CRITICAL RISK FACTORS IN CONSTRUCTION PROJECTS: A DEMATEL-BASED MODEL

Chia Kuang Lee[1], Fui Yee Chong[1], Siau Chuin Liew[2], Joo Hui Tay[3] and Tien Choon Toh[4]
[1]Faculty of Industrial Management, Universiti Malaysia Pahang, Pahang, Malaysia.
[2]Faculty of Computing, Universiti Malaysia Pahang, Pahang, Malaysia.
[3]Faculty of Industrial Sciences and Technology, Universiti Malaysia Pahang, Pahang, Malaysia.
[4]Department of Surveying, Universiti Tunku Abdul Rahman, Kajang, Malaysia.

Abstract
Construction projects are defenceless to more risks compared to the other industries due to their nature and complexities. These risks can lead to performance reductions, increased costs, scheduling delays, and even project failure. It is noted that the success of the project depends on identifying the most common risk factors and mitigate them effectively. Numerous studies have discussed the significance of investigating the critical risks in the construction projects but the complex causal relationships among the risk factors and their relative significance with respect to each other remain unexplored. The purpose of this paper is to identify the critical risk factors and investigate the interrelationship among the risk factors in the construction projects. Detailed literature review has been conducted and ten risk factors were identified. Decision Making Trial and Evaluation Laboratory (DEMATEL) is employed in the study to prioritize the risks and then analyse the causal relationship among the factors. Based on the interview data from thirteen experts, the results show design risks are the critical risk factors. The findings in this study can provide structural visualization of complex causal relationships among risk factors and also allow construction experts to prioritize the resource allocation to achieve project objectives.

Keywords: *Construction Industry; Critical Risks; Decision Making Trial & Evaluation Laboratory (DEMATEL).*

INTRODUCTION

One of the main contributors to the economy of any country is the construction industry (Riazi et al., 2018). The jobs created, outputs generated and income provided by the industry contributes towards sustainable economic development. According to Durdyev and Ismail (2012); Kwabena A. Anaman (2007), the construction output has a positive relationship towards the economic growth, especially in developing countries. Based on Hasmori et al. (2018)), the construction industry in Malaysia contributes to the Gross Domestic Product (GDP) value. In 2019, the construction industry contributed 4.2% to the GDP value (Department of Statistics, 2019). Although the construction industry in Malaysia is developing at a rapid rate, delay of projects and cost overruns, unsatisfactory quality of performance, inadequate local labour workers and insufficient resources are classified as chronic issues that exist in the construction industry. According to Abdul Rahman et al. (2012); Vaardini, Karthiyayini, and Ezhilmathi (2016), 92% of construction projects faced delays and 89% of the projects were over budget.

There are many factors that may affect the quality, schedule and budget of the projects in which the risks involved in a project may also be considered a factor (Ibrahim & Esa, 2018). During the construction stage, the risks involved greatly affects a project's performance. Cakmak and Tezel (2019); Ehsan et al. (2010) revealed that the risks involved cannot be excluded in projects and the consequences of the risk varies according to the project type. Khan and Gul (2017) highlighted that the reason to projects being exposed to multiple risk factors are due to the involvement of various stakeholders with multiple stages of work with prolonged work hours.

In the past decade, extensive studies of risk management in construction have been done, which according to Ghasemi et al. (2018); Hanna, Thomas, and Swanson (2013); Monat and Doremus (2018); Stosic, Isljamovic, and Mihic (2013) includes risk identification, risk assessment (Boulaid, Bahi, & Ouadif, 2018; Daniilidis, Doddema, & Herber, 2016; N. Li, Fang, & Sun, 2016; Monzer et al., 2019), and risk mitigation based on Dai, Wu, and Li (2017); Kirthika and Praveen Kumar (2015); Nishaant et al. (2019); Zuo and Zhang (2018). Although various construction risk factors have been identified, there has not been much attention given on the critical risk identification which consider the direct, indirect, and interdependencies among the risk attributes in the construction projects. Therefore, the research gap can be addressed by the present study.

