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Supply Chain Strategy in Philippine Construction Industry: A Case Study of Joint Risk Management Approach during the COVID-19 Pandemic

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Abstract. The COVID-19 pandemic was one of the unforeseeable risks in the construction industry. The supply chain (SC) trend globally and locally was disrupted by the sudden pandemic that forced people to limit the movement to minimize the further infection of the virus. Joint risk management (JRM) is a strategy that encourages and enhances collaboration in construction. Furthermore, with the complexity of the industry, joint risk management is an alternative tool for managing unforeseeable risks in construction. The objective of this research is to identify the impact, problems, and solutions companies have encountered in the construction industry supply chain amid the pandemic in CALABARZON. Moreover, developed a strategy using joint risk management. The data for the case study was collected through interviews. The study results show that some companies are not significantly affected by the pandemic in terms of projects. However, construction companies face delays and lack in supply, problems in mobility, an increase in raw and construction material, and problems with human resources. The construction adapted to the situation and strategized through effective planning, scheduling, time management, and good communication with each project stakeholder. Lastly, a joint risk management strategy was developed to encourage collaboration with each construction project stakeholder.

Keywords: supply chain management, construction industry, joint risk management

1. Introduction

In late 2019, the coronavirus was detected in Wuhan, a city of 11 million people in Hubei, China. In late January and early February, when the pandemic was at its peak, cases of the COVID-19 rose by thousands per day in the nation [1]. It is announced by WHO that to avoid the spread of COVID-19, people are urged to wear a mask, keep a safe distance, clean their hands, remain at home if feeling ill if there are significant symptoms, consult physicians quickly, and finally, acquire a vaccination when it is available. By these means, COVID-19 (Coronavirus) has harmed most of everyday life, companies, and is causing the world economy to slow down [2].

Construction is one of the most affected industries due to the COVID-19 epidemic. It was observed that numerous routines have shifted due to the epidemic [3,4]. The pandemic's effects on supply chain management (SCM), transportation movement, labor inadequacy, financial concerns, contractual ramifications, and inoccupation have been severe. As a consequence of the economic crisis, companies continue to struggle to retain various contracts. One of the consequences for the community is supply chain management which is a web of people, organizations, resources, procedures, and technology that is engaged in the manufacturing and distribution of goods [5]. The supply chain encompasses the movement of raw materials from the supplier to the production and ultimately to the end customer. A supply chain's components include all functions that begin with the receipt of an order and conclude with the fulfillment of the consumer's desire [6]. The industry and its employees are particularly susceptible to these difficult economic times. Additionally, it had a detrimental influence on the labor market, material supply, firm liquidity, project delivery, and a significant component of construction costs, among other things [7]. Supply Chain Management (SCM) is used at four levels in construction, depending on the scope, which may be on supply on-site, construction project-site, or both. Supply chain management's primary function is to diminish the expense and period of project operations by concentrating on the supply chain's effect on the construction site [8]. The second function of SCM is to concentrate on the supply chain itself, with the objective of reducing costs, especially those associated with transportation, lead time, and inventory [9]. The third

function of SCM is to concentrate on the process of moving work from the site to an earlier stage in the supply chain. Finally, supply chain management concentrates on the integrated management and development of the manufacturing site's production and supply chain, such as supply chain management incorporating manufacturing site production [10].

According to the Philippine Statistics Authority (PSA), there are 33,981 constructions from certified building permits as of the third quarter of 2021 as shown in Fig. 1. The overall value of construction in the third quarter of 2021 was Php 85.62 billion, representing a 10.4% increase from the value of the previous quarter.

