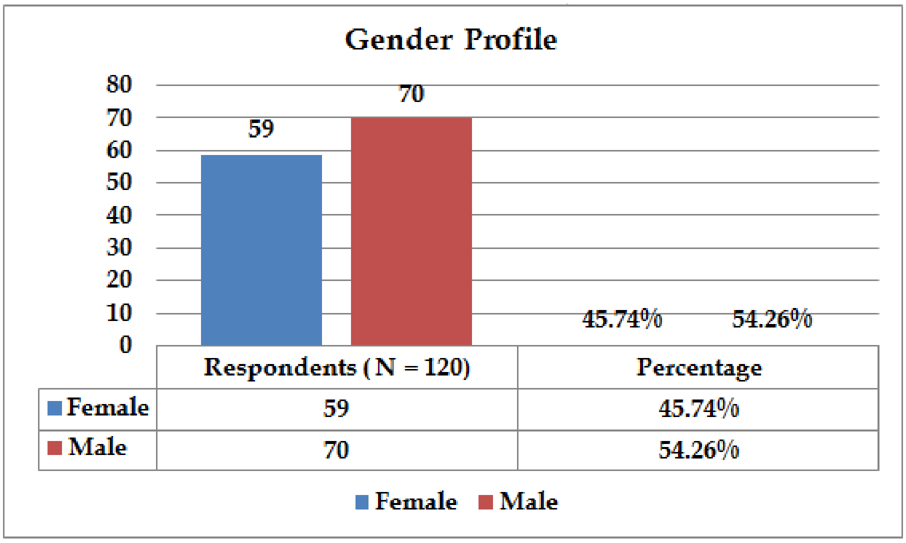
4. Results summary

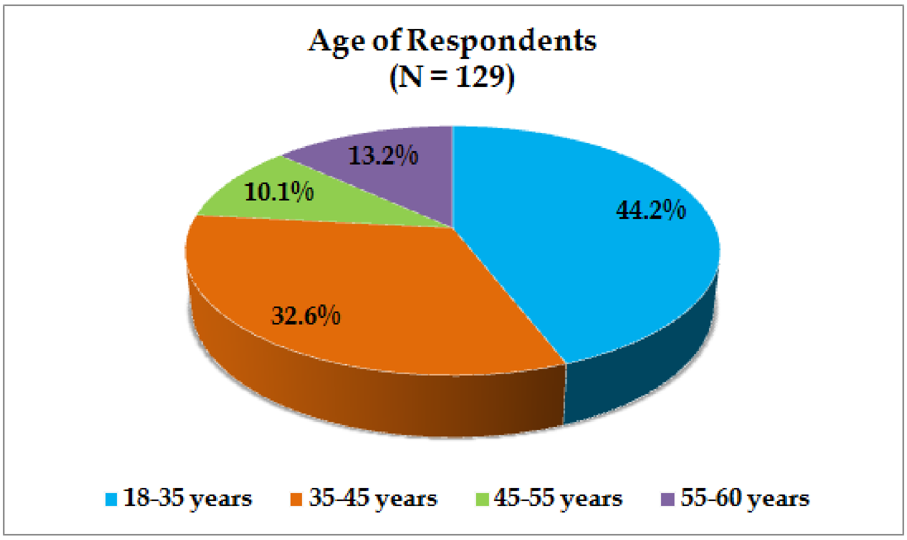
4.1 Factual Analysis

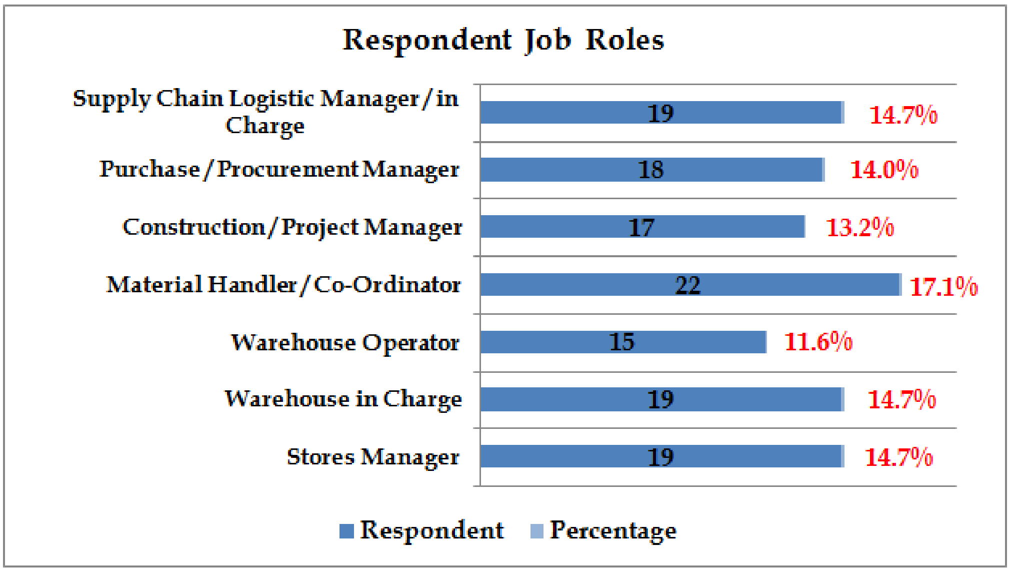
Table 1 indicates the Demographic information and Table 2 indicates Factors influencing SCM. The opinions of the responses have been recorded and represented in figure 5 & 6 for statistics visualization.