This study is conducted to determine the critical risk in the construction projects and to investigate the causal relationship among the risk factors. This finding would provide useful information for the construction experts to prioritize the resource allocation and maximize the utilization of resources in order to improve the overall performance of construction projects. Besides, the management team can have better understanding on how the risks are generated and be aware of the critical risk factors in the future. Moreover, the findings allow construction practitioners to make proper decisions in mitigating the risk effectively.

LITERATURE REVIEW

Risk Management in Construction Projects

In the construction industry, risk management is a noteworthy field and in recent years, this field has gained worldwide attention as many studies have been conducted. In order to contribute significantly towards the construction industry, Iqbal et al. (2015) suggested that risk management should be focused in future studies. Risk management has to be properly performed at the initial stage of projects as if it is not performed properly, the project managers would find it more complexed and difficult to handle the risks that occur in projects (Serpella et al., 2014; Srinivas, 2019). The description level, difficulty of tools, the sum of time and resources spent in risk management should correlate to the type of projects and the value that they can provide to the results when implementing risk management in the construction sector. For instance, based on Rehacek (2017), the larger the project, the resources, time and attention required to conduct risk management also increases. The implementation of risk management may not guarantee the achievement of success in projects, however, the likelihood of project failures may be reduced (Abazid & Harb, 2018). Risk management is noteworthy as it can contribute to a positive potential return on investment for the project.

Types of Risk in Construction Projects

Technical Risk

Technical risk may refer to an individual or a group of people who can possibly have an impact on a certain goal. Technical risk is often linked with various procedures or product design decisions and has potential to affect the outcomes. Furthermore, inaccurate calculations and omission errors can be described as technical risks according to Khan and Gul (2017). Inefficient communication, lack of supervision, insufficient resources, equipment failures and poor material quality and work are examples of technical risks (Dey, 2001; J. Lee, Lee, & Kim, 2013; Mañelele & Muya, 2008; Reddy, 2015; W. Tang et al., 2007). Technical risks will end in many shortcomings and subsequently have an impact on the construction work as well as huge expenditures would be required to cover up the defects.

Financial Risks

According to Sohrabinejad and Rahimi (2015); Ehrlich et al. (2008); Khan and Gul (2017) and Z. Wu et al. (2017), the most crucial risks in their research was mentioned as financial risks. Financial risks correlate with the funding system and implications on whether the initial cost can be recovered through the return on investment. According to Han et al. (2014), financial risks are variables related to the market that takes into consideration the external financial circumstances and contract particulars including exchange rates, interest rates, inflation rates and depreciation rates. Improper management of financial risk can cause the construction companies to result in failure of their business activities. Failure to address financial risks will result in projects falling behind schedule, contractors rejecting to correct defects, demanding for additional payments and declaring bankruptcy intentionally (H. Li, Arditi, & Wang, 2015).

Site Condition Risks

According to Shahbodaghlou and Samani (2012) and Ferreira, Santos, and Silva (2019), the site condition should be a factor to be taken into consideration in risk assessment. The risks related to site condition include condition of roads, utility services and other structures and infrastructures on the construction sites. Unknown physical condition refers to site conditions that differ materially from what has been documented in contracts. Based on the findings of Amarasekara, Perera, and Rodrigo (2018), there is a high impact on design and build contracts when the site conditions are different. As a result of differing site conditions, projects may be delayed and cost overrun may occur. These consequences may happen as it is unexpected and unforeseeable by the contractor when bidding. The projects that undergo work stoppage on site can only resume when relevant decisions are made.