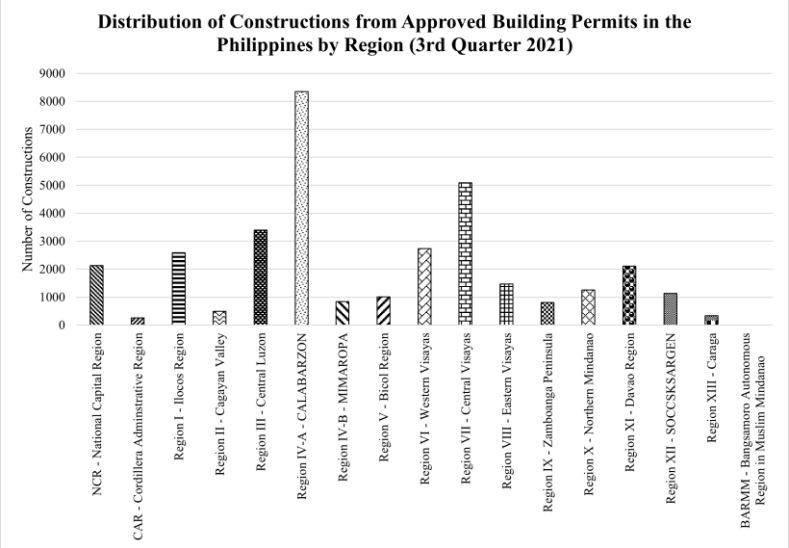

Fig. 1: Distribution of Construction from Approved Building Permits in the Philippines by Region (3rd Quarter 2021).

Contractors have been tasked with the responsibility of completing existing projects while protecting on-site staff, adhering to government rules and travel restrictions, and managing supply chain delays and project cancellations in the midst of the pandemic. With the epidemic still ongoing, various changes have occurred in the building industry, as well as some advancements. The most significant advancements in construction, on the other hand, went beyond cleanliness and safety and emphasized remote labor and digital technologies to assist in the efficient operation of projects [11,12].

Joint Risk Management is a collaborative approach to risk identification, assessment, and response that relies on ongoing interaction between project stakeholders to foster the sharing of expertise and understanding, thereby minimizing the negative consequences of uncertain events, and maximizing the opportunities they may present. Additionally, it is critical to ensure that project players are not enticed to protect themselves from inflated costs by over-stuffing a risk register with contingencies. Although JRM is the best option for mitigating unanticipated risks, integrating a project team comprised of the owner, consultant, contractors, subcontractors, and suppliers via relational integration is only possible if clients adopt a proactive approach. It is a form of construction that enables the client, designer or engineer, site supervisor, general contractor, and subcontractors to work throughout the design and construction phases in an increasingly interdependent trust, commitment to shared objectives, and open communication [13].

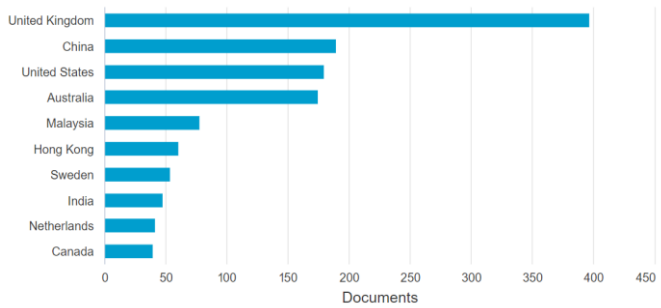

Fig. 2: Research about Supply Management and Construction Industry in different countries.

Based on the Scopus analytics data as of March 2022, there are 1,536 documents about the supply chain and construction industry. Most of these documents were from the United Kingdom with 396 documents in the last 25 years as shown in Fig. 2.

Moreover, there are only 19 documents available about the supply chain in the construction industry during the COVID-19 pandemic. The objective of the study is to evaluate the supply chain in the construction industry during the pandemic and to create effective ways for enhancing supply chain management via the use of joint risk management.

2. Methodology

2.1. Research Flow

The research flow consists of the pilot testing and preliminary survey, evaluation of preliminary survey results and rubrics formulation, determining the impact of COVID-19 based on the case studies, current situation analysis of the SC in construction during the pandemic, and development of strategy in enhancing the supply chain management using joint risk management. The flow of the activities implemented in this study were exhibited in Fig. 3.

