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Managing Supply Chain Disruptions in Private Construction Projects: Insights from Malaysian Contractors

Nurul Farahdiana Mohd Joharudin[1], Maisarah Makmor[1*], Umi Kalsum Zolkafli @ Zulkifly[2], Abdul Hadi Ahamad[1], Mohd Farhan Mohd Nasir[1]

[1]*Centre of Surveying and Management (Quantity Surveying), Faculty of Built Environment, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia*
[2]*Department of Quantity Surveying, Faculty of Built Environment, Universiti Malaya, 50603 Kuala Lumpur, Malaysia*

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ABSTRACT

Fragmented supply chains in construction causes severe coordination issues, delays and transaction costs. Risk management is to counter the issues with supply chain but the divide between developed nations with developing and undeveloped nations have hampered the success of risk management. Countless research has extensively discussed construction supply chain challenges internationally. Nonetheless, there is a lack of literature that focuses on the supply chain disruptions faced by Malaysia's private construction contractors. This research provides the context-specific assessment of supply chain disruptions faced by Malaysian contractors in the private sectors. This research aims to assess supply chain disruptions among contractor in private construction projects in Malaysia. Three (3) objectives are administered to achieve the research aim which are to identify the types of supply chain disruptions, to examine the causes if supply chain disruptions and to analyse the impact of supply chain disruptions among contractors in private construction projects in Malaysia. Quantitative research was conducted utilising questionnaire survey distributed to 150 registered G7 contractors in Klang Valley and Shah Alam. Descriptive analyses were administered using SPSS to demonstrate that the most common supply chain disruptors are material shortages, regulatory factors, and unresponsive suppliers. The underlying causes of supply chain disruptions are found to be economic instability and poor practices in risk management. The results also show that the most severe disruption is observed in the planning and construction stages where the parties involved in the project generally experience disagreements and court battles. This research identifies mitigation measures to overcome these disruptions such as diversification of suppliers, flexible contractual agreements and adoption

[1*]Corresponding author. *E-mail address:* maisarahmakmor@uitm.edu.my
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of digital technologies such as Building Information Modeling (BIM) and Artificial Intelligence (AI). Applying these measures will help to improve the performance of the project delivery and the resilience of the private Malaysian construction sector.

INTRODUCTION

Supply chain interruptions have become a major issue in the construction sector worldwide, often leading to cost overruns, delays, and project compromises. Such disruptions are usually fuelled by interconnected risks, including political instability, regulatory changes, and market volatility, which disproportionately affect contractors in the private sector working under fixed contractual terms. The intensity of this issue can be seen in large-scale projects in Malaysia, including the MATRADE Exhibition and Convention Centre, which took 9 years to open and had its cost increase by 70 per cent due to inefficiencies in the supply chain (Zainal Abidin & Ingirige, 2018) Besides external forces, internal financial reliance, particularly payment delays, can contribute to the supply chain's fragility, further disrupting cash flow and increasing the likelihood of conflict and low-quality work (Judi & Rashid, 2010; Zainon et al., 2025). Such circumstances highlighted the need for a proactive, integrated risk management methodology throughout the project life cycle (Sheffi, 2005).

The weakness of the Malaysian construction industry is closely associated with the discontinuous and intricate nature of its construction supply chains. Such a disjointed structure makes procurement processes more difficult, increases transaction costs, and limits coordination among various stakeholders (Zulhumadi et al., 2013). Recently, it has been emphasised that this kind of fragmentation results in mismatched goals, poor communication, and inefficient operations, which adversely impact time and quality performance (Heri, 2024). Even though it can be argued that some of the latest technologies, like AI and IoT, can serve as a solution to enhancing resilience and risk visibility, they are not implemented equally, especially in firms operating in developing economies, since a balance between innovation and operational flexibility remains a problem (Itumo et al., 2025; Reynolds, 2024).

