

The Challenges of Supply Chain Management (SCM) in Industrialised Building System (IBS): Case Study in Selangor

Amira Aisyah Aini¹, Seow Ta Wee^{1,2*}, Haryati Shafii^{1,2}, Zailawati Khalid^{1,2}

¹ Department of Construction Management, Faculty of Technology Management and Business, Universiti Tun Hussein Onn Malaysia, Parit Raja, Batu Pahat, Johor, 86400, MALAYSIA

² Centre of Sustainable Infrastructure and Environment Management, Faculty of Technology Management and Business, Universiti Tun Hussein Onn Malaysia, Parit Raja, Batu Pahat, Johor, 86400, MALAYSIA

*Corresponding Author: tawee@uthm.edu.my

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Abstract

This research explores the challenges in supply chain management (SCM) within the Industrialised Building System (IBS) in Selangor, focusing on fragmentation, inefficiencies, and a shortage of skilled labour. The objective for this study is the challenges of supply chain management in IBS and the solutions of supply chain management in IBS. The disjointed nature of the IBS supply chain hampers the timely arrival of components, causing project delays and increased costs. Moreover, a lack of collaboration among construction parties worsens these inefficiencies. A quantitative research method was used, gathering data from 30 IBS suppliers through structured questionnaires. Using SPSS, the data was analysed to find the links among challenges. The results indicate that the adoption of advanced technologies like Building Information Modelling (BIM), enhanced communication among all parties, and the standardisation of IBS components can greatly improve SCM efficiency. Additionally, proactive cost management strategies and workforce training programs are crucial to tackling labour shortages and enhancing project outcomes. These actions promote better coordination, reduce delays, and optimise resource use. The study highlights that effective collaboration, bolstered by strong digital tools, can alleviate fragmentation and allow real-time material tracking. By stressing the importance of strategic SCM approaches, this research offers practical insights to address operational challenges in IBS projects. The conclusions emphasise the necessity for sustainable SCM tactics to ensure the timely delivery of high-quality components and foster the wider adoption of IBS in Selangor. Ultimately, this study aids in the evolution of a more efficient, innovative, and sustainable construction industry in Selangor and beyond.

1 Introduction

This section explains the research background, problem statement, research question, research objectives, scope of study and significance of the study. The Industrialised Building System (IBS) is a system or method of building construction in which the components are produced in controlled conditions in a factory or on a construction site, transported and installed during construction with the minimal use of workers on-site (CIDB Malaysia Because IBS replaces components on-site building, work can be completed more quickly (Fauzi, Hasim, & Mustafa, 2018). The Malaysian construction industry is actively promoting the adoption of Industrialised Building Systems (IBS) to address challenges like labour shortages, improve efficiency, and enhance project quality. IBS relies heavily on a well-functioning supply chain for the timely delivery of prefabricated components. The adoption of IBS requires an elevated level of coordination and collaboration among parties, including suppliers, manufacturers, and contractors' references. It is because IBS uses off-site manufacturing and prefabricated components, which necessitate meticulous planning and execution to guarantee quality and on-time delivery. In addition, the IBS supply chain is characterised by a high degree of complexity and uncertainty, which can make it difficult to manage inventory levels, transportation, and logistics. Supply Chain Management (SCM) has garnered significant attention in Malaysia's construction industry as a potential option for improving the industry's reality. The Construction Industry Master Plan (CIMP) was a collaborative effort involving all construction parties that had concerns regarding the construction 2 planning process. All positive and negative input must be properly considered in this partnership to achieve Supply Chain Management (SCM) on Industrialised Building System (IBS) in the Malaysian construction sector (Zulhumadi & Udin, 2013). Effective Supply Chain Management (SCM) is paramount for ensuring the timely delivery of high-quality IBS components to construction sites (Fauzi, Hasim, & Mustafa, 2018).

The problem statement highlights the current Industrialised Building System (IBS) supply chain in Selangor faces a significant challenge due to fragmentation, resulting in inefficiencies across various stages of the construction process. The fragmentation of these elements poses challenges for effective communication, coordination, and information exchange amongst significant parties such as suppliers, manufacturers, and contractors (Fauzi, Hasim, & Mustafa, 2018). Consequently, delays and disruptions frequently impede project timeframes and raise overall costs. To fully realise the promise of IBS in Selangor, this disjointed supply chain must be streamlined to promote better cooperation, quicker project completion, and higher quality standards. Improved supply chain integration and communication can result in faster construction, more successful operations, and, ultimately, more successful implementation of IBS in the area. To address this issue, the study's research questions focus on the challenges of supply chain management in IBS in Selangor and the solutions for enhancing supply chain management in Selangor's IBS.