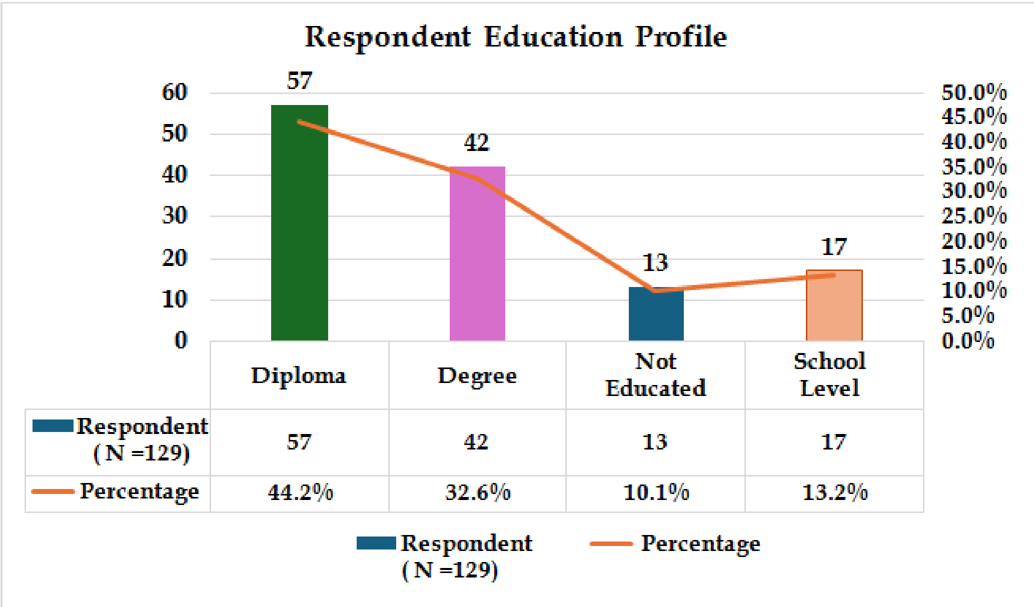
Table 1: Demographic Information

Gender Profile	*Respondents (N = 129)*	*Percentage*
Female	59	45.7%
Male	70	54.3%
Job Role		
Stores manager	19	14.7%
Warehouse in charge	19	14.7%
Warehouse operator	15	11.6%
Material handler / co-ordinator	22	17.1%
Construction / project manager	17	13.2%
Purchase / Procurement Manager	18	14.0%
Supply chain logistic manager / in Charge	19	14.7%
Educational Profile		
Diploma	57	44.2%
Degree	42	32.6%
Not educated	13	10.1%
School level	17	13.2%
Age Group		
18-35 years	57	44.2%
35-45 years	42	32.6%
45-55 years	13	10.1%
55-60 years	17	13.2%
Total	129	100.0%


Gender Profile
80
70
60
50
40
30
20
10
0
59
70
45.74%
54.26%
Respondents (N = 120)
Percentage
Female
59
45.74%
Male
70
54.26%
Female
Male


Age of Respondents
(N = 129)
13.2%
10.1%
44.2%
32.6%
18-35 years
35-45 years
45-55 years
55-60 years


Respondent Job Roles
Supply Chain Logistic Manager/in Charge
Purchase/Procurement Manager
Construction/Project Manager
Material Handler/Co-Ordinator
Warehouse Operator
Warehouse in Charge
Stores Manager
19
14.7%
18
14.0%
17
13.2%
22
17.1%
15
11.6%
19
14.7%
19
14.7%
Respondent
Percentage


Respondent Education Profile
60
50
40
30
20
10
0
50.0%
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
57
42
13
17
Diploma
Degree
Not Educated
School Level
Respondent (N =129)
57
42
13
17
Percentage
44.2%
32.6%
10.1%
13.2%
Respondent (N =129)
Percentage