Added to these structural problems are inefficiencies in material handling and information sharing. The lack of transparency in the flow of materials creates accountability gaps, whereas the absence of information flow frequently causes the so-called bullwhip effect, leading to unstable delivery times and locations (Heaton et al., 2022; Shurrab & Johansson, 2022). Even though some researchers claim that the complexity of supply chains can encourage innovation under certain circumstances, the available evidence indicates that inefficient knowledge transfer usually negatively affects project performance (Ahmed et al., 2022; Ateş et al., 2021). It is against this background that this research will explore the nature, causes, and effects of supply chain disruptions in Malaysian privately owned construction projects to provide more robust management practices.

LITERATURE REVIEW

Definition of Supply Chain

The construction supply chain (CSC) is an interconnected collection of organisations, people and resources that form part of the non-linear process of delivering construction projects, from the procurement of raw materials through to the completion of final structures. In contrast to manufacturing supply chains, the CSC is complex due to the semi-bespoke nature of construction projects, which all require custom

https://10.24191/bej.v23i2.11338

planning and coordination (Muhamad Nazri et al., 2026; Vrijhoef & Koskela, 2000). In the Engineering, Procurement, and Construction (EPC) model, supply chain management (SCM) plays a critical role in ensuring cost, schedule, and efficient labour and material flows (Huang et al., 2024; Puneeth, 2024). Sustainability aspects are also increasingly integrated into SCM through the adoption of Green Supply Chain Management (GSCM) and real-time data systems to reduce risks of price volatility, delivery uncertainty, and other risks (Aziz & Hafez, 2013; Hussain, 2024).

The successful operation of the CSC relies heavily on coordination and information exchange among key stakeholders in the process, including contractors, suppliers, logistics providers, and project professionals. Central coordinators are contractors, and the reliability of suppliers and the efficiency of logistics are very important for avoiding cascading delays and cost increases (Ekeskär & Rudberg, 2020). The CSC has been known to have a poor relationship and mismatched incentives, despite its importance to the company's strategy. Nonetheless, it has been indicated that joint risk management practices facilitated by combined digital solutions can increase coordination of responses, enhance transparency, and support the transition from a reactive, problem-solving strategy to a disruptive management approach (Hanh et al., 2024).

Definition of Supply Chain Disruptions

Supply chain disruptions in construction are any major disruption in the supply of materials, information, or financial support that negatively affects the execution of the project. In the Malaysian case, these disruptions result from a set of political, regulatory, market-based, and latent systemic vulnerabilities that are visible in times of stress (Zainal Abidin & Ingirige, 2018) These shortcomings became apparent during the COVID-19 pandemic, which catalysed massive material shortages, labour constraints, and logistical breakdowns, creating a cascading effect on the industry (Ramli et al., 2024).

The impact of supply chain disruptions is typically reflected in project delays, increased budgets, and decreased stakeholder satisfaction. Nonresponsive suppliers and logistical bottlenecks often compel contractors to resort to expensive emergency procurement measures, and payment delays and contractual disputes continue to increase the project's risk (Azahar et al., 2025; Shehu et al., 2015). Recruitment expenses and the risk to quality and safety standards are escalating due to chronic labour shortages, which exacerbate these challenges (Rahim et al., 2016; Yusoff et al., 2021). The industry is responding by moving towards more integrated approaches to resiliency that focus on digitalisation, supplier diversity, and greater collaboration with regulatory bodies to reduce the risk of disruption (Zainuddin et al., 2022).

The Causes of Supply Chain Disruptions Among Contractors in Private Construction Projects

The intermediary causes of supply chain breakdowns in the Malaysian construction industry's private sector are complex and intertwined, and can include logistical failures at the global level and local operational flaws. The main factor behind these difficulties is the acute shortage of raw materials, including steel, concrete, and timber, due to long-term geopolitical tensions and structural delays caused by the COVID-19 pandemic. These delays are often compounded by substantial transport delays, including port delays, inefficient customs processes, and poor last-mile infrastructure, resulting in resources arriving at project sites on time (Halimin & Mohd Roshdi, 2024). Moreover, the sector experiences acute shortages of skilled workers due to post-pandemic workforce trends, which inevitably contribute to rising labour costs and the use of less experienced staff, directly affecting construction timeframes and safety (Rahim et al., 2016; Yusoff et al., 2021)