Human Capital Risks

Previous studies identified manpower as the main factor that contributes to the success of projects (Khan & Gul, 2017; Mañelele & Muya, 2008; Park et al., 2019; Shahbodaghlou & Samani, 2012). Human capital risks refer to events that are associated to the workers or the operation of company influenced by the conduct of the workers (Shahbodaghlou & Samani, 2012). Employees with capabilities, knowledge and skills that vary are considered as human capital assets. These assets are important in the implementation of the policies, practices and technologies in construction projects (Yusof et al., 2018). The common human capital risks are lack of labour supply, insufficient professionals, inexperience administration or supervision and the over dependency of foreign workers. Human capital risks can reduce productivity, increasing the risk of delays, quality problems, and safety concerns.

Project Management Risks

In order to achieve success in construction projects, the project management team plays an imperative part in contributing to the achievement. Therefore, the project management risks are considered as an important risk factors (Sohrabinejad & Rahimi, 2015). From initiation to the construction phase, many impacts can be resulted from improper project planning and budgeting. According to Banaitiene and Banaitis (2012); J. Lee et al. (2013); Sathishkumar, Ragunath, and Suguna (2015), estimation inaccuracy, unclear objectives of project, undefined scope of project, legally binding issues, delays, affected quality and insufficient period for bid preparations are risks associated with poor project management.

Political Risks

When a threat towards the project income resulting from an impact from outside a project, usually regulatory actions, it can be considered as political risk (Alfraidi et al., 2020). Mubarak, Husin, and Oktaviati (2017) also mentioned that the attribute in political risks includes government law, political uncertainty and labour strikes. Political risks may cause organisations existing inside a particular nation to breach the rules and regulations, resulting in financial penalties (T. Chang, Hwang, et al., 2018; Shahbodaghlou & Samani, 2012). According to T. Chang, Deng, et al. (2018); Xiaopeng and Pheng (2013), the risks under this category are more complexed, unpredictable, and out of project scope in which affects projects before and during construction period. If there is inadequate legal vision of the criteria and changes to comply with government regulations, companies may be put at risk.

Health and Safety Risks

Matters regarding safety and environment should be taken into consideration in construction projects (Cha & Shin, 2011; Shamsuddin et al., 2015; W. Tang et al., 2007). Risks that involve people such as fatalities and accidents are referred to as health and safety risks. The assurance of these risks depends on the physical conditions of any specific worker that develops a specific adverse reaction. During construction, the equipment with defects such as machineries, scaffold and ladder are the main cause of physical risk. Common hazards that are present on site include insufficient number of personal protective equipment (PPE), lacking security protection for machines, clutter of the floor and noise. Besides, if not properly controlled and managed, chemical and biological hazards can have an indirect impact on human beings. Other than that, insufficient systematic inspection of machineries, fire extinguishers and handrails may increase the possibility of mishaps when constructing a building (Gunduz & Laitinen, 2018).

Contract Risks

Cha and Shin (2011), Mañelele and Muya (2008), and Park et al. (2019) stated that contract risks are considered a factor affecting the cost performance level in a project. It is not an easy task to incorporate everything into the contract agreement, since many things are unpredictable. Contract risks emerge from contractual activities. As the allocation of budget is more for procurement activities, it may have an adverse effect on the primary goal of the project. For example, unsatisfactory workmanship of the parties involved in the contract, bad contract management, early termination of contract, inexperienced contractors and legal formalities. On the off chance that either one party comes up short to meet the terms and conditions agreed, legal disputes may arise.

Design Risks

Liu et al. (2017); Nieto-Morote and Ruz-Vila (2011) stated that design errors or unsatisfactory designs which do not achieve requirements of employers or relevant legislation are the factors that contribute to these problems. Design risks also include designs that do not correspond to the proposed timeline, unsuitable building design codes and standards, deficiency of management practices and experiences and inflexibility of designs (P. Wu et al., 2019). Furthermore, increasing design complexities raises challenges for contractors in sourcing, which results in the need to incorporate design expertise to ensure there are no issues during the project execution. Öztaş and Ökmen (2004) revealed that scope and quantity change, unexpected ground condition and delay in design are the major contributors of schedule delay.