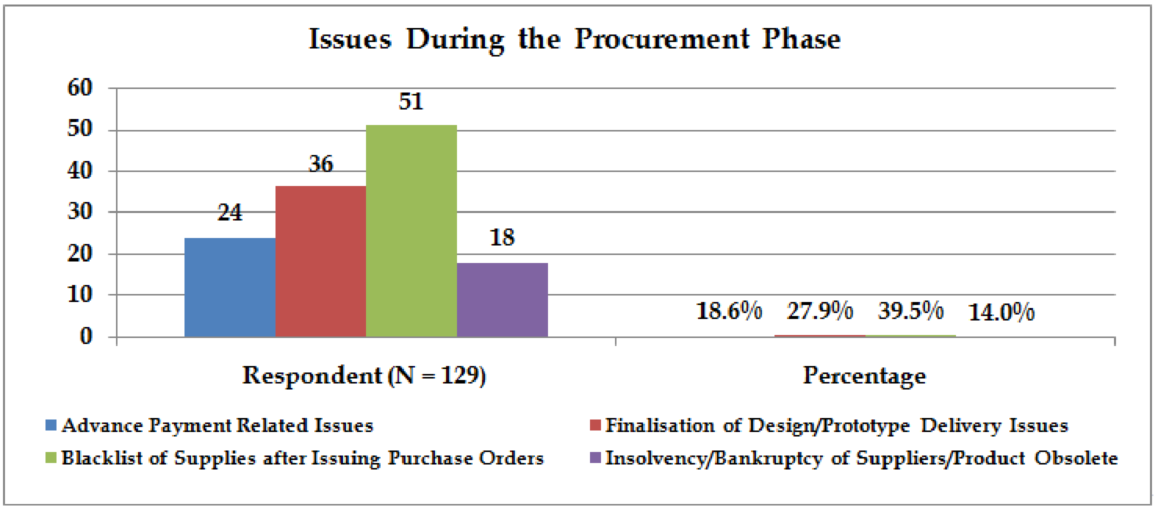
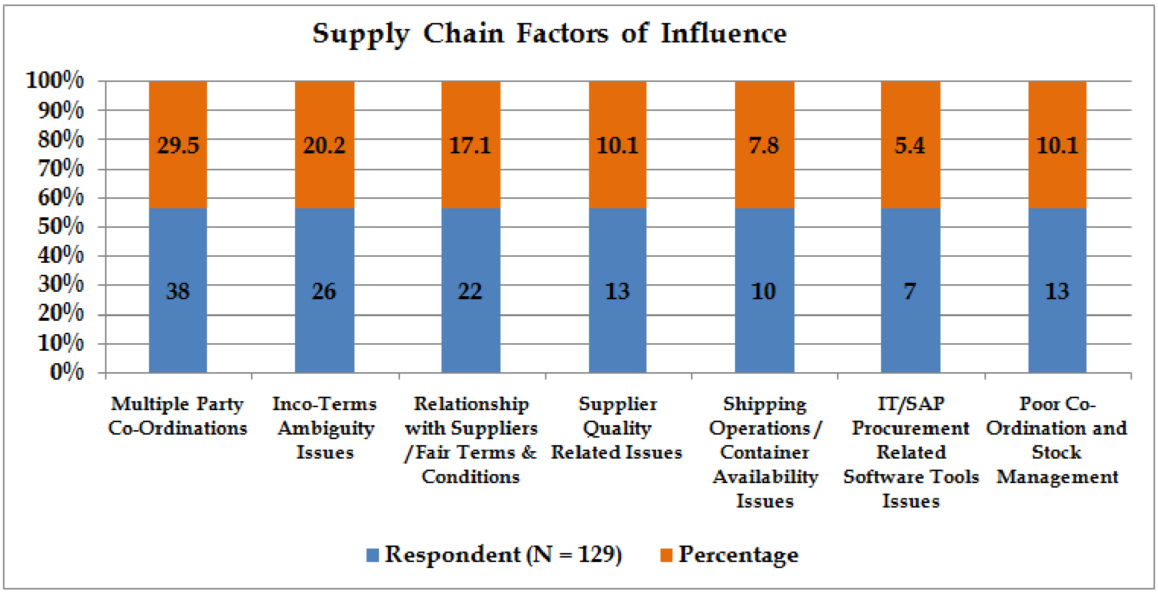