https://10.24191/bej.v23i2.11338

In addition to physical resource constraints, financial and organisational vulnerabilities also contribute significantly to the impact of external shocks. The volatility of the market, manifested in the inconsistent rise and fall of raw material costs driven by global prices and demand spikes, often renders project budgets obsolete, leaving contractors to spend without planning (Halimin & Mohd Roshdi, 2024). This financial burden is further aggravated by systematic late payment to main contractors and subcontractors, which cripples cash flow and halts site activities (Fateh et al., 2024). On the internal front, many companies have suffered from poor information exchange and a lack of real-time tracking systems. Studies on the Relative Importance Index (RII) have identified failures in organisational coordination as a major impediment to efficiency (Nurisra et al., 2024).

These disruptions are further complicated by the domino effect, in which when one (1) area fails, like a quality control rejection or even a delay in regulatory compliance, this spreads into the whole project lifecycle by creating a wave of inefficiencies. Lawsuits arising from contractual agreements and inadequate risk-contingency planning tend to increase legal costs, which consume more project resources (Goh et al., 2023). To address these interdependencies, contractors are being urged more to have a multi-pronged mitigation approach. This involves diversifying the supplier base to local vendors, using predictive analytics for demand planning, and automating processes to minimise reliance on labour. Finally, it is crucial to focus on closer cooperation with government agencies and industry organisations to overcome the changing regulatory and economic environment of the Malaysian construction market (Khairul Anuar et al., 2023).

The Impacts of Supply Chain Disruptions Among Contractors in Private Construction Projects

The impact of supply chain failure on the performance of privately funded construction projects is extensive and significant, particularly in terms of costs, time, productivity, and stakeholder relationships. One (1) of the most immediate and well-documented consequences will be that material prices will increase considerably, the cost of logistics will rise, and emergency procurement methods will be used. The rising material prices have long been cited as the greatest impact of the supply chain disruptions, and post-pandemic inflation, global demand, and production capacity have put pressure on contractors' finances. In projects funded on a fixed or lump-sum basis, unforeseen costs significantly reduce profit margins and increase the risk of financial stress.

Simultaneously, supply chain disruptions often delay schedules, as late deliveries and labour gaps disrupt the planned sequence. Various work packages can be affected by a single delay in key materials, leading to labour idleness, underutilised equipment, and inefficient rescheduling (Ismail, 2021). These types of interruptions affect project completion times and productivity, predisposing contractors to liquidated ascertained damages (LAD) and prolonged overhead costs. In situations of extreme delays, chronic delays undermine project viability and lead to contractor insolvency, particularly for those with a small financial buffer.

In addition to the time-cost loss, supply chain issues also negatively impact construction quality, safety, and the workforce. The shortage of labour forces contractors to use less skilled or temporary employees, increasing the risk of workmanship errors and accidents (Juricic et al., 2021; Rahim et al., 2016; Yusoff et al., 2021).

Likewise, hasty procurement decisions aimed at reducing material shortages can result in the use of poor-quality materials or materials that do not meet quality standards, leading to rework, quality issues, and further delays. These results demonstrate that supply chain reliability and the overall quality of the project are interconnected in the built environment.

https://10.24191/bej.v23i2.11338

Supply chain disruptions also have devastating effects on the relationships and contracts of construction stakeholders. Late deliveries, financial constraints, and cost overruns often strain relationships among clients, contractors, suppliers, and subcontractors. The tensions often turn into contractual tussles, claims and lawsuits, which distract the manager's focus on delivering the project and raise administrative expenses (Shehu et al., 2015). Repeated disturbances over time may erode trust, ruin professional reputations, and diminish contractors' competitiveness in future tender exercises.

The residual impacts of supply chain disruptions undermine organisational strategic performance and long-term sustainability. The contractors who keep experiencing disruptions are less stable in their cash flows, have diminished confidence in the market, and have less ability to invest in innovation or in developing their workforce. Such issues are especially severe in the Malaysian domestic construction industry, where contractors often operate with limited margins and are highly vulnerable to macroeconomic and government shocks (Nee et al., 2024). Therefore, supply chain disruptions cannot be considered solely as operational inconveniences but rather as strategic risks with far-reaching implications for project success and industry resilience.