Environmental and Force Majeure Risks

Environmental risk is known as a threat to natural resources and to the environmental deterioration, which has an indirect impact on human health. Environmental risks are usually related specifically or by implication with the construction activities. The environmental risks in the construction industry are such as risk of land degradation, risk of air pollution and risk of water pollution. These risks may occur during stages of construction, operation or stages in the closing of operations and in unusual condition or contingency situation such as heavy rain or avalanches (Rahman & Esa, 2014). Natural calamities like earthquakes, volcano eruptions and external factors such as new environmental regulations can also be categorised as environmental risks. Environmental risks are not easy to mitigate and usually, the risks would need to be accepted by the stakeholders. For instance, extension of time for work delay will be given to contractors due to force majeure events (Al-Ashwal & Al-Sabahi, 2018).

METHODOLOGY

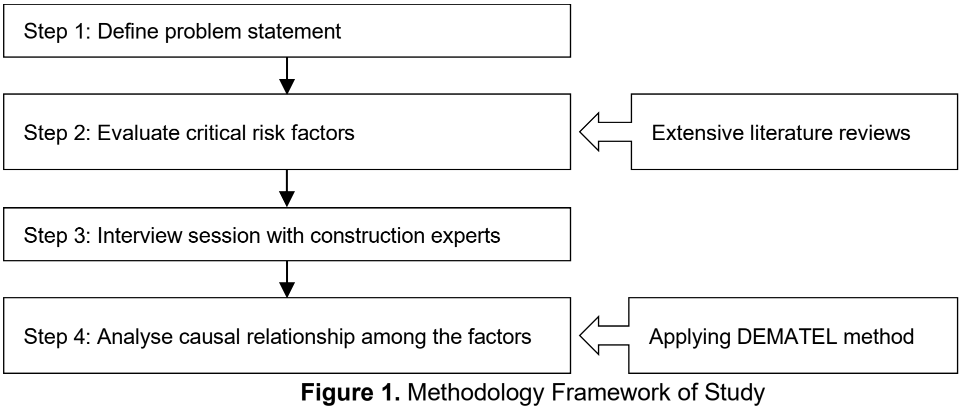

Figure 1. Methodology Framework of Study

This paper was initiated with the definition of the problem statement. Next, extensive literature review had been performed to find relevant articles of construction risks. The risk factors in the construction project were determined by implementing systematic review to filter the articles. After the questionnaires were established, interview sessions were conducted with professionals for data collection. This study applied the purposive sampling method in order to select the respondents to participant in the study. The target respondents in this study were experts with a minimum of 10 years of involvement in the construction industry. After receiving the completed questionnaires from experts, DEMATEL technique was used to analyse the causal relationship among the factors. In Figure 1, the overview of the proposed framework is depicted.

Purposive Sampling Method

This study uses the purposive sampling method to select respondents for the study. This method is acquires the judgement of the researcher as to who will provide the best information to achieve the research objectives (Etikan & Bala, 2017). The researcher would be able to depend on the researcher's judgement to select the specific units for the study. According to Sharma (2017), the purposive sampling method is able to provide the researcher with justifications to make produce generalisations from the sample that being studied, whether it is theoretical, analytical or logical in nature.

Systematic Review

Baird (2018) suggested that systematic review is aimed to resolve specific research questions by collecting, assessing and outline all verifiable evidence that fulfils the pre-established eligibility requirements. This procedure would help researchers identify and discuss the best evidence, confounding findings and research gaps in the literature (Gupta et al., 2018). The reliability of the research can be increased by using the systematic review process (Ke, Wang, & Chan, 2012; C. K. Lee, Yiu, & Cheung, 2016).

Through systematic review, research questions were established clearly and precisely. A thorough search was then conducted using the "Scopus" search function. In order to meet the requirements of this study, the search keywords with the specific term "project risk" or "construction risk" were inserted in the field "title/abstract/keywords." Based on this step, the results showed a total of 1973 articles related to construction risk and project risk. After narrowing down the subject area, the articles shown were reduced to 1591 articles. Then, a more thorough visual analysation of content was conducted to extract the articles that are closely related to the research topic and the results are presented in Table 1. Ultimately, 10 risk factors are identified from the articles as shown in Table 2.