Figure 5: Facts & figures



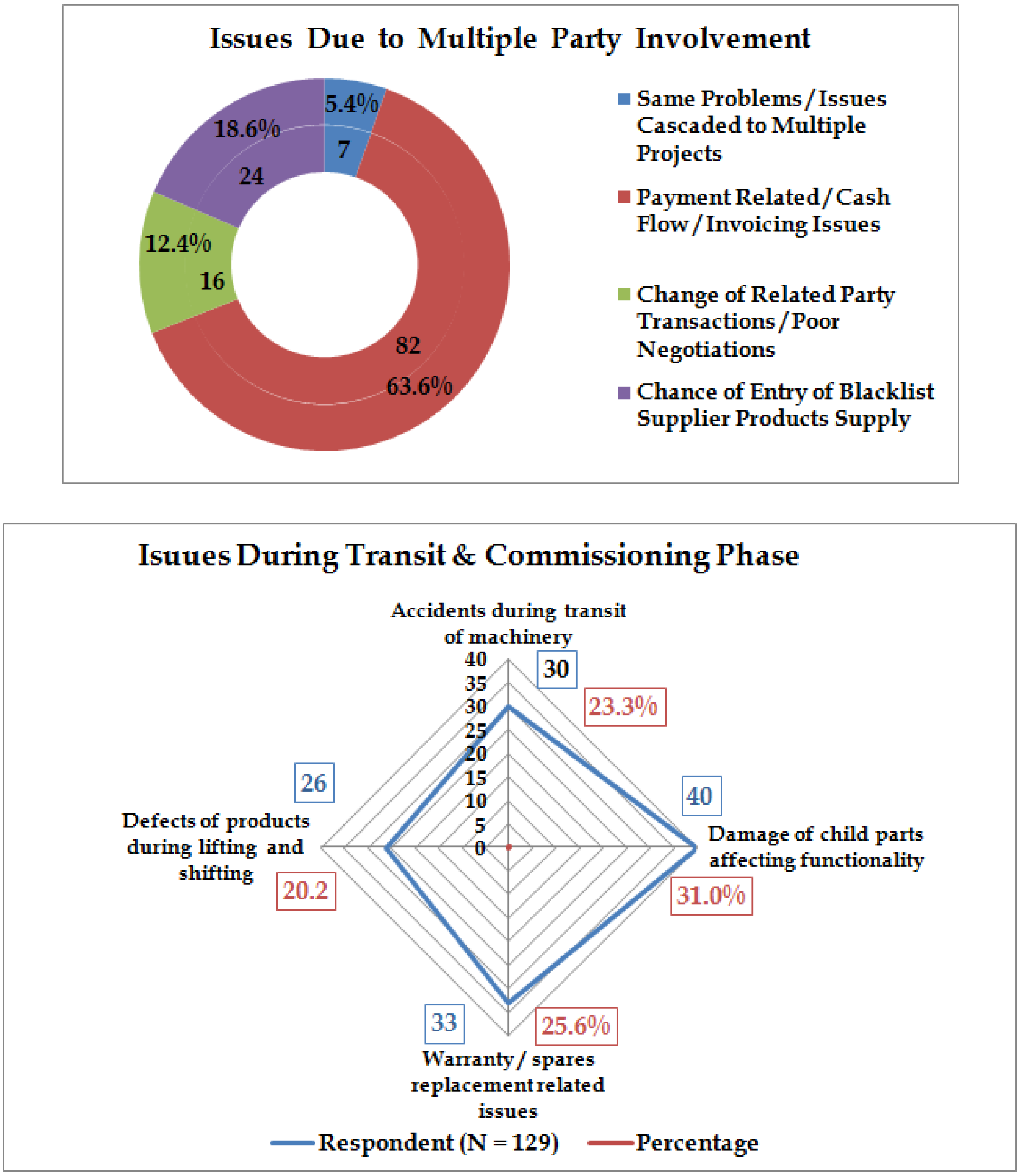


Figure 6: Facts & figures

Table 2: Factors Influencing SCM

Factors of Influence SCM	**Respondents (N = 129)**	**Percentage**
Multiple party co-ordinations	38	29.5%
Incoterms ambiguity issues	26	20.2%
Relationship with suppliers / fair terms & conditions	22	17.1%
Supplier Quality related issues	13	10.1%
Shipping operations / Container availability issues	10	7.8%
IT / SAP procurement-related software tools issues	7	5.4%
Poor co-ordination and stock management	13	10.1%
Total	129	100.0%

Table 2 indicates the Factors influencing SCM whereas Table 3 indicates the Factors influencing during the procurement phase.

Table 3: Factors Influencing During the Procurement Phase

Supply Chain issues during the procurement phase	**Respondents (N = 129)**	**Percentage**
Advance payment-related issues	24	18.6%
Finalisation of design / prototype delivery issues	36	27.9%
Blacklist of suppliers after issuing purchase orders	51	39.5%
Insolvency / bankruptcy of suppliers/product obsolete	18	14.0%
Total	129	100.0%

Further Table 4 indicates the Ranking of factors influencing during manufacturing and delivery phase and it has been represented in Figure 7. Table 5 indicates Factors related to multiple-party involvements. Table 6 indicates Factors influencing during the transit and commissioning phase. Further, Table 7 indicates the Ranking of factors based on the Relative Importance Index.

Table 4: Factors Influencing During Manufacturing and Delivery Phase

Ranking of factors during manufacturing and delivery phase	**No Impact**	**Low**	**Medium**	**High**	**Very High**
Delays due to import duty / customs related issues	38	13	27	44	7
Delays due to pandemic / natural calamities	34	34	22	35	4
Shipping delays/sailing issues of subassembly parts	33	36	23	36	1
Delay in getting child part / spares	34	35	23	34	3

Failures of operation performance / Quality checks	36	35	23	34	1
Fault found during factory acceptance test	34	35	22	34	4
Delays in packing / kitting of the delivered products	68	23	34	4	0
Delays due to manpower related issues	61	35	10	8	15
Breakdown of lifting and shifting equipment	60	24	20	20	5
Theft / security-related issues	33	34	23	35	4
Internal financial issues / sub supplier payment issues	37	34	23	34	1
Clearance issues / buffer stock unavailability	81	41	7	0	0