In general, the literature highlights that the effects of supply chain disruptions go far beyond single delays or increased prices. They pose endemic risks to project performance, stakeholder relationships, and the sustainable development of the construction industry. This supports the argument that combined risk management models, proactive planning, and digital supply chain planning are needed to reduce the effects of disruption and increase resilience in private building development.

METHODOLOGY

A quantitative research design has been adopted in this research to investigate the disruptions in the supply chain of the Malaysian private construction industry. The selection of the quantitative method is chosen as it enables the generation of numbers, facilitates statistical analysis, and allows trends to be extracted. The research design is appropriate according to the research aim, which is to evaluate the supply chain disruptions faced by the Malaysian contractors in the context of the private construction industry. A structured questionnaire survey was chosen as the quantitative data collection tool for this research.

Purposive sampling was applied to this research to identify respondents who have first-hand experience of supply chain disruptions as contractors in the construction private sector in Malaysia. The research targeted professionals who were in active employment with private contractor companies directly involved in managing or experiencing breakages in the supply chain. The targeted respondents consisted of G7 contractor firms that are registered with the Construction Industry Development Board (CIDB) in the Klang and Shah Alam regions. The unit of analysis for this study was the G7 contractor firm, represented by one (1) qualified management professional from each firm to ensure organisational-level insights. The total population of the targeted respondents was 240 contractor firms. In reference to the Krejcie and Morgan table, the sample size suitable for this research is 150 contractor firms.

The measurement scales and items within the questionnaire were carefully adapted from established literature on construction supply chain disruptions and tailored to the Malaysian context. The research instrument was structured into four (4) distinct sections to capture the necessary empirical data. Section A captured the demographic profiles and institutional characteristics of the respondents. Section B measured the baseline knowledge and awareness regarding the supply chain disruptions among the respondents. The third section (Section C) evaluated the core constructs aligned with the research objectives, namely the types of supply chain disruptions, the causes of supply chain disruptions and the impacts of supply chain

disruptions within the construction industry. Finally, section D investigated industry practices and effective strategic mitigation measures to counteract the supply chain volatility. A five (5) point Likert scale was integrated to evaluate the respondents' perceptions. The five (5) point Likert scale utilised was integrated into the core items (section B, C and D), ranging from 1= strongly disagree to 5= strongly agree, or equivalent intensity anchoring depending on the variable.

An invitation email with an attached link to the questionnaire survey was distributed to the contractor firms. Reminder emails were distributed one (1) and a half weeks after the invitation email was sent. The data collection was administered over a period of four (4) weeks. The total responses received were 86 out of 150 contractor firms, which represented 57% of the sample size.

Descriptive analyses were conducted using the Statistical Package for the Social Sciences (SPSS) software. The descriptive analyses administered include percentages and frequencies, the measure of central tendency (mean, median, mode), and the measure of dispersion using standard deviation. Formal statistical reliability testing was not administered for this study, as the analysis focuses strictly on exploratory descriptive frequencies and index rankings. However, instrument validation and content validity were firmly established through rigorous expert vetting and supervisor review before survey distribution.

FINDINGS AND ANALYSIS

The results suggest that supply chain failures are a prevalent yet influential problem in the private construction sector in Malaysia. A shortage of materials, reduced delivery times, price fluctuations, regulatory delays, and labour shortages are the most frequently recognised forms of disruption. These interruptions were cited as the most common during the planning and construction stages, where procurement and resource coordination are highly essential. The fact that these problems have become common indicates that the weak areas in the supply chain are incorporated into the project delivery mechanism rather than constituting a unique operational failure.

Table 1 highlights that material shortages (21.7%) are the most critical disruption, followed by regulatory delays (20.9%), delivery delays (20.5%), and price fluctuations (20.1%), with labour shortages (16.9%) also significant. These findings reflect ongoing challenges from global crises, unstable markets, weak logistics, and workforce shortages, all of which continue to delay projects, increase costs, and strain the construction supply chain in Malaysia.