Table 1. Segmentation of Articles According to Themes

Theme	Number of Articles	Percentage %
Risk modelling and analysis	151	27
Risk perception from third party	32	5.7
Risk assessment	59	10.6
Risk factors	36	6.4
Risk impact	24	4.3
Risk management	117	20.9
Risk mitigation	21	3.8
Risk management approach	119	21.3
Total	**559**	**100**

Table 2. Risk Factors in The Construction Projects

Factors	Author
C1: Design risks	Rostami and Oduoza (2017), Liu et al. (2017)
C2: Political risks	(Niazi & Painting, 2017), Mubarak et al. (2017)
C3: Financial risks	Park et al. (2019),Mubarak et al. (2017)
C4: Site condition risks	Forteza, Carretero-Gómez, and Sesé (2017), Jayasudha and Vidivelli (2016)
C5: Human capital risks	Windapo (2016), Khanizad and Montazer (2018)
C6: Project management risks	Abiodun, Ruben, and Julius (2018), R.Sakthiganesh, Dr.S.Suchithra, and S.Saravanakumar (2017)
C7: Health and safety risks	(Gunduz & Laitinen, 2018), Mashia, Subramaniama, and Joharia (2016)
C8: Contract risks	Dziadosz, Tomczyk, and Kapliński (2015), Sohrabinejad and Rahimi (2015)
C9: Technical risks	Khan and Gul (2017), Al-Ashwal and Al-Sabahi (2018)
C10: Environmental & Force majeure risks	Eskander (2018)

DEMATEL Method

In order to resolve the complex relationship within the correlated factors, this study implemented the Multi-criteria decision making (MCDM) method. Among the MCDM tools that are available, this study adopted the Decision Making Trial and Evaluation Laboratory (DEMATEL) to carry out the analysis of multiple interrelated attributes. In the recent years, this method has been adopted in an increasing rate to address different matters including social, economic, or technical matters. The DEMATEL method has been commonly used in scientific discipline comprising of management, technology innovation and engineering sectors (Hsu & Lee, 2014). According to Gołąbeska (2018); Gawlik (2016) and Mardani et al. (2015), the DEMATEL method was suggested in their studies as one of the best complex decision making tool as it comprises the mixture of qualitative and quantitative criteria. Moghaddam et al. (2011) highlighted that it is important to suggest a correct model for taking steps to obtain the most important factors in a precise direction. The final key factors obtained would be inaccurate or weak if the defining method lacks verification and integrity. Therefore, any strategies implemented to resolve the conflicts between the factors would be invalid. This technique includes the following basic steps (1) Gather expert's opinion and compute the average matrix, (2) Calculate the normalized initial direct-relation matrix D, (3) Derive the total relation matrix T, (4) Calculate the sum of rows and columns of matrix T, (5) Set a threshold value. (6) Build a cause-and-effect relationship diagram.

Step 1: Gather Expert's Opinion and Compute the Average Matrix

A group of professionals were required to assess the level of direct influence among two variables listed in the pair-wise comparisons form. In order to view the pair-wise comparison form, a discrete scale range from 0 to 4 levels are used. According to the ascending order of the numbers, it symbolises the meaning of "no influence", "low influence", "medium influence" and "high influence". The notation of x_{ij} is alluded as the degree to which the expert believes factor i influence factor j. For each expert, an $n \times n$ non- negative matrix is formed as $X^k = [x_{ij}^k]$, where k is the number of experts with $1 \leq k \leq m$. Hence, X^1, X^2, X^3, $\ldots X^m$ are the matrices from m experts (Sumrit & Anuntavoranich, 2013). The average matrix $Z = [z_{ij}]$ is established as follows:

$$z_{ij} = \frac{1}{m} \Sigma_{k-1}^{m} x_{ij}^{k} \quad (1)$$

Step 2: Calculate the Normalized Initial Direct-Relation Matrix D.