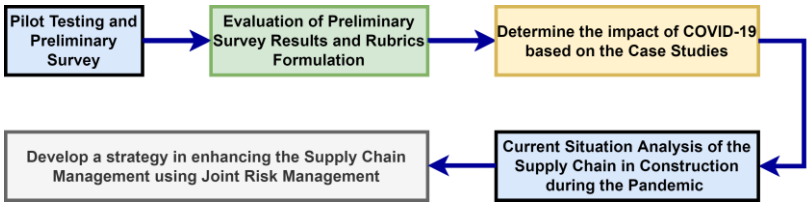

Fig. 3: Research flow.

2.2. Data Gathering

A preliminary survey was implemented in the study to gather the data concerning the effect of the COVID-19 pandemic in the supply chain of the construction industry in Region IV-A (CALABARZON) [14].

Respondents in the preliminary survey were based on their knowledge and experience. The respondents must have broad construction experience and have worked during the COVID-19. The preliminary survey and interview results were utilized for creating the rubrics for the case study's chosen case. In the preliminary interview, researchers focus on the respondents of the study, which are the general contractors, contractors, subcontractors, clients, and suppliers.

2.3. Analysis of data and proposed SCM-JRM strategy

The researchers analyzed and interpreted how these contractors and supplier was affected by the COVID-19 pandemic. From these results, a case study of two companies was likewise implemented to examine and discuss the effect of the pandemic in the SC within the company. Moreover, a proposed SCM-JRM strategy was developed to enhance the system of the SC in the companies.

3. Results and Discussion

3.1. Case Study 1 – Construction Company

ABC Construction Services commenced operations in 2016. Cabuyao City, Laguna is the location of the company. During the first months of the outbreak, the majority of firms and enterprises suspended operations. ABC Construction Services remains operational despite the following COVID-19 infection. With the continuous pandemic, the organization has several choices for ensuring the continued provision of excellent services, but there are still challenges. The pandemic of COVID-19 had a minimal impact. Except for the lockdowns and quarantines that were necessary, it had a limited effect on the project's delay. The firm had difficulties with construction worker mobility owing to health regulations, delivery delays due to capacity limits, and SC disruptions due to COVID. When the risk of COVID-19 infection is considered, it also has an effect on the cost of constructing materials and labor. The outbreak had little impact on ABC Construction

Services' projects, which are mostly funded by the government's Build-Build-Build program. The COVID-19 outbreak, on the other hand, has resulted in financial and project delays.

ABC Construction Services has gradually adapted to the construction industry's 'new normal.' While the pandemic continues, the firm continues to retain and apply pre-pandemic processes. As a result, they plan or manage a construction project while the outbreak is ongoing. As a reference, personnel may utilize it to rapidly come up with solutions to issues that may develop throughout the course of the project's execution. ABC Construction Services' best course of action would have been to consider the company's procurement, whether for necessities or construction materials.

3.2. Case Study 1 Discussion – Impact on the Company

Construction workers' movement was restricted owing to health norms, causing delays in material deliveries, project delays, and labor delays. The primary objective of SCM is to lower the cost and time of building site operations by focusing on the supply chain's influence [15]. A steady supply of materials and manpower to the project site is thus critical. Pandemic-induced lockdowns were implemented in most nations including the Philippines. The mandated lockdowns not only halt building projects but also lead certain enterprises to temporarily cease operations, delaying the supply of construction materials, both local and foreign.

Most of the ABC Construction Services are BUILD-BUILD-BUILD projects. Therefore, the company was able to avoid lengthy project delays. However, the company's delivery of construction materials was delayed. During the pandemic, there was a serious shortage of building supplies, which had a negative impact on the construction industry [16]. Even prior to the outbreak, delays were common in construction projects which entails resource constraints and delays. COVID-19 exacerbates construction delays. In the case study, the business experienced a one-month delay in material delivery [17]. A month was the longest period of material delay they encountered. During this period, the business and contractors concentrated on acquiring and stockpiling construction materials to ensure the project's completion and avoid closure. Businesses invest in construction materials to ensure that projects are completed on time and that stock supplies are used. The business sought strategies to overcome expected or unplanned delays by adhering to equipment and labor schedules, providing, and enrolling in suitable material inventories and assuring enough supply of daily commodities. This scheduling has aided the company in maintaining a healthy balance between time and cost. It assists the company in successfully and efficiently managing the project, its personnel, suppliers, and supplies.