Table 1. Types of Supply Chain Disruptions Encountered in Construction Projects

Types of Supply Chain Disruptions	**Responses**		**Percentage of Cases**
	N	Percentage (%)	
Material shortages	54	21.7%	63.5%
Delayed deliveries	51	20.5%	60.0%
Price fluctuations	50	20.1%	58.8%
Labor shortages	42	16.9%	49.4%
Regulatory delays	52	20.9%	61.2%
Total	249	100.0%	292.9%

Source: Authors (2025)

https://10.24191/bej.v23i2.11338

When analysing the causes of supply chain disruptions, the findings show that both internal and external factors contribute to it. The internal factors are poor risk management practices, poor planning, poor coordination with suppliers, and overdependence on a few suppliers. At the external level, economic uncertainty, regulatory and approval delays, fluctuations in the global market, and client tardiness were identified as significant sources of disruption. It was revealed that the global crises, especially the COVID-19 pandemic, intensified these problems by derailing production, logistics and labour supply. A combination of internal management vulnerabilities and external uncertainties reveals the systemic characteristics of supply chain disruptions in the context of private construction projects.

Table 2. Main Causes of Supply Chain Disruptions in Construction Projects

Types of Supply Chain Disruptions	**Responses**		**Percentage of Cases**
	N	Percentage	
Poor supplier reliability	64	25.2%	74.4%
Political/regulatory changes	40	15.7%	46.5%
Economic instability	51	20.1%	59.3%
Transportation/logistics failures	46	18.1%	53.5%
Poor risk management	53	20.9%	61.6%
Total	254	100.0%	295.3%

Source: Authors (2025)

Table 2 highlights poor supplier reliability as the most critical supply chain challenge, with the highest number of respondents affected. In contrast, political/regulatory changes are seen as the least impactful. Meanwhile, economic instability, logistics failures, and poor risk management remain significant concerns, indicating that operational issues and internal preparedness pose greater risks to supply chain performance than external macro factors.

The effects of supply chain disruptions on project performance are enormous. The results indicate that interruptions are primarily responsible for delays in the project, cost overruns, low productivity, and poor resource use. It was also realised that the long-term disruptions adversely affected stakeholder relations, leading to conflicts between contractors, suppliers, and clients and, in some instances, culminating in legal suits. The presence of financial losses related to the long project period, high procurement costs, and the wasted labour undertakings makes it even more critical to note the importance of effective supply chain management. In general, the findings demonstrate the direct and indirect effects of supply chain disruptions on the timing, cost, quality, and contractual relations of a private construction project.

Table 3. Impacts of Supply Chain Disruptions in Construction Projects

Types of Supply Chain Disruptions	**Responses**		**Percentage of Cases**
	N	Percentage	
Increased project costs	64	24.8%	74.4%
Delayed project completion	52	20.2%	60.5%
Quality issues	43	16.7%	50.0%
Disputes with stakeholders	47	18.2%	54.7%
Loss of clients/contracts	52	20.2%	60.5%

https://10.24191/bej.v23i2.11338

Total	258	100.0%	300.0%

Source: Authors (2025)

Table 3 shows that the most significant impact of supply chain challenges is increased project costs (24.8%), making it the top concern among respondents. This is followed by loss of clients/contractors (20.2%) and delayed project completion (20.2%), both of which can directly affect project continuity and reputation. Disputes with stakeholders (18.2%) and quality issues (16.7%) are also notable, though less dominant.

DISCUSSION

The findings of this research reveal that supply chain disruptions in the Malaysian private construction sector are not limited to operational mishaps but also encompass systemic vulnerabilities. This is mainly caused by the mixture of internal management deficiencies and volatile external environments.