Normalize initial direct -relation matrix D is obtained by dividing the average matrix (Z) by a scalar λ (Singhal, Tripathy, & Kumar Jena, 2018). It is calculated by using the following formula.

$$\lambda = \text{Min}\left[\frac{1}{\max 1 \le \text{i} \le n \Sigma_{j=1}^{n} z_{ij}}, \frac{1}{\max 1 \le \text{i} \le n \Sigma_{j=1}^{n} z_{ij}}\right] \quad (2)$$

Step 3: Derive the total relation matrix T.

The total-influence matrix T is obtained by using Equation (3), where D is normalized matrix and I is an *n x n* identity matrix.

$$T = D(I - D)^{-1} \quad (3)$$

Step 4: Calculate the sum of rows and columns of matrix T.

Characterise r and c be n x 1 and 1 x n vectors indicating the sum of rows and sum of columns of the total relation matrix T, respectively. Assume r_i be the sum of *i*th row in matrix T, then r_i summarizes both direct and indirect effects given by factor *i* to the other factors. If c_j represents the sum of *j*th column in matrix T, then c_j denotes both direct and indirect effects by factor *j* from the other attributes. When *j*=*i*, the sum ($r_i + c_j$) indicates the total effects given and received by factor *i*. That is (r*i* +c*j*) represents the degree of importance that factor *i* plays in the entire system. In contrast, the difference (r_i-c_j) shows the net effect that factor *i* contributes to the system. Factor *i* is a net cause if (r_i- c_j) is positive, while it is a net receiver if (r_i-c_j) is negative (Shieh, Wu, & Huang, 2010).

Step 5: Set a threshold value.

The elements in matrix T are averaged to calculate the threshold value (α). This computation aims to remove some negligible effects elements in matrix T. The factors with greater value than the threshold value would be chosen and then depicted in the cause-and-effect relationship diagram.

Step 6: Build a cause-and-effect relationship diagram.

The diagram can be obtained by mapping the dataset of (r_i+r_i, r_i-r_i). The cause-and-effect relationship diagram is vital as it provides decision makers with information for judgement. The diagram shows the most significant factors and how the factors impact each other.

RESULTS

Data were collected from 13 individuals who were professionals in the construction management position and with a minimum of 10 years of involvement in the construction sector. The experts were requested to determine the degree to which a factor influence or being influenced by other factors. Since most of the respondents are unfamiliar in using the DEMATEL method for data collection, thus, explanation on the meaning of integer scores of 0-4 scale and the function of pairwise comparisons table were given to the respondents to ensure the accuracy of data. Besides that, the respondents were encouraged to give some explanation or justification to prove their claims during completion of questionnaire to increase the credibility of data. Each of the respondents took approximately 60 minutes to finish the survey. Snowball sampling method was implemented in this study in which the respondents would provide recommendation of other experts. This method can ease the difficulties of getting potential participants in this study.

Table 3 exhibits the profiles of the respondents. The experiences of respondents in this study are within the range of ten to more than twenty years. About 38.46% of the respondents hold a master's degree and the others 61.54% hold a bachelor's degree. The respondents hold the positions of project manager, senior project manager, consulting engineer, project engineer, contract manager, associate director and company director. This information shows that the respondents have a position in senior management level in which are considered an important role in the industry. Furthermore, some of the respondents are qualified as a professional engineer as they are entitled to the 'Ir' designation in front of their name. Hence, they have significant knowledge and profound understanding in the construction industry.