The research scope encompasses two primary objectives, including determining the specific challenges faced by IBS suppliers in managing the supply chain and identifying potential solutions to enhance supply chain management practices in Selangor's IBS projects. Respondents include suppliers of IBS components in Selangor. The significance of the research benefits IBS suppliers, construction companies, and policymakers in Selangor by identifying challenges and proposing solutions to enhance IBS supply chain efficiency, productivity, and market adaptability, ultimately fostering a robust construction ecosystem. By providing actionable insights and strategies, the study promotes cost reduction, efficient resource utilisation, policy-driven initiatives, and data-driven decision-making for sustainable growth and innovation in the IBS sector. In terms of methodology, quantitative methods, including data collection through Google Forms.

2 Literature Review

The literature review section presents all relevant literature associated with the research and provides a critical analysis. This section may be organised based on the study's objectives and focus or any other appropriate logical structure.

2.1 The Challenges of Supply Chain Management in IBS

2.1.1 Fragmented Supply Chains

The construction industry is fragmented, with separate parties operating under their own rules, which creates inefficiencies in IBS supply chains. This lack of integration hampers the smooth and timely delivery of IBS components (Fauzi *et al.*, 2018). Fragmentation arises from the involvement of multiple parties including suppliers, manufacturers, contractors and logistic providers. Each party works independently leading to poor coordination.

2.1.2 Interdependency

IBS supply chains are characterised by interdependence (Fauzi *et al.*, 2018). While SCM can improve delivery management, issues still arise due to the complex relationships among all parties. IBS involves suppliers, manufacturers, contractors, and logistics providers (Imam, 2024). These industry partners rely on each other for timely delivery of components, coordination, and seamless execution of construction projects.

2.1.3 Time Delays

Timely delivery of IBS components is challenging in construction projects. SCM practices must mitigate delays stemming from transportation, production or other factors. While IBS adoption aims to shorten construction periods compared to address potential delays caused by transportation, production, or other factors. IBS adoption should lead to shorter overall construction periods than conventional construction (Mohd Nawi *et al.*, 2019).

2.1.4 Attitude and Relationship

Attitude and relationships in the IBS industry refer to how individuals perceive their work and their enjoyment or dissatisfaction. According to Mohd Nawi, Akmar, *et al.*, (2014), a positive work attitude can serve as a strong motivator for group performance encouraging consistency and self-improvement. However, Shukor *et al.*, (2011) highlighted a lack of respect, understanding and commitment among IBS players.

2.2 The Solutions of Supply Chain Management in IBS

2.2.1 Improved Collaboration and Communication

Utilising collaborative tools to improve coordination and communication among all construction parties. Communication can establish effective communication channels to ensure timely and accurate information flow. Next, collaboration and communication between suppliers, manufacturers, and contractors, among other parties must be effective. This minimises delays and maximises resource utilisation by guaranteeing flawless coordination and prompt delivery of components. Improved collaboration and communication also can enhance knowledge management of supply chain and logistics to improve decision-making for the projects (Fauzi *et al.*, 2018).

2.2.2 Streamlined Supplier Management

A robust method for evaluating IBS component manufacturers must be established to provide a trustworthy supply chain. This method guided by CIDB (2021) based on quality, capacity, and dependability. Construction parties can establish a pool of trustworthy suppliers who fulfil the requirements by putting strict qualification and accreditation procedures in place. This enhances the consistency and quality of IBS components and mitigates risks associated with supply chain disruptions, ultimately leading to more efficient and successful construction projects in Selangor.

2.2.3 Improved Planning and Scheduling

Using digital tools like Building Information Modelling (BIM) enhances project planning and scheduling by enabling early detection of potential setbacks and implementing proactive measures. BIM, combined with IBS construction, aids in minimising construction waste and supports the development of a BIM-IBS waste minimisation framework (Othman *et al.*, 2020). Additionally, Collaborative Planning, Forecasting, and Replenishment (CPFR) improves supply chain efficiency by sharing demand forecasts and inventory data among IBS suppliers, contractors, and manufacturers. This fosters transparency, reduces disruptions, and ensures synchronised production and delivery schedules (Hollmann *et al.*, 2015).

2.2.4 Risk Management Framework

Developing a comprehensive risk management framework to identify, assess, and mitigate risks associated with the IBS supply chain is crucial for reducing uncertainties. This framework should encompass regular risk assessments and contingency planning to address various potential issues, including material shortages, transportation delays, and quality concerns. By systematically evaluating these risks and preparing appropriate responses, the framework enhances the resilience and reliability of the supply chain (Jamalluddin *et al.*, 2022).