Types of Supply Chain Disruptions

The data indicated that material shortages (63.5% of cases), regulatory delays (61.2% of cases), and delayed deliveries (60.0% of cases) are categorised as primary supply chain disruptions that impact the G7 contractors in the Klang Valley and Shah Alam. The focus on material and delivery-related issues aligns with Shurrab and Johansson's (2022) and Heaton et al. (2022) elaborations on the 'bullwhip effect' in supply chains. Minor changes in site requirements amplified into massive material bottlenecks at the supplier level due to fragmented information sharing across the construction supply chain. Construction supply chains are complex and unpredictable, any changes in planning and construction cause ripple effects across the entire project lifecycle, leading to a series of delays (Muhamad Nazri et al., 2026; Vrijhoef & Koskela, 2000).

Causes of Supply Chain Disruptions

The research discovers the causes of supply chain disruptions at the operational level and at the global level. The data collected indicated that the leading causes of supply chain disruptions are poor supplier reliability (74.4% of cases), followed by poor risk management (61.6% of cases) and economic instability (59.3% of cases). Zulhumadi et al. (2013) and Heri (2024) both noted that the causes of supply chain disruptions are present due to the fragmented nature of the Malaysian construction industry. The Malaysian private construction projects rely heavily on a high number of subcontractors and suppliers. As a result, the heavy reliance resulted in the rapid raw material price fluctuation when global crises occur, such as a pandemic and geopolitical tensions. Private contractors normally operate on fixed lump-sum contractual terms, which results in the lack of a financial buffer to absorb sudden price surges. Consequently, they delay payments to subcontractors and suppliers. This financial strain affects the cash flow of small suppliers, which results in poor supplier reliability on the construction site. Poor supplier reliability is a direct byproduct of internal financial strains and inadequate risk management.

Impacts of Supply Chain Disruptions

The data showed the most severe consequences of supply chain disruptions, which are increased project cost (74.4% of cases), followed by delayed project completion (60.5% of cases) and a loss of clients or contracts (60.5% of cases). This is supported by research conducted by Ismail (2021) and Shehu et al.

(2015). The prolonged supply chain disruptions expose contractors to Liquidated Ascertained Damages (LAD) and multiple overhead costs, which significantly reduce the contractors' profit margins. Furthermore, the supply chain disruptions affect the industry relationships in construction projects. The data showed that the stakeholder disputes represent 54.7% of cases reported, which supported the research conducted by Judi and Rashid (2010) and Zainon et al. (2025). Payment delays and material shortages often result in contractual conflicts and legal disputes. Thus, contribute to the degradation of professional reputations and contractor insolvencies.

Industry Practices and Mitigation Strategies

The review shows that the contractors are mostly aware of the significance of supply chain management in minimising risks in projects, but their readiness to future interruptions is moderate. Although current supply chain management practices were seen to positively affect risk reduction, the findings demonstrated that risk management policies are not regularly reviewed, suggesting mostly responsive rather than proactive planning. This shows a lack of awareness of supply chain risks and the industry's failure to systematically adopt structured risk management approaches.

Despite these shortcomings, several mitigation measures proved effective in addressing supply chain disruptions. Supplier diversification was one (1) of the strategies put in place to minimise reliance on a single or a few sources, ensuring material availability and flexibility. Better communication and coordination of stakeholders were also considered key to improving information flow, aligning the project schedule, and eliminating misinterpretations. Moreover, the flexibility of the contractual arrangements was also seen to assist contractors in better controlling price fluctuations and delays.

The use of digital technologies was found to be an enabler of supply chain resiliency. Technologies such as Building Information Modelling (BIM) and artificial intelligence (AI) were seen to enhance planning precision, improve supply chain visibility, and enable data-driven decision-making. The tools enable contractors to anticipate potential disruptions and address them more effectively. On the whole, the results indicate that although mitigation practices are becoming more popular in the industry, more stakeholders should be committed to proactive risk management, the broader application of digital technologies, and increased cooperation among supply chain participants to enhance resilience and project outcomes in the built environment sector.

RECOMMENDATIONS

Based on the results of the present research, some recommendations are offered to improve supply chain resilience during the implementation of a private project in the Malaysian construction industry. First, the more proactive and structured approach to supply chain risk management should be adopted by the contractors. This involves conducting early risk identification in the planning phase, periodically reviewing supply chain risk registers, and incorporating contingency planning schedules and cost plans into project schedules and expenditure plans. Incorporating risk management into normal project management processes would allow contractors to foresee potential disruptions, rather than react when it is too late or when shortages occur.