Table 5: Factors Related to Multiple Party Involvements

Supply Chain issues due to multiple party involvements	**Respondents (N = 129)**	**Percentage**
Same problems / issues cascaded to multiple projects	7	5.4%
Payment-related / cash flow/invoicing issues	82	63.6%
Chance of related party transactions / poor negotiations	16	12.4%
Chance for entry of blacklist supplier products supply	24	18.6%
Total	129	100.0%

Table 6: Factors Influencing During the Transit and Commissioning Phase

Supply Chain issues during the transit and commissioning phase	**Respondents (N = 129)**	**Percentage**
Accidents during transit of machinery	30	23.3%
Damage of child parts affecting functionality	40	31.0%
Warranty / spares replacement-related issues	33	25.6%
Defects of products during lifting and shifting	26	20.2%
Total	129	100.0%

4.2 Challenges during Manufacturing & Delivering

Table 7: Ranking of Factors Based on the Relative Importance Index

Ranking of factors during manufacturing and delivery phase	Rank	Total	W	RII = ΣW / (A*N)	Average	Mean	SD
Delays due to import duty / customs related issues	1	129	356	0.551938	2.75969	2.36	1.34
Theft / security related issues	2	129	330	0.5116279	2.55814	2.24	1.22
Delays due to pandemic / natural calamities	3	129	328	0.5085271	2.542636	2.22	1.23
Fault found during factory acceptance test	4	129	326	0.5054264	2.527132	2.2	1.23
Shipping delays/sailing issues of subassembly parts	5	129	323	0.5007752	2.503876	2.2	1.17
Delay in getting child part / spares	6	129	324	0.5023256	2.511628	2.2	1.21
Failures of operation performance / Quality checks	7	129	316	0.4899225	2.449612	2.14	1.18
Delays in packing / kitting of the delivering products	8	129	232	0.3596899	1.79845	1.58	0.94
Delays due to manpower related issues	9	129	268	0.4155039	2.077519	1.73	1.36
Breakdown of lifting and shifting equipment's	10	129	273	0.4232558	2.116279	1.78	1.26
Internal financial issues / sub supplier payment issues	11	129	315	0.4883721	2.44186	2.13	1.19
Clearance issues / buffer stock unavailability	12	129	184	0.2852713	1.426357	1.32	0.6

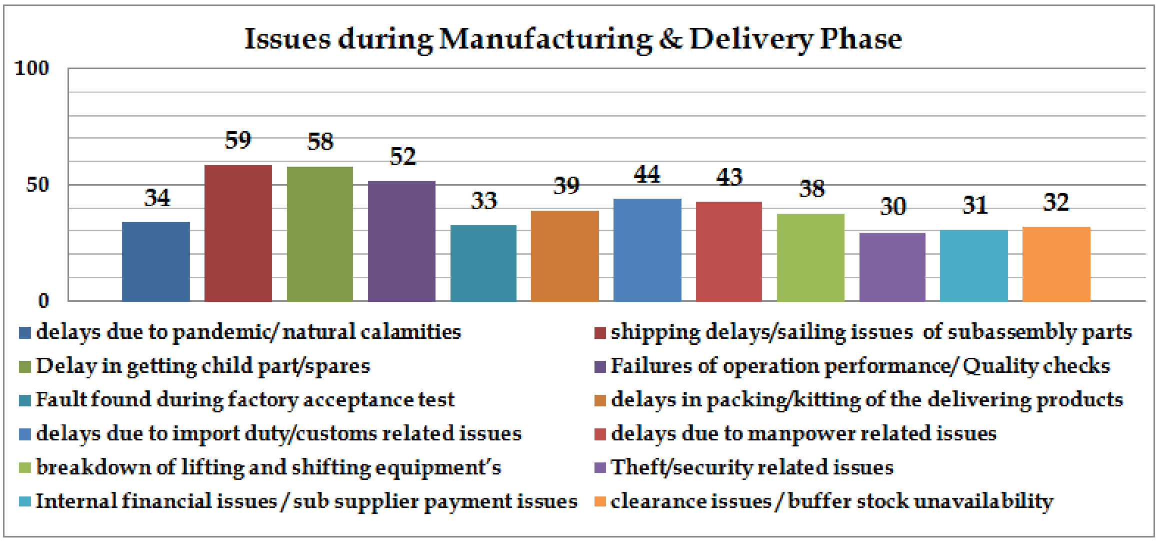


Figure 7: factors that influence during manufacturing and delivery phase

4.3 ANOVA, Regression Results and Interpretation

Table 8: Regression ANOVA Results

Source	DF	Sum of Square	Mean Square	F Statistic (df_1, df_2)	P-Value
Regression (between $\hat{y}_i$ and $\bar{y}$)	1	202861.8992	202861.8992	5571269.9489 (1, 131)	0.001
Residual (between y_i and $\hat{y}_i$)	131	4.77	0.03641		
Total (between y_i and $\bar{y}$)	132	202866.6692	1536.8687		