2.2.5 Relationship between construction parties

Implementing Integrated Project Delivery (IPD) frameworks fosters collaboration among all project parties, including designers, contractors, and suppliers. This method promotes open communication and shared accountability, which strengthens cooperation and trust (Zaliha *et al.*, 2019). This can be accomplished by

conducting frequent meetings, workshops, and collaborative problem-solving sessions, which promote transparency and confidence (Fauzi *et al.*, 2018).

3 Research Methodology

Research methodology is the approach by which research problems are solved thoroughly. Research methodology is a more scientific approach that is adopted for conducting research (Mishra, 2017). Research methodology comprises the phases of a study that include planning, design, data collection, analysis, and interpretation. The overarching goal of these phases is to provide reliable and useful findings. The choice of an appropriate research methodology is extremely important since it has a direct influence on the quality and validity of the results that are acquired.

3.1 Data Collection

Data collection is the systematic process of gathering and measuring information on relevant variables to answer specific research questions, test hypotheses, and evaluate outcomes. This process is a fundamental aspect of research across all fields of study, including the physical and social sciences, humanities, and business, among others. While the methods employed may differ by discipline, the commitment to ensuring accurate and honest data collection remains a constant priority.

3.1.1 Primary Data

Primary data refers to information collected for the first time through personal experience or evidence, typically for research purposes. It is also known as raw data or first-hand information (Ajayi, 2023). The method of gathering such information can be costly, as it often involves analysis by an external organisation and requires significant human resources and investment. For this study, the questionnaire method was employed as the primary data-gathering technique, which uses Google Forms.

3.1.2 Secondary Data

Secondary data refers to information previously collected by researchers for different studies, rather than for the current research problem. This data comes from various sources, such as government publications, censuses, internal organisational records, books, journal articles, websites, and reports. (Prasad Tripathy, 2013). Using secondary data is cost-effective and time-consuming, but it may not always align with current research needs or be completely accurate. In this study, secondary data was used to explore definitions of IBS in Malaysia, along with challenges and solutions related to Supply Chain Management (SCM) in the construction industry. Analysing this data provided a comprehensive understanding of these aspects within IBS and SCM in Malaysia's construction sector.

3.2 Population and Sample

The population refers to the entire group of individuals, objects, or events that share a common characteristic and are the focus of the study (Sileyew, 2019). According to Fraenkel & Wallen (1990), the population is the target group for applying research findings. This study focuses on Selangor, which hosts 46 IBS suppliers and manufacturers registered with CIDB, making it a hub for construction activities (CIDB, 2023). This study takes place in Selangor, notable for its high prevalence of construction activities, including residential, commercial, tourism, and industrial projects. This diversity makes it an ideal location for research. The focus is on suppliers of IBS components for construction in Selangor.

3.3 Quantitative Research Method

The quantitative research approach entails methodically collecting and analysing numerical data to investigate and explain occurrences. Quantitative research entails the quantification of variables and poses inquiries such as "how many," "how long," and "the degree to which." Quantitative research aims to measure the data and generalise findings from a sample of studies conducted from various angles. To support the hypothesis generated in a particular study, quantifiable data must be gathered, analysed, and interpreted (Ghanad, 2023). Quantitative methodologies play a crucial role in establishing associations or causations between variables. These approaches rely on structured data collection instruments and random sampling, enabling researchers to produce results that are easily summarized, compared, and generalized. They are commonly employed to test hypotheses derived from theoretical frameworks or to estimate the magnitude of various phenomena. In quantitative research, statistics and mathematics are utilized to convey findings. Researchers may also gather participant and situational data to

statistically control for their potential impact on the outcome variable. When necessary, probability sampling is used to extend findings from the research participants to a broader population.

3.4 Hypothesis Testing

H₀: There is no significant relationship between challenges in supply chain management (SCM) and solutions in supply chain management in IBS.

H₁: There is significant relationship between challenges in supply chain management (SCM) and solutions in supply chain management in IBS

Correlation analysis is a research tool used to identify the connections between two variables and the strength of those connections. It helps determine whether and to what extent one variable changes when the other does. Correlation can be either positive or negative. In this study, correlation analysis was employed to examine the elements of challenges in supply chain management. The study explored the relationships among five key challenges: lack of collaboration between different construction industries, current construction practices are not well suited for managing Just-In-Time (JIT) inventory, the fragmented nature is difficult to track and manage of supply chains and limited skilled labour for handling and installing.