The Philippine Statistics Authority forecasts a significant fall in construction value in the first quarter of 2021. The growing cost of construction materials and budget constraints affect the services and expenses of the business. The COVID-19 outbreak causes supply chain disruptions and delays. As a result, construction and raw material prices have increased. Increased prices, pandemic expenditures, and required lockdowns to prevent viral transmission result in gridlock, project delays, and higher overall costs. However, for enterprises, the impact is mostly on the construction phase, with supply and shortage issues. Certain activities are also terminated as a result of rising healthcare expenditures. Without supplies and equipment, workers are unable to function, and a human resource deficit results in delays and increased costs. The triple constraints such as time, budget, and scope are related with their distinct and combined functionality and elements in such a way that they impact one another, particularly in construction projects according to Silva et al. [18].

In a pandemic, communication is challenging. According to research conducted by Aneesa et al. and Silva et al., enhancing contractor communication and guaranteeing firm continuity helps stakeholders and improve productivity on-site, reducing problems [18,19]. The researchers found that the organization's success is contingent upon regular interaction with employees. Additionally, it aids in the comprehension on the part of stakeholders. It conforms to Silva et al. findings that stable and robust culture is defined by identifying and relating to exceptional individuals and teams who adhere to the organization’s values. Furthermore, they identified that developing the people and promoting teamwork improves the organization’s values [20] The research indicates that the construction industry's historical adversarial approach has inhibited the formation of trusting relationships. The company in the case study has a long

history in the construction industry. This has resulted in the establishment of connections to the suppliers and subcontractors. The organization pledged to safeguard its ties with suppliers and subcontractors in order to maintain high standards of quality and business. Additionally, the company interacted with its partners without difficulty during the outbreak. The company facilitates project collaboration and management. The company in the case study was able to extend its operations outside conventional construction techniques. It facilitated the company's development of strong ties with other project stakeholders, which aided them in overcoming pandemic-related challenges.

The steady adaption of the ABC Construction Services to industry changes was investigated by the researchers. As a consequence of the current pandemic, the organization has shifted its focus to project planning and management, which encourages staff to remain engaged. While unexpected occurrences may occur during a pandemic, it is critical to maintain business operations and complete all duties that demand adaptation. ABC Building Services has understood the value of strategic procurement when it comes to critical items or construction supplies. Stockpiling commodities may also help to alleviate shortages and delays on projects. Savings and earnings potential for the business is critical, as is greater investment in construction materials. Companies must have procedures and backups in place to prevent financial losses. Contractors must rapidly change for the organization to continue working and avoid losing prospects. When the processes will resume regular operation is unknown at this time. This information may aid the organization in preparing for unforeseeable events that may or may not be in conformity with COVID-19.

3.3. Case Study 2 – Construction Materials Supplier

The XYZ Corporation commenced operations in 1992. The business has since shifted its concentration to government construction projects. XYZ Construction Corporation may continue working on government-related projects despite the outbreak. Several business endeavors, however, were put on hold due to the COVID-19 outbreak.

The pandemic has taken a heavy toll on XYZ Construction Corporation. In other instances, the pandemic forced the firm to close the plant. Regulations imposed by the government require quarries to close. Thus, results in a scarcity of supplies. Due to a scarcity of raw materials, prices have increased. Additionally, it is their responsibility to inform the buyer but despite these difficulties, the company managed to survive the pandemic. When confronted with a supply shortage, the company addresses supply delays via scheduling and time management. The company is constantly storing and monitoring its own and its suppliers' raw material inventories.

XYZ Construction Corporation's quarry supplier always informs the client in advance if the quarry will be temporarily closed. The corporation takes advantage of this warning to stock up. Additionally, the organization inquiries about the client's schedule for the next 1-2 months to prepare ahead. Additionally, the firm receives notification from the raw material supplier 1-2 weeks prior to the price rise, giving them sufficient time to notify their customers. Despite the price rise, the XYZ Construction Corporation did not lose any customers throughout the pandemic. The firm is transparent in its pricing practices and notifies customers of price hikes. Despite the unforeseen nature of the pandemic, XYZ Construction Corporation seized the chance to learn a great deal from the event. The organization gained valuable knowledge about time management, scheduling, employee care, and valuing their employment, enterprises, and customers.