The above table 8 indicates the regression ANOVA results. AI & IoT based supply chain practice predicted problem reductions in SCM, R2 =, F(1,131) = 5571269.95, p < .001.β = , p < .001, α = 1, p < .001. Problem reductions in SCM and AI & IoT based supply chain practice relationship R-Squared (R2) equals 1. It means that 100% of the variability of problem reductions in SCM is explained by AI & IoT based supply chain practice. Correlation (R) equals 1. This means that there is a very robust straight association between AI & IoT based supply chain practice and problem reductions in SCM. The Standard deviation of the residuals (Sres) equals 0.1908.The slope: b_1=0.9967 CI[0.9956, 0.9978] means that when there is an increase AI & IoT based supply chain practice by 1, the rate of problem reductions in SCM increases by 0.9967.The y-intercept: b_0=1.0046 CI[0.9604, 1.0488] means that when AI & IoT based supply chain practice equals 0, the prediction of problem reductions in SCM's value is 1.0046.The x-intercept equals -1.0079. Goodness of fit - Overall regression: right-tailed, F(1,131) = 5571269.9489, p-value = 0. Since p-value < α (0.01), hence, reject null hypothesis H0. Residual normality. The linear regression model assumes normality for residual errors. The Shapiro-Wilk p-value equals 0. It is assumed that the data is not normally distributed, but since the sample size is large, it should not adversely affect the regression model. Outliers may affect the regression line. In this case, the distribution of the residuals is normal. The linear regression model, $Y = b0 + b1X + \varepsilon$, provides a better fit than the model without the independent variable resulting in $Y = b0 + \varepsilon$. The slope (b_1): two-tailed, $T(131)=2360.3538$, p-value = 0. For one predictor it is the same as the p-value for the overall model. The y-intercept (b_0): two-tailed, $T(131) = 59.3834$, p-value = 0. Hence, b_0 is significantly different from zero.

5. Discussion

In an attempt to lessen the adverse effects that manufacturing and consumption processes have on the environment, green and sustainable SCM techniques have been created. Simultaneously, the circular economy discourse has been promoted in the literature on production economics and industrial ecology, as well as, more recently, in business and practice. Towards the ideas of the circular economy, the notion of altering goods in a way that creates feasible connections between ecological systems and economic growth can push the boundaries of environmental sustainability. Another paper argues that these principles should be incorporated into the theory and practice of green SCM. It does this by using a case study from the construction industry to show how some circular economy principles can reduce carbon emissions more than traditional linear production systems. Therefore, despite certain external supply chain effects and situations, the paper claims that integrating circular economy concepts into sustainable SCM may offer certain environmental benefits (Nasir, M. H. A., Genovese, A., Acquaye, A. A., Koh, S. C. L., & Yamoah, F., 2017). In an attempt to lessen the adverse effects that manufacturing and consumption processes have on the environment, green and sustainable SCM techniques have been created. Simultaneously, the circular economy discourse has been promoted in the literature on production economics and industrial ecology, as well as, more recently, in business and practice. Towards the ideas of the circular economy, the notion of altering goods in a way that creates feasible connections between ecological systems and economic growth can push the boundaries of environmental sustainability. Another paper argues that these principles should be incorporated into the theory and practice of green SCM. It does this by using a case study from the construction industry to show how some circular economy principles can reduce carbon emissions more than traditional linear production systems. Therefore, despite certain external supply chain effects and situations, the paper claims that integrating circular economy concepts into sustainable SCM may offer certain environmental benefits (Nasir, M. H. A., Genovese, A., Acquaye, A. A., Koh, S. C. L., & Yamoah, F., 2017). Innovating 3D modeling software, open access to information, and multidisciplinary integration are some of the ways that Emerging Building Information Modelling (BIM), a ground-breaking technology and information management process, promotes collaboration and more effective design and construction processes. Since the deadline for all centrally procured public sector building projects to comply with BIM level 2 has passed, many construction companies are eager to implement BIM. There are very few peer-reviewed research on construction logistics management; the most often recorded uses of BIM have been in quantities surveying, architectural and structural design, construction project