4 Results and Discussion

4.1 Cronbach's Alpha Reliability Test

Table 1 Reliability test of Cronbach's Alpha Test

Section	Cronbach's Alpha	N for Item
Lack of collaboration between different construction parties in the IBS supply chain.	.938	5
The current construction industry practices are not well-suited for managing the just-in-time (JIT) needs of IBS projects.	1.000	5
The fragmented nature of the IBS supply chain in Selangor makes it difficult to track and manage the movement of materials.	.844	4
The limited availability of skilled labour for handling and installing IBS components poses a challenge to effective Supply Chain Management.	.787	4
Section	Cronbach's Alpha	N for Item
Improved communication and collaboration between all parties in the IBS supply chain are crucial for success.	.937	5
Implementing collaborative Planning, Forecasting, and Replenishment (CPFR) practices can improve inventory management in IBS projects.	.938	5
Standardization of IBS components can improve efficiency and reduce delays in the supply chain.	.933	4
Utilising technology such as Building Information Modelling (BIM) can improve supply chain visibility and coordination.	.812	4
Implementing robust cost management strategies can help control and mitigate cost overruns in IBS supply chains.	.733	4
Total	.965	40

4.2 Pilot Test

The pilot test was already conducted to assess the reliability of this study. This pilot test involved 5 respondents in Supply Chain Management (SCM) in the Industrialised Building System (IBS). A reliability test was conducted to evaluate the questionnaire. The calculation of Cronbach's Alpha yielded a value of 0.965, based on a sample of 5 respondents and 40 questions. This elevated Cronbach's Alpha score indicates that the questionnaire items are effective and reliable. The high level of reliability demonstrates that the measurement items used in the study are

consistent and trustworthy. Consequently, these results validate the reliability of the questionnaire, reinforcing the credibility of the study's outcomes.

4.3 Respondents' Demographic

An outline of the respondents' demographic background is given in this section. To provide a thorough breakdown of the participants, a demographic analysis was carried out, concentrating on elements like gender, age, education level, employment positions, and industry experience. The data was organised and analysed using frequency distribution methods. As shown in Appendix A the most reveals that most respondents are male, with 19 respondents representing 63.3% of the total. Among the respondents, those aged 31 to 40 comprise 46.7%. Additionally, respondents holding a bachelor's degree make up the largest educational group, totalling 16 individuals or 53.3%. Furthermore, the predominant job title among the respondents is manager, with 13 individuals representing 43.3%. Lastly, most respondents have between 6 to 10 years of work experience in the IBS construction industry, totalling 12 respondents or 40.0%. In conclusion, the demographic analysis provided valuable insights into the characteristics of the individuals participating in this research.

4.4 Objective 1: The Challenges of Supply Chain Management (SCM) in IBS

Table 2 Lack of collaboration between different construction industries

No.	Item	Total Respondents					Mean	Scale	Ranking
		1	2	3	4	5			
1.	Effective communication	0	10	4	16	0	3.20	Moderated	4
2.	Suppliers and contractors work collaboratively	0	4	4	21	1	3.63	Moderated	2
3.	Suppliers actively participate in the planning and decision-making processes.	0	6	7	17	0	3.37	Moderated	3
4.	The construction parties regularly share information and updates	0	15	9	6	0	2.70	Moderated	5
5.	Collaboration between different construction is sufficient	0	4	3	21	2	3.70	High	1
Mean Average Overall Level of Agreement						3.32	Moderated		

The challenges in SCM for IBS in Selangor involve issues with collaboration, communication, and information sharing between construction parties. The most significant challenge, with a mean score of 3.70, is the sufficiency of collaboration between construction parties. A review by Mohd Nawi *et al.*, (2023) identifies commitment issues as a significant barrier to joint efforts and technological collaboration among IBS project supply chains. Suppliers and contractors working collaboratively for timely material delivery scored 3.63, emphasising the need for stronger partnerships. Manufacturers' active participation in planning and decision-making processes was rated 3.37, showing room for improvement in their involvement (Mohamad *et al.*, 2023). With an overall average score of 3.32, rated "moderate," these findings emphasise the need for better coordination to enhance SCM in IBS projects.