3.4. Case Study 2 Discussion – Impact of the Supplier

The COVID-19 has a negligible impact on suppliers, particularly those involved in government construction projects. While the effect may be little, it is important to remember that it is felt across the supply chain. Global and local lockdowns have a variety of effects on the supply chain, including delays, shortages, and price increases. The company in the case study was experiencing a supply shortage. The construction supply chain is more vulnerable to COVID-19 because it is reliant on worldwide supply chains for materials, equipment, plant, and people [21]. Due to the lockdowns, material manufacturers have suspended operations, and critical construction supplies are unable to reach the site. Lockdowns forced the closure of aggregate quarries in this case which resulted in a halted plan due to a lack of supplies [22]. Each organization and project have a standard that must be adhered to ensure the consumer receives the highest

quality goods. Regardless of a supply deficit or a delay, XYZ Corporation did not shift suppliers. However, due to the firm's strict criteria, locating a supplier is challenging. Along with the outbreak, the company had difficulty procuring the raw materials required by their client which caused delays in the execution of the project, raising the overall cost.

Project managers (PMs) learned and adapted during the outbreak. PMs created tools to assist with time management, scheduling, and stock monitoring. PMs were aware of potential risks and were prepared to handle the supply chain during the outbreak. Supply chain management is all about detecting and controlling risks. To survive a pandemic, good decision-making and flexibility are required [23]. During the pandemic, the government building project was a lifeline for XYZ Corporation. The company adapted rapidly to changes in construction technologies. Utilizing time management and scheduling, the company was able to eliminate supply chain delays. Businesses were affected by supply delays and shortages caused by the pandemic. Time management, scheduling, and supply monitoring are further strategies that XYZ business use to remain operational and execute construction projects.

COVID-19 imposes government-mandated lockdowns and stringent health requirements. As a consequence, the construction supply chain has been disrupted, increasing the cost of raw materials. Imports of raw materials have been delayed and prices have increased as well as prices for both imported and local raw materials. Despite price increases, XYZ Construction Corporation retains clients via openness and communication. In the findings of Silva et al., the triple constraints significantly impact the project, supporting the claims on streamlined networks of communication, the dynamics, and flexibility of triple constraints in a quality project delivery [18]. XYZ Construction Corporation was hurt by the supplier's price increase. The long-term connection of a supplier with the prime contractor and client has proved challenging. As observed in the study of Briscoe and Dainty, the majority of long-term relationships exist between clients and main contractors; clients and primary contractors are cautious of dealing with subcontractors and clients. Increased product cost might result in a supplier losing clients [24].

According to Esa et al., the effect of COVID-19 on the SC resulted in project suspensions and cancellations, as well as the closure of the majority of suppliers [25]. The "Build-Build-Build" programs ensure the continuation of government construction projects. As a result, the program has no effect on government-affiliated construction suppliers. According to the case study, the company recorded that the majority of its private construction projects had been temporarily delayed because of the elevated expenses associated with the pandemic. Government-sponsored building projects persisted, helping other companies to continue operating throughout the outbreak. COVID-19 has a significant impact on these firms, which specialize in government construction projects, in terms of the supply chain, increased costs associated with the pandemic, and human resources.

In pandemic supply chain management, communication is key. Clients and primary contractors form the majority of long-term relationships in construction. Additionally, clients have concerns about subcontractors and suppliers. Despite construction's adversarial nature, the two businesses might complement one another successfully. In Meng and Zhang & Li’s research findings, a lack of trust is highlighted as an obstacle to construction management [26,27]. According to the current case study, XYZ maintains positive relationships with both its customers and raw material suppliers. Communication and transparency were critical throughout the pandemic. Transparency helped each project participant to overcome challenges, whether it was the client, prime contractor, subcontractor, or supplier. Despite pandemic-related delays and price increases, the company was able to manage inventories and retain consumers via communication and trust.