management, and sustainability. An additional research aims to explore the use of BIM to construction logistics management. Finding the advantages and disadvantages of using BIM for construction logistics was the study's final output (Whitlock, K., Abanda, F. H., Manjia, M. B., Pettang, C., & Nkeng, G. E., 2018).
The transportation of commodities to and from urban building sites has received relatively little attention in recent years, but a lot of emphasis has been dedicated to urban freight transport operations created by certain market sectors like food; retail; or home deliveries. Significantly still, up to thirty percent of freight movements in cities include the transportation of building materials, and the amount of pollutants emitted is significantly higher. In totalling to outlining the possible advantages of establishing construction consolidation sites, the research offers a deeper comprehension of the urban freight transport activities associated with construction. It is a novel strategy that seeks to decrease the quantity of deliveries while improving the efficacy and efficiency of logistical operations. Being an outcome, applying this strategy in cities can lessen traffic and pollution from the transportation of building materials. The study shows the outcomes of utilisation simulations for construction consolidation centres for the four aforementioned building sites. The findings support the recommendation that academics and decision-makers from the public and commercial sectors focus more on this market segment, as the distribution of commodities to and from building sites appears to be unique when compared to other, more well-known urban supply chains (Guerlain, C., Renault, S., & Ferrero, F., 2019). Though its relevance and effects on building projects have not been fully investigated, material kitting has been suggested as an efficient way to schedule just-in-time material supplies around assembly chores. Another study intentions to measure the applicability of kitting by concentrating on its effects on job performance and management needs. The researchers compared four refurbishment projects in the indoor construction phase with and without kitting as part of a case study to investigate a kitting intervention in a general contractor and logistics organisation. The results show that kitting can boost on-site labour productivity, workspace utilisation, and assembly process stability. However, it necessitates subcontractors' dedication to the manufacturing model, centralised material logistics, and seamless information flow across activities. By recommending that kitting be connected to a redesign of the general production model towards a synchronised takt-based production system, the research adds to the relationship between material logistics and job performance (Tetik, M., Peltokorpi, A., Seppänen, O., Leväniemi, M., & Holmström, J., 2021).
Container port drayage operation is the most important factor in providing door-to-door service, even if long-haul intermodal container transit involves several modes of transportation, including ships. The first/last-mile issue that the container logistics sector faces is effectively resolved by container port drayage, which links clients and container ports. Being an outcome, container port drayage has a big influence on the managerial, environmental, and social benefits of all parties participating in the long-haul intermodal container transportation chain, in totalling to the economic benefits. Another paper offers a thorough analysis of the body of research on container port drayage studies from a variety of methodological perspectives, including model construction, algorithm design, and technology viewpoints, such as blockchain technology and driverless trucks. Furthermore, as the industry focus shifts from conventional container port drayage operations and management to e-commerce platforms, possible problems for future

research areas are identified (Chen, R., Meng, Q., & Jia, P., 2022). Although there are numerous concerns about the supply of materials and equipment, construction 3D printing has the potential to shorten, reduce waste, and increase the cost-effectiveness of supply chains. In a different paper, a construction 3DP multi-stage network-based logistics cost assessment model for the materials, equipment, and waste flows of low-story building construction is developed. The model supports the following tasks: evaluating the project logistics network; determining the best logistics strategies for the project; and conducting a feasibility analysis by comparing different logistic scenarios with traditional construction. Case studies are used to illustrate the viability and usefulness of the model creation process, which uses a two-type costing technique and a node approach for the logistics systems analysis. Towards the results, transportation is the main logistical cost category for three-dimensional printing, and careful consideration of this factor makes a building project feasible (Besklubova, Svetlana, Bing Qing Tan, Ray Y. Zhong, and Nikola Spicek., 2023).