Table 3 The current construction industry practices are not well suited for managing JIT

No.	Item	Total Respondents					Mean	Scale	Ranking
		1	2	3	4	5			
1.	Support timely procurement and material delivery	0	7	11	12	0	3.17	Moderated	1
2.	Project management methods are compatible with the JIT requirements	0	14	13	3	0	2.63	Moderated	2
3.	There are sufficient systems to handle the JIT delivery schedules	0	18	10	2	0	2.47	Moderated	3
4.	The current logistics and supply chain management practices in the construction industry align with the JIT	0	18	11	1	0	2.43	Moderated	4

5. Construction industry practices are flexible to adapt to the JIT	0	20	0	9	1	2.37	Moderated	5
Mean Average Overall Level of Agreement						2.61	Moderated	

The table above highlights several challenges in SCM within the current construction industry, particularly regarding JIT practices. The highest-rated challenge, with a score of 3.17, indicates that existing construction practices for timely procurement and materials delivery are somewhat effective. Implementing detailed project schedules and material requirements can help reduce delays and storage costs (Building, 2024). Next, existing project management methods have a compatibility score of 2.63, with 14 respondents disagreeing. In third place, systems for managing JIT delivery schedules in IBS projects scored 2.47, with 18 respondents in disagreement. Implementing JIT requires meticulous planning and synchronisation among all project parties (Lean Construction Institute, 2019). The overall average score for these challenges was 2.61, indicating a moderate level of agreement.

Table 4 *The fragmented nature makes it difficult to track and manage the material's movement*

No.	Item	Total Respondents					Mean	Scale	Ranking
		1	2	3	4	5			
1.	The fragmented structure complicates the tracking of materials	0	3	1	25	1	3.80	High	2
2.	It is easy to manage the material's movement	0	7	9	13	1	3.27	Moderated	3
3.	Fragmentation within the IBS supply chain leads to delays in material movement.	0	3	0	17	10	4.13	High	1
4.	Construction parties in the IBS supply chain have clear visibility	0	7	12	9	2	3.20	Moderated	4
Mean Average Overall Level of Agreement						3.60	High		

The table highlights challenges in SCM due to its fragmented nature, which complicates tracking and managing material movement. The highest-ranked challenge received a mean score of 4.13, indicating significant delays that can disrupt the entire flow of materials. The second challenge, reflecting a mean score of 3.80, pertains to the difficulties in tracking materials across different companies involved in the IBS supply chain (Shukor *et al.*, 2011). This fragmentation complicates maintaining a clear overview of material locations. Respondents noted that moving materials are generally straightforward, indicated by a mean score of 3.27. This suggests that despite some tracking challenges, mechanisms are in place to keep parties informed about material status (Shukor *et al.*, 2011). Overall, while managing the IBS supply chain presents notable challenges, there is agreement on its manageability. The need for better coordination and communication is emphasised by a mean score of 3.60, reflecting the urgency to address fragmentation issues.

Table 5 *The limited availability of skilled labour for handling and installing IBS components*

No.	Item	Total Respondents					Mean	Scale	Ranking
		1	2	3	4	5			
1.	The limited availability of skilled labour does not affect the installation	7	22	0	1	0	1.83	Low	4
2.	The challenge of finding skilled labour impacts the overall effectiveness	0	7	1	21	1	3.53	Moderated	3
3.	Training programs for IBS component handling and installation are adequate	0	2	2	23	3	3.90	High	2
4.	The shortage of skilled labour leads to delays in IBS project timelines.	0	1	0	22	7	4.14	High	1
Mean Average Overall Level of Agreement						3.35	High		

The table shows to analyses the limited availability of skilled labour for handling and installing IBS components poses a challenge to effective SCM. The shortage of skilled labour leads to delays in IBS project timelines, which is the highest ranking with means score of 4.14. This factor identifies the shortage of skilled

labour as the most impactful challenge for the IBS projects. The high agreement with 22 respondents highlights the widespread concern about the lack of qualified personnel (Jaffar & Lee, 2020). Next, training programs for IBS component handling and installation are adequate to meet the demand for skilled labour with a mean score of 3.90 this factor emphasises the importance of training programs in equipping workers with the necessary skills. The high agreement indicates that training programs are considered crucial for IBS project success (Mohsen *et al.*, 2019). Moreover, the challenges of finding skilled labour impact on the overall effectiveness of SCM in the IBS project. This factor highlights the difficulty in finding skilled labour for IBS projects. The moderate level of agreement suggests that while this is a concern, it's not the most significant challenge (Mohsen *et al.*, 2019) Overall, it reveals that while the shortage of skilled labour is a significant concern, the availability of effective training programs and other resources can mitigate the impact. To conclude the item, this item gets 3.35.