3.5. Proposed Strategy

The researchers discussed a process called the JRM Process for the assessment of risks in projects. This strategy will establish a friendly work environment in which each construction stakeholder may identify the risks associated with their project and build connections. The different stages of construction, including bidding and contract signing, are shown in Figure 4. The project starts with bidding, which, in contrast to standard bidding circumstances, includes specifications, drawings, a bill of quantities, and bidding forms, as specified in the DPWH Procurement Manual Volume II - Infrastructure. According to the contract’s special condition, the additional requirement must include the usage of the Joint Risk Management Strategy Process.

This provision requires an initial risk assessment meeting and a post-phase report after each phase. This agreement shall remain in effect until the project is completed. An overall project report, relationship evaluation, and closeout meeting at the end of the project shall be implemented. Risks shall be identified, analyzed, and addressed to, as well as risk documentation. Risk management consists of three stages: identification, assessment, and response. A risk assessment meeting is performed before initiating the planning, pre-construction, and construction stages [13]. The risk register will include risk prioritization, strategies for mitigating and resolving recognized dangers.

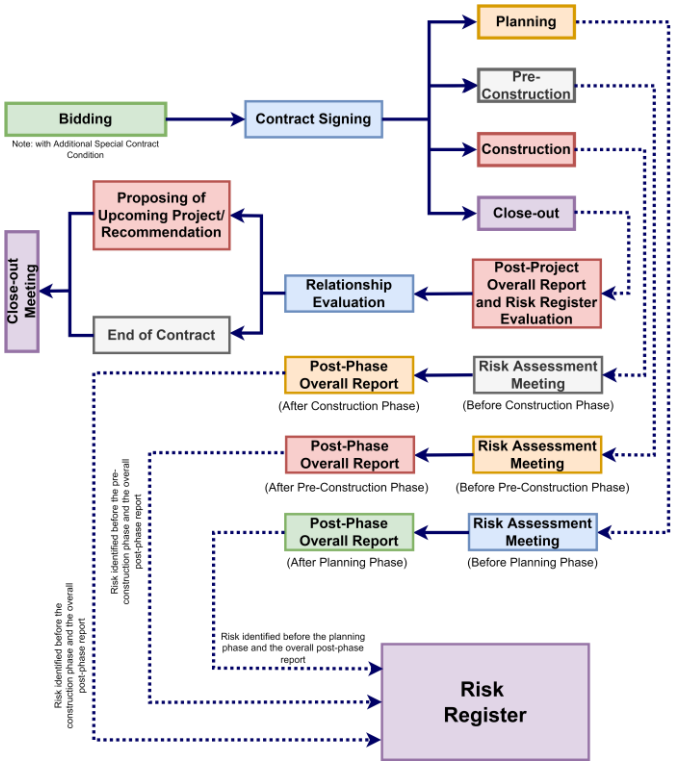

Fig. 3: The proposed process to assess project risks using JRM.

The suggested technique stated that upon contract execution, both parties must agree to the contract's extra condition describing what would happen when the project begins. When both stakeholders agree to the new requirement, all parties involved must begin planning the risk assessment meeting's schedule. A meeting shall be held at the start of each construction phase, including planning, pre-construction, and construction, as specified in the contract. Osipova's proposal of JRM Process activities in 2013 was inspired by the Risk Assessment Meeting [13]. The following are the activities he discussed in his study: (a) collaborative risk identification and assessment; (b) collaborative risk registers and risk response plans; and (c) continuous risk register and response plan updates.