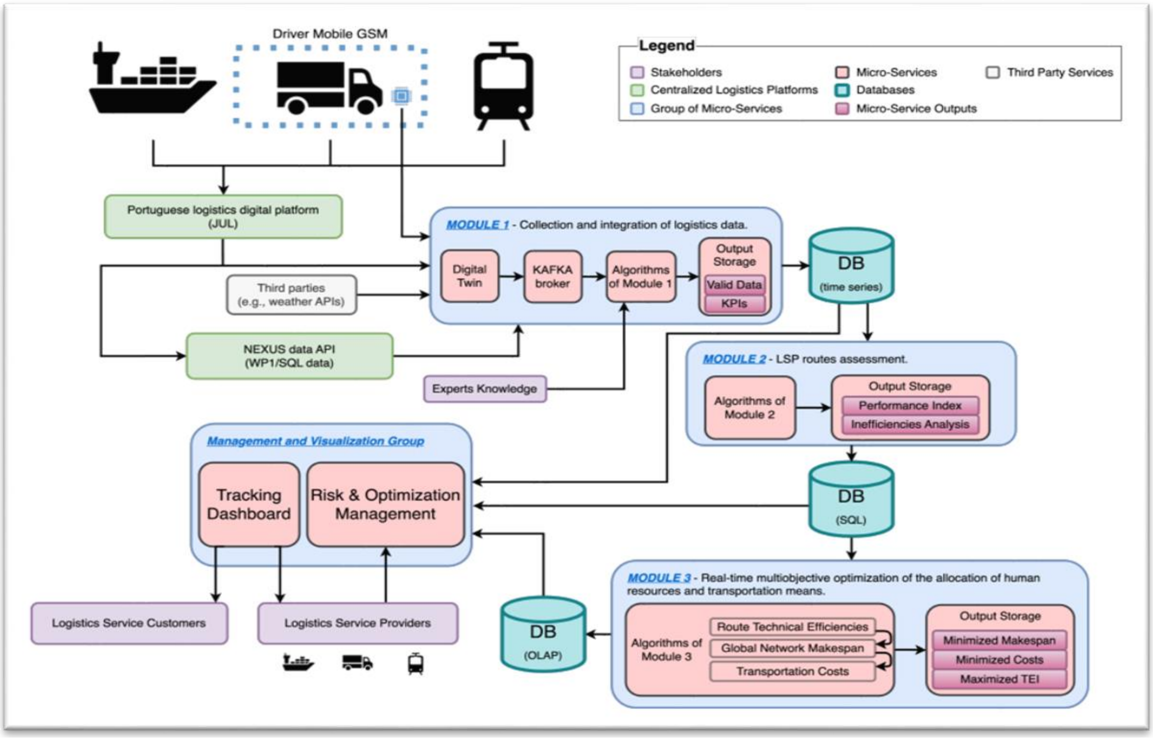


Figure 8: internet-of-things (IoT) algorithm based logistic optimization.
Source: (Brochado, Â. F., Rocha, E. M., & Costa, D. et al., 2024)

Restrictions on data sharing and quality/quantity problems related to data collecting have a big influence on logistics. However, the creation of integrated tools for performance monitoring and real-time logistics network optimisation is made possible by public data from national bodies and internet-of-things (IoT) solutions. A different research suggests a three-module data-driven system design that addresses the shift to synchromodal systems, logistics data gathering technologies, and the assessment of logistics services performance. Multisource data from embedded devices within intermodal containers and national logistics systems are integrated in Modules. It is thought of as a multigraph representation of the problem. A digital twin is created and filled with operational, financial, and environmental data. Being an outcome, the acquired data is either directly transformed or simulated to calculate key performance indicators. Multi-directional Efficiency Analysis, an optimisation technique used in Modules, compares multimodal container transportation routes based on historical KPIs. Outputs include technical performance indicators that are pertinent to logistics customers and ways for logistics service providers to improve. The answer suggested for Modules is applied in a real-world case study. Using CP-sat solvers, Modules offers real-time scheduling and assignment models that minimise makespan and operating costs while accounting for changing system dynamics and resource availability (Brochado, Â. F., Rocha, E. M., & Costa, D., 2024). The significant influence of managerial duties on the efficiency of yard cargo handling machinery in container terminals is investigated empirically. The results of the study show that managing, organising, and planning greatly increase the productivity of yard freight handling equipment, while leading has no discernible beneficial effect (Nguyen, L.H., 2024). In the modular building sector, artificial intelligence (AI) has attracted a lot of interest and is now a major frontier development trend. Another research takes a critical stance as it explores the several facets of AI application in this industry. Analysing the advancements, applicability, and research trends in AI for production, operations, and logistics management in the modular project industry is the goal. First, a brief synopsis of AI technologies relevant to current studies on the logistics, manufacturing, and operations management of the modular building sector is given along with bibliometric analysis. Particularly, artificial intelligence with relation to logistics, operations, and production management in the modular building sector (Liu, Q., Ma, Y., Chen, L., Pedrycz, W., Skibniewski, M. J., & Chen, Z. S., 2024). Supply chain interruptions have become a typical occurrence in today's competitive marketplace. New technology development, fluctuating consumer demand, and unpredictable pandemics have all contributed to supply chain ecosystem disturbances. Every company's supply chains must be sustainable and circular to handle unforeseen interruptions, and the project industry is no different. A different research focusses on determining the resilient construction supply chain's key performance metrics and ranking the most important ones. Evaluation and Trial of Fuzzy Decision Making the impact of performance indicators on the degree of resilience in CSCs was demonstrated using a laboratory approach. Additionally, a strategy map is created to emphasise the cause-and-effect methodology and organisational strategy. Towards the study's findings, the top seven performance indicators that are visible in the causal group for sustainable supply chain are: preserving an appropriate level of security; strong cooperation among supply chain partners; effective supply chain designs; the capacity to identify inconsistencies, bottlenecks, and vulnerabilities; and resource conservation to support sustainable operations. The impact group's key performance metrics are adaptability, sound financial standing, and effective resource management. By defining and evaluating important performance metrics for implementing resilient, sustainable, and circular practices in the project industry, the research also contributes to the body of current knowledge (Singh, A., Dwivedi, A., Agrawal, D., & Chauhan, A., 2024).

6. CONCLUSION

Among the many problems with traditional SCM were the inability to monitor items in real time and less transparent supply chain procedures. Challenges like counterfeit goods resulting from a lack of supply chain transparency are also included. One new method for leveraging IoT to update the conventional SCM process is IoT-based SCM. Since product tracking is not a problem, modern SCM is more transparent. The goods from the acquisition of raw materials, production, and distribution are also easily tracked. Adopting the IoT-based SCM practices may improve the efficiency of container management in logistics and also improve the performance of the construction industry (Taj, S., Imran, A. S., Kastrati, Z., Daudpota, S. M., Memon, R. A., & Ahmed, J., 2023). The results of this study also pointed out the same clearly. The future scope for research in this topic may extend to various regions of India to explore the change in the factors analysed in this study. However, the results are limited to the region of the study carried out and may be changed from time to time and province to province accordingly.

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