4.4.1 The correlation between the challenges and solutions of supply chain management in the IBS construction industry

Table 6 *The correlation between challenges and solutions*

			Improved Communication	CPFR Improve Inventory	IBS Standardisation	BIM Technology	Cost Management Strategies
Spearman's rho	Lack of collaboration	Correlation Coefficient	.369*	.211	.331	.418*	.264
		Sig. (2-tailed)	.045	.263	.074	.022	.158
		N	30	30	30	30	30
	Fragmented nature	Correlation Coefficient	.221	.113	.096	.240	.177
		Sig. (2-tailed)	.242	.551	.613	.202	.349
		N	30	30	30	30	30
	Limited skilled labour	Correlation Coefficient	.280	.393*	.084	.509**	.315
		Sig. (2-tailed)	.134	0.32	.659	.004	.090
		N	30	30	30	30	30
**Correlation is significant at the 0.01 level (2-tailed)							
*Correlation is significant at the 0.01 level (2-tailed)							

Table 6 shows the correlation between the challenges and solutions of supply chain management in the IBS construction industry. The strongest correlation is observed between limited skilled labour and BIM technology, with a correlation coefficient of $\rho = 0.509$ ($p > 0.004$), which is moderately positive. Next, the second highest correlation is moderate positive between lack of collaboration and BIM technology, with a coefficient of $\rho = 0.418$ ($p > 0.022$). The relationship between limited skilled labour and CPFR improving inventory ranks third, with a correlation coefficient of $\rho = 0.393$ weak positive and a significance value of 0.032, suggesting that collaborative practices can mitigate the effects of skill shortages. Furthermore, the relationship is between lack of collaboration and improved communication, with a coefficient of $\rho = 0.369$ ($p > 0.045$) which is a weak positive. Other correlations, such as those between fragmented nature and BIM technology with a $\rho = 0.240$ not significant and limited skilled labour and IBS standardisation a $\rho = 0.084$ not significant, show lower strength or lack statistical significance. Hence, it indicated that H1 is accepted and H0 is rejected.

4.5 Objective 2: The Solutions of Supply Chain Management (SCM) in IBS

Table 7 Improved communication and collaboration between parties

No.	Item	Total Respondents					Mean	Scale	Ranking
		1	2	3	4	5			
1.	Improved communication	0	0	0	21	9	4.30	High	1
2.	Collaboration among all parties	0	0	0	27	3	4.10	High	5
3.	Regular meetings and updates	0	0	0	25	5	4.17	High	4
4.	Effective communication channels	0	0	0	24	6	4.20	High	2
5.	Lack of collaboration between parties	0	0	0	24	6	4.20	High	2
Mean Average					4.19				
Overall Level of Agreement					High				

The tables present solutions for SCM in the IBS construction industry, emphasising the importance of communication and collaboration among various parties. The top-ranked solution is improved communication between parties, receiving a mean score of 4.30, which highlights its significance in successful IBS projects. Next, establishing effective communication channels, such as WhatsApp and project management software, can reduce delays and achieve a mean score of 4.20. In the delivery process of IBS components, unloading to the site project, huge size of components, redesigning issues, and transportation processes need careful and cohesive planning from different project teams, which is important in maintaining close relationships and understanding their specific roles in the overall task to provide better solutions (Affendi *et al.*, 2017). Additionally, the solution to collaboration and communication scored 4.20 as well, indicating significant negative impacts on project efficiency. Regular meetings and updates ranked third with a mean score of 4.17 are essential for keeping everyone informed. Discussed tools for managing communication mainly focused on team processes (Ahmad Pozin & Mohd Nawi, 2017). Overall, these findings underscore the construction industry's recognition of communication and collaboration as critical factors in effective SCM.

Table 8 CPFR improve inventory management

No.	Item	Total Respondents					Mean	Scale	Ranking
		1	2	3	4	5			
1.	Enhance inventory accuracy in IBS projects	0	0	0	28	2	4.07	High	5
2.	Lead to better synchronisation of supply and demand in IBS projects.	0	0	0	26	4	4.13	High	4
3.	Reduce the risk of inventory shortages and overages in IBS projects.	0	0	1	21	8	4.23	High	1
4.	Improve the efficiency of the supply chain in IBS projects.	0	0	0	25	5	4.17	High	2
5.	Construction parties collaborate to enhance inventory management.	0	0	0	25	5	4.17	High	2
Mean Average					4.15				
Overall Level of Agreement					High				

Tables show that CPFR practice can improve inventory management in IBS projects. With the highest mean score of 4.23, CPFR practices can reduce the risk of inventory shortages and overages in IBS projects. This indicates that this solution is considered the most effective for improving inventory management in the IBS project (Hollmann *et al.*, 2015). Next, ranking 2 about CPFR practices can improve the efficiency of the supply chain in IBS projects and construction parties in the IBS supply chain should collaborate to enhance inventory management with a mean score each 4.17. This shows that by working closely with suppliers, companies can reduce the lead times and improve the speed of their supply chain. By working closely with suppliers, companies can reduce lead times and improve the speed of their supply chain (Elmasys, 2024). The mean average is 4.15, which is the overall level of agreement that this item can be the solution of SCM in the IBS industry.