This is analogous to the joint risk management plan's risk assessment meeting. This meeting must be beneficial for everyone involved. Risk registers and risk plans must be prepared and maintained at the start of each phase of the project (planning, preconstruction, construction). Everyone must concur on all points and vote as a single unit. It enables participants to maintain control over project risk while also establishing strong working ties with commercial partners. Both parties must provide a post-phase overall report at the conclusion of each project's construction phase. This documentation details all dangers and the methods used by each actor to mitigate them. Each participant should submit comments on each step of the project in order to improve future construction. Similar to Motiar Rahman and Kumaraswamy's work, constructing complete contracts is expensive and time-intensive [28]. One of these steps requires time since both teams must meet at the start of each project phase. Numerous unexpected construction dangers are introduced by the pandemic. The suggested method, on the other hand, enhanced supplier connections with their partners, notably the general contractor. Subcontractors and suppliers are critical to achieving the project's objectives and completion via the use of the Joint Risk Management approach. Adopting this strategy also helps the project participants in a variety of ways, from developing connections with partners to minimizing the risk and price

of losing project financing. This strategy benefits the general contractor, subcontractors, and suppliers. Additionally, the study conducted by the experts will help project stakeholders in establishing trust and transparency.

4. Conclusion

The current study serves as a framework for understanding the construction industry supply chain risk and context. This research proposed a framework structure to capture the overall supply chain process as well as the associated risks in the construction industry from planning, pre-construction, and post-construction, as well as the closing out phase of the project. The framework could assist the stakeholders in identifying risks and developing a risk register or lessons learned in the project that can be tapped in the event that there will be unexpected circumstances in the construction project. The researchers proposed a joint risk management strategy that can help the project have an extensive risk assessment of the potential risks. All stakeholders have a different point of view in construction; it helps to identify potential risks on each side of the project. Moreover, every stakeholder present in the meeting could assist in providing effective strategies to minimize or avoid negative risks and exploit the positive. Moreover, it encourages a good relationship and communication with each project stakeholder working on the project.

5. References

[1] H. Liu, Z. Rong, X. Qi, J. Fu, H. Huang, L. Cao, L. Shan, Y. Zhao, K. Li, Y. Hao, M. Jiao, Q. Wu, and X. Zhang. Comparative and quantitative analysis of COVID-19 epidemic interventions in Chinese provinces. *Results Phys.* 2021, **25**: 104305.

[2] A. Haleem, M. Javaid, and R. Vaishya. Effects of COVID-19 pandemic in daily life. *Curr. Med. Res. Pract.* 2020, **10** (2): 78.

[3] G. K. Nair, S. Hameed, and S. Prasad. Ready for recovery: Hoteliers' insights into the impact of COVID-19 on the Indian hotel industry. *Res. Hosp. Manag.* 2021, **11** (3): 199-203.

[4] D. Silva, K. L. De Jesus, B. Villaverde, R. G. D. Torre, N. Espero, K. J. Fermin, and R. R. Ramirez. Post-pandemic Project Change Management Model: An Adaptable Framework Utilizing Levenberg–Marquardt Algorithm and Dynamic Causal Loop Diagram for Construction Innovation. *In Proc. 2021 4th Int. Conf. Civ. Eng. Archit.* 2022, 587-600.

[5] R. Azzi, R. K. Chamoun, and M. Sokhn. The power of a blockchain-based supply chain. *Comput. Ind. Eng.* 2019, **135**: 582-592.

[6] Z. Asim, S. A. Jalil, and S. Javaid. An uncertain model for integrated production-transportation closed-loop supply chain network with cost reliability. *Sustain. Prod. Consump.* 2019, **17**: 298-310.

[7] S. Majumder and D. Biswas. COVID-19: impact on quality of work life in real estate sector. *Qual. Quant.* 2021, 1-15.

[8] P. L. Le, W. Elmughrabi, T. M. Dao, and A. Chaabane. Present focuses and future directions of decision-making in construction supply chain management: a systematic review. *Int. J. Constr. Manag.* 2020, **20** (5): 490-509.

[9] M. Attaran. Digital technology enablers and their implications for supply chain management. *In Supply Chain Forum: Int. J. Taylor & Francis* 2020, **21** (3): 158-172.

[10] Y. Liu, J. Dong, and L. Shen. A conceptual development framework for prefabricated construction supply chain management: an integrated overview. *Sustainability* 2020, **12** (5), 1878.

[11] B. Orzeł and R. Wolniak. Digitization in the Design and Construction Industry—Remote Work in the Context of Sustainability: A Study from Poland. *Sustainability* 2022, **14** (3), 1332.