Second, supplier diversification must be emphasised to minimise over-dependence on a single or a few sources of materials. Contractors should also establish strategic relationships with various suppliers, including local suppliers, to enhance material availability and responsiveness during disruptive periods. Established long-term mutual relationships with suppliers have the potential to increase trust, better

information flow, and maintain stability, so that the risks associated with disruptions in the global market or the inability of the logistics systems to withstand the changes are low.

Third, the findings also indicate that there should be better stakeholder communication and flexibility in the contract. There must be effective communication channels between clients, contractors, and suppliers to ensure on-time information flow on material availability, delivery schedules, and payment schedules. Also, the application of flexible contractual terms, such as price fluctuation clauses and alternative sourcing terms, can help better manage uncertainties arising from cost escalation and contractor regulatory delays.

Fourth, digital technologies should be embraced more to enhance the visibility of supply chains and decision-making. Building Information Modelling (BIM) and artificial intelligence (AI) are tools that can assist with more efficient demand prediction, real-time monitoring of materials, and risk prevention in the supply chain. With digital solutions integrated into supply chain management practices, it would be easier to coordinate the activities of various stakeholders and the overall project performance.

Lastly, capacity-building to enhance supply chain management efficiency in the construction industry should be encouraged by industry stakeholders and policymakers. Knowledge-sharing platforms, training programmes, and industry guidelines focused on risk management and digital adoption can support contractors (especially small and medium-sized ones) in enhancing the resilience of the supply chain. The combination of these recommendations helps improve project timelines, control costs, and deliver better outcomes for stakeholders, and contributes to the sustainable development of the built environment sector in Malaysia.

CONCLUSION

This paper discusses supply chain disruptions in Malaysian private-sector construction projects, their types, causes, effects, and mitigation measures as perceived by contractors. The results support the assertion that supply chain disruptions remain a serious problem in the private construction industry. Material shortages, delayed delivery, price variations, delays in regulatory processes, and labour shortages are the most common types of disruption. These were identified as the highest in the planning and construction phases, with the construction supply chain's vulnerability lying in its structure.

The paper has also shown that a mix of internal management weaknesses and external uncertainties causes supply chain disruptions. Poor risk management, planning, and supplier coordination, combined with economic instability, regulatory restrictions, a volatile global market, and delayed payments, increase the risk of disruption. These interferences have severe negative impacts on the project's performance, leading to time overruns, increased costs, low productivity, and poor relationships among stakeholders, thereby compromising the success of the entire project.

The results show the significance of proactive supply chain management practices for enhancing project resilience. Although contractors are usually aware of the importance of supply chain management, preparedness for future disruption is average in the industry. Among the identified effective mitigation measures, it is possible to note diversification of suppliers, enhanced communication with stakeholders, flexibility in contractual relations, and the implementation of digital technologies, including Building Information Modelling (BIM) and artificial intelligence (AI). Though these strategies are limited in effectiveness by inconsistent implementation.

https://10.24191/bej.v23i2.11338

In general, the current work can be included in the literature on supply chain disruptions because it provides empirical data on disruptions in the context of Malaysian private construction projects. The results reveal the need for a more active risk management culture, greater stakeholder cooperation, and greater involvement in digital technologies to improve supply chain resiliency. These areas are necessary to enhance the project's performance and contribute to the sustainable development of the Malaysia n private.

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CONFLICT OF INTEREST STATEMENT

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare the absence of conflicting interests with the funders.

AUTHORS' CONTRIBUTIONS

Nurul Farahdiana binti Mohd Joharudin carried out the research and preparation of the original draft of the manuscript. Maisarah binti Makmor supervised the research and contributed to the review and editing of the manuscript. Umi Kalsum Zolkafli @ Zulkifly, Abdul Hadi Ahamad and Mohd Farhan Mohd Nasir have provided critical reviews and approved the article for submission.

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