Table 3. Respondents' Profile

Measure	Item	Frequency	Percentage (%)
Gender	Male	8	61.54%
	Female	5	38.46%
Age group	31 - 35	2	15.38%
	36 - 40	6	46.15%
	41 - 45	2	15.38%
	46 - 50	-	-
	51 - 55	3	23.08%
Education Level	Degree	8	61.54%
	Master	5	38.46%
Years of experience	10 - 14	4	30.77%
	15 - 19	6	46.15%
	20 - 24	-	-
	25 - 29	3	23.08%
Job titles/ Position	Project Manager	1	7.69%
	Senior Project Manager	1	7.69%
	Contract Manager	1	7.69%
	Consulting Engineer	6	46.15%
	Project Engineer	2	15.38%
	Associate Director	1	7.69%
	Company Director	1	7.69%

According to the Equation (1), the average matrix (Z) was constructed by using the inputs received from thirteen professionals after making the pairwise comparison. The results of average matrix (Z) are exhibited in the Table 4. The normalized matrix shown in Table 5 is determined by dividing the scalar λ. The value of λ is equal to 22.8462 which is obtained using the Equation (2). Total relation matrix T which is calculated by utilizing Equation (3) can be seen in Table 6. The average all elements of matrix T makes up the threshold value (α) which is 0.28498.

Following step 4 of DEMATEL, (r*i* +c*j*) indicates the importance of each factor in the overall analysis. Based on the Table 7. three factors such as financial risk (C_3), design risk (C_1) and project management risk (C_6) contain the highest value of (r+c) in matrix T, which show their strongest dominance over other factors. According to (r+c) values, the overall ranking of the importance of ten risk groups was $C_3 > C_1 > C_6 > C_7 > C_8 > C_4 > C_5 > C_9 > C_{10} > C_2$.

The (r-c) value for each factor was further calculated to investigate the influence of each net cause and net receiver. Thus, the ten risk factors were divided into cause group and effect group based on the (r-c) value. If the value of (r-c) was positive, such factors were categorized in the cause group or net cause which directly impact on the others. The highest (r-c) factors had the largest influence on the others. In this finding, political risk ($C_{2.}$), environmental & force majeure risk (C_{10}), site condition risk (C_4), design risk (C_1) and human capital risk (C_5) were classified in the cause group, having the (r-c) values of 0.9608, 0.8444, 0.0684, 0.0656 and 0.3017 respectively. It also indicated that political risk (C_2) was the most critical impact factor on the others.

If the value of (r-c) was negative, such factors were classified in the effect group or net receiver, and highly influenced by the others. In this findings, contract risk (C_8), financial risk (C_3), health & safety risk (C_7), project management risk (C_6), and technical risk (C_9) were categorized in the effect group, with the (r-c) values of -0.7913, -0.5828, -0.4404, -0.2260 and -0.2003, respectively. Contract risk(C_8) is the most impacted factor because it has the lowest (r-c) value.

According to the value listed in Table 7, cause and effect diagram is illustrated between a factor's importance r_i+c_j (x-axis) and the strength of its influence r_i-c_j (y-axis). The ten factors can be categorized into two groups of five through a line at $r_i-c_j = 0$. When $r_i-c_j > 0$, it indicates that the factors' influence is relatively strong compared with those factors for which $r_i-c_j < 0$. An impact relation map is drawn in Figure 3 to visualize the data and further understand the interrelationships between the factors. Only entries of greater value than the threshold value are considered in the causal relationship map. The dark boxes represent the top four strong influential factors while the light boxes are all the other factors. In Figure 3, the direction of the influence between two risk factors in construction projects is indicated by the arrow. The significant bi-directional relationship is illustrated by using a solid line while the significant uni-directional relationship is depicted by using broken lines. From Figure 3, it shows that design risk (C_1) was the most critical factors because it directly influenced on the other six factors. Design risk (C_1) had a mutual interaction on financial risks (C_3), site condition risks (C_4), project management risks (C_6), health & safety risks (C_7), contract risks (C_8), technical risks (C_9).