Table 9 Standardisation of IBS components can improve efficiency and delays

No.	Item	Total Respondents					Mean	Scale	Ranking
		1	2	3	4	5			
1.	Lead to improved efficiency in the construction process.	0	0	0	25	5	4.17	High	3
2.	Significantly reduce delays in the supply chain.	0	0	0	26	4	4.13	High	4
3.	Facilitate better coordination between suppliers and contractors.	0	0	1	24	6	4.20	High	1
4.	Help in minimising project disruptions	0	0	0	24	6	4.20	High	1
Mean Average						4.18			
Overall Level of Agreement						High			

The standardisation of IBS components is crucial for enhancing efficiency and reducing delays in the supply chain management of the IBS industry. It facilitates better coordination between suppliers and contractors, significantly minimising project disruptions, as indicated by a mean score of 4.20. Effective communication is vital in managing the complexity of IBS projects, and improved alignment helps streamline operational processes, thus reducing inefficiencies (Fauzi, Hasim, & Mustafa, 2018). Standardised components also decrease the likelihood of delays due to inconsistent materials or designs, ensuring smoother project execution. Additionally, a mean score of 4.17 highlights that standardisation simplifies design and production, reducing errors and rework, which leads to timely project completion and cost savings (CIDB Malaysia, 2018). Furthermore, with a mean of 4.13, standardisation effectively mitigates delays in supply chains, ensuring timely shipments. Overall, a mean average of 4.18 reflects strong agreement among respondents on the benefits of standardisation in IBS.

Table 10 Using BIM technology can improve visibility and coordination

No.	Item	Total Respondents					Mean	Scale	Ranking
		1	2	3	4	5			
1.	Improve the supply chain visibility	0	0	0	20	10	4.33	High	1
2.	Lead to better coordination with suppliers and manufacturer	0	0	1	23	6	4.17	High	2
3.	Help identify potential supply chain issues	0	0	0	27	3	4.10	High	3
4.	The cost of implementing BIM outweighs	0	0	3	23	4	4.03	High	4
Mean Average						4.16			
Overall Level of Agreement						High			

The data shows that Building Information Modeling (BIM) technology provides significant benefits for supply chain management. Respondents largely agree that BIM enhances visibility and coordination, with the highest mean score of 4.33 highlighting its effectiveness in tracking and monitoring supply chain processes. This implies that construction views BIM as a useful tool for improving supply chain process tracking and monitoring (Papadonikolaki *et al.*, 2015). With a mean score of 4.17, BIM improves collaboration with suppliers of IBS components, leading to more efficient project delivery by reducing errors and ensuring timely resource availability. Additionally, it can identify potential supply chain issues, such as delays or material shortages, with a mean score of 4.10, enhancing risk management and proactive problem-solving (Ibrahim *et al.*, 2024). The overall mean score of 4.16 indicates strong agreement on its significant role in improving supply chain efficiency within the IBS framework.

Table 11 Implementing cost management strategies

No.	Item	Total Respondents					Mean	Scale	Ranking
		1	2	3	4	5			
1.	Help to identify and prevent cost overruns	0	0	0	18	12	4.40	High	1
2.	Lead to more efficient cost management.	0	0	0	25	5	4.17	High	4
3.	High initial investment costs of IBS components hinder effective cost management.	0	0	0	22	8	4.27	High	2
4.	Help to mitigate the risk of cost overruns in IBS projects.	0	0	0	24	6	4.20	High	3
Mean Average						4.26			
Overall Level of Agreement						High			

The highlight the significance of cost management strategies in the IBS supply chain. The respondents highlighted key strategies, including identifying and preventing cost overruns, which received the highest mean score of 4.40. This indicates a strong consensus on its critical role in avoiding unnecessary expenses and enhancing project control (Uzoma Okwudili Nnaji *et al.*, 2024). With a mean score of 4.27, controlling high initial investment expenses was also identified as a critical factor. Despite the difficulties they may cause, these upfront expenses are necessary to achieve long-term cost effectiveness in IBS projects. According to the study, good outcomes are further influenced by tactics like reducing the risk of cost overruns with a mean of 4.20 (Wong *et al.*, 2018). The overall mean score of 4.26 reflects a high level of agreement among participants on the collective importance of these strategies. This agreement emphasises the necessity of proactive cost management frameworks designed specifically for IBS projects.