[12] D. L. Silva, K. L. M. De Jesus, B. S. Villaverde, and E. M. Adina. Management Competency Model: Predictive Neural Network Approach for Empirical Components of Construction Project Proficiency. *Mod. Manag. based Big Data II Mach. Learn. Intell. Syst. III* 2021, 266.

[13] E. Osipova and P. E. Eriksson. Balancing control and flexibility in joint risk management: Lessons learned from two construction projects. *Int. J. Proj. Manag.* **2013, 31** (3): 391-399.

[14] J. Tipmontian, J. C. Alcover, and M. Rajmohan. Impact of blockchain adoption for safe food supply chain management through system dynamics approach from management perspectives in Thailand. *Multidiscip. Digit. Publ. Inst. Proc.* 2020, **39** (1): 14.

[15] Y. Qi, B. Huo, Z. Wang, and H. Y. J. Yeung. The impact of operations and supply chain strategies on integration and performance. *Int. J. Prod. Econ.* 2017, **185**: 162-174.

[16] Y. Gamil and A. Alhagar. The impact of pandemic crisis on the survival of construction industry: a case of COVID-19. *Mediterr. J. Soc. Sci.* 2020, **11** (4): 122-122.

[17] M. M. Rahman, Y. H. Yap, N. R. Ramli, M. A. Dullah, and M. S. W. Shamsuddin. Causes of shortage and delay in material supply: a preliminary study. *In IOP Conf. Ser.: Mater. Sci. Eng.* 2017, **271** (1): 012037.

[18] D. Silva, K.L. De Jesus, B. Villaverde, A.I. Enciso, M.N. Mecija, J.O. Mendoza. Interdisciplinary Framework: A Building Information Modelling Using Structural Equation Analysis in Lean Construction Project Management. *Frontiers in Artificial Inte. And App.* 2021, 274-281.

[19] M. Aneesa, A. K. Gupta, D. B. Desai. Supply chain management: effective tool in construction industry. *Int. J. Nov. Res. Eng. Sci.* 2015, **2** (1): 35-40.

[20] D. Silva, B. Villaverde, K.L. De Jesus, L. Marcial.Jr., R.L. Ejera, C.V. Villa-Real, J.M. Zarraga. Design Initiative Implementation Framework: A Model Integrating Kolmogorov-Smirnov in Sustainable Practices for Triple-Bottom-Line Principles in Construction Industry. *Civil Eng. And Arch.* 2020, **8** (4): 599-617.

[21] X. Fu, Y. Qiang, X. Liu, Y. Jiang, Z. Cui, D. Zhang, and J. Wang. Will multi-industry supply chains' resilience under the impact of COVID-19 pandemic be different? A perspective from China's highway freight transport. *Transp. Policy* 2022, **118**: 165-178.

[22] S. Majumder and D. Biswas. COVID-19 impacts construction industry: now, then and future. *In COVID-19: Predict. Decis.-Mak. Impacts* 2021, 115-125.

[23] D. Ivanov and A. Dolgui. A digital supply chain twin for managing the disruption risks and resilience in the era of Industry 4.0. *Prod. Plan. Control* 2021, **32** (9): 775-788.

[24] G. Briscoe and A. Dainty. Construction supply chain integration: an elusive goal? *Supply Chain Manag.: Int. J.* 2005.

[25] M. B. Esa, F. S. B. Ibrahim, and E. B. M. Kamal. Covid-19 pandemic lockdown: The consequences towards project success in Malaysian construction industry. *City* 2020, **25**: 2.

[26] X. Meng. The effect of relationship management on project performance in construction. *Int. J. Proj. Manag.* 2012, **30** (2): 188-198.

[27] R. Zhang and D. Li. A review of the adoption of supply chain management in construction. *In 2011 IEEE Int. Conf. Autom. Logist. (ICAL)* 2011, 187-191.

[28] M. Motiar Rahman and M. M. Kumaraswamy. Assembling integrated project teams for joint risk management. *Constr. Manag. Econ.* 2005, **23** (4), 365-375.