5 Conclusion

This section details the findings related to the challenges of supply chain management (SCM) in industrialised building systems (IBS) and outlines the solutions needed for the construction industry. It specifically examines how SCM is applied in IBS construction projects in the Selangor area. Additionally, this chapter addresses the objectives established at the beginning of the study, focusing on the challenges and solutions regarding SCM in IBS construction within the Selangor industry. The initial objective was addressed through SPSS analysis to pinpoint the challenges contributing to the identification of challenges of supply chain management in IBS. The challenges in SCM for the IBS are significant and ranked based on their mean average impact. The supply chain's fragmented structure is the most critical challenge since it makes it difficult to track and manage the movement of materials, which causes delays and inefficiencies. This emphasises how urgently parties must coordinate better and be more visible to streamline procedures. The second-ranked factor is the absence of cooperation among construction parties, which reduces relationships, delays the delivery of materials, and impedes efficient supply chain management. This problem is made worse by a lack of dedication to teamwork and technological integration, underscoring the significance of developing closer partnerships. Lack of communication between the manufacturer and IBS participants will affect the quality of the information, and a lack of expertise in the IBS components and process will hinder communication within the IBS supply chain (Fauzi, Hasim, Awang, *et al.*, 2018). The lack of skilled labour for handling and installing IBS components is the third-ranked challenge. It is necessary to give workers specialised training to improve their capacity for daily tasks (Mohsen *et al.*, 2019). Overall, these challenges underline the importance of enhancing communication, fostering collaboration, and investing in training programs to ensure the success and efficiency of IBS projects. To analyse the relationship between all elements of challenges of supply chain management in the IBS construction industry, this study can conclude that there is a moderately positive relationship between limited skilled labour and BIM technology, with a correlation coefficient of $\rho = 0.509$ ($p > 0.004$), which is moderately positive. The solutions in the supply chain management of IBS are ranked based on their impact and effectiveness, offering a structured approach to overcoming industry challenges. The highest-ranked solution is the implementation of cost management 100 strategies, which play a critical role in preventing budget overruns, managing the high initial investments required for IBS projects, and ensuring long-term cost effectiveness. This involves practices such as accurate budgeting, cost tracking, and value engineering to mitigate financial risks and optimise resource allocation. The second-ranked solution emphasises the importance of improved communication between construction parties, which is essential for fostering collaboration, reducing delays, and ensuring project success (A. Halim *et al.*, 2024).

Enhanced communication, facilitated by digital tools, regular coordination, and clear documentation, aligns suppliers and construction companies on goals and timelines while minimising misunderstandings. Ranked third is the standardisation of IBS components, which enhances efficiency by streamlining the design and production processes, minimising errors, and reducing delays. Standardisation also simplifies installation and ensures better compatibility between components, contributing to higher quality and faster project completion (Idrus Din *et al.*, 2017). Collectively, these solutions underscore the critical need for strategic cost management, effective communication, and component standardisation to address SCM challenges, improve productivity, and ensure the successful implementation of IBS projects.

This study elucidates the critical challenges and potential solutions pertaining to supply chain management (SCM) for Industrialised Building Systems (IBS) within the construction sector in Selangor. The fragmented structure of the IBS supply chain complicates the processes of material tracking and management, thereby inducing delays and inefficiencies. This scenario emphasises the imperative for enhanced coordination and transparency among supply chain stakeholders. A subsequent challenge is the deficiency in collaboration among construction entities, which obstructs the efficient delivery of materials and diminishes overall productivity. This issue is further aggravated by limited teamwork and insufficient technological integration. Additionally, a notable concern is the inadequate availability of skilled labour for the handling and installation of IBS components, which postpones project timelines and compromises quality, thereby necessitating targeted training initiatives to mitigate the skills

deficiency. Furthermore, the incongruity of prevailing construction practices with Just-In-Time (JIT) requirements engenders inefficiencies, as these practices lack the requisite flexibility for efficient material scheduling and delivery. Collectively, these identified challenges underscore the significance of fostering collaboration, allocating resources towards workforce development, and integrating sophisticated technologies to enhance the efficiency of SCM in IBS projects.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm their contribution to the paper as follows: **study conception and design:** Amira Aisyah Binti Aini, Seow Ta Wee; **data collection:** Amira Aisyah Binti Aini; **analysis and interpretation of results:** Amira Aisyah Binti Aini; **draft manuscript preparation:** Amira Aisyah Binti Aini, Seow Ta Wee. All authors reviewed the results and approved the final version of the manuscript.

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