The other three top risk factors listed in the causal group include site condition risks (C_4), human capital risk (C_5) and environmental and force majeure risk (C_{10}) based on the "R+C" values and these factors had a direct impact to the other six risk factors. For instance, site condition risk (C_4) had directly affected contract risks (C_8), technical risk (C_9) and had a mutual interaction on design risks (C_1), financial risks (C_3), project management risks (C_6), health& safety risks (C_7), contract risks (C_8) and technical risks (C_9). Besides that, human capital risks (C_5) have direct influence on the design risk (C_1), health and safety risks (C_7), contract risks (C_8), technical risks (C_9) and had a mutual interaction on financial risks (C_3), project management risks (C_6). Meanwhile, Environmental risk and force majeure risks (C_{10}) have direct influence on design risks, financial risks (C_3), site condition risks (C_4), project management risks (C_6), health & safety risks (C_7) and contract risks (C_8).

Table 4. Average Matrix

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}
C_1	0	0.8462	3.1538	2.7692	1.2308	1.9231	2.0769	2.4615	2.7692	2.0000
C_2	1.5385	0	2.4615	1.0000	1.5385	1.7692	1.4615	2.1538	0.9231	0.3077
C_3	2.8462	1.0769	0	2.1538	2.0000	2.4615	2.3077	2.6923	2.1538	1.3077
C_4	1.6154	1.0769	2.1538	0	1.3846	1.8462	3.0000	2.1538	2.0000	2.3077
C_5	2.4615	0.6923	2.3846	0.8462	0	2.5385	2.3846	2.0769	2.1538	1.2308
C_6	2.3077	0.6923	2.9231	2.0769	2.0000	0	2.3077	3.0000	1.6923	0.8462
C_7	1.8462	0.5385	2.3846	2.2308	2.0769	2.4615	0	2.0000	1.5385	1.4615
C_8	1.7692	1.1538	2.9231	1.3077	1.8462	2.2308	1.6923	0	1.5385	0.8462
C_9	2.0000	0.3077	2.2308	1.9231	1.3077	2.2308	1.6923	2.0769	0	1.0769
C_{10}	2.3846	1.0000	2.2308	2.4615	1.4615	1.8462	2.6154	1.6923	1.0769	0

Table 5. Normalized Matrix

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}
C_1	0	0.0370	0.1380	0.1212	0.0539	0.0842	0.0909	0.1077	0.1212	0.0875
C_2	0.0673	0	0.1077	0.0438	0.0673	0.0774	0.0640	0.0943	0.0404	0.0135
C_3	0.1246	0.0471	0	0.0943	0.0875	0.1077	0.1010	0.1178	0.0943	0.0572
C_4	0.0707	0.0471	0.0943	0	0.0606	0.0808	0.1313	0.0943	0.0875	0.1010
C_5	0.1077	0.0303	0.1044	0.0370	0	0.1111	0.1044	0.0909	0.0943	0.0539
C_6	0.1010	0.0303	0.1279	0.0909	0.0875	0	0.1010	0.1313	0.0741	0.0370
C_7	0.0808	0.0236	0.1044	0.0976	0.0909	0.1077	0	0.0875	0.0673	0.0640
C_8	0.0774	0.0505	0.1279	0.0572	0.0808	0.0976	0.0741	0	0.0673	0.0370
C_9	0.0875	0.0135	0.0976	0.0842	0.0572	0.0976	0.0741	0.0909	0	0.0471
C_{10}	0.1044	0.0438	0.0976	0.1077	0.0640	0.0808	0.1145	0.0741	0.0471	0

Table 6. Total Relation Matrix T

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}
C_1	0.2755	0.1493	**0.4494**	**0.3623**	0.2736	**0.3603**	**0.3682**	**0.3941**	**0.3507**	0.2588
C_2	0.2562	0.0798	**0.3281**	0.2164	0.2200	0.2705	0.2572	**0.2956**	0.2090	0.1367
C_3	**0.3832**	0.1564	**0.3251**	**0.3350**	**0.2999**	**0.3770**	**0.3721**	**0.3997**	**0.3260**	0.2294
C_4	**0.3174**	0.1479	**0.3846**	0.2309	0.2609	**0.3332**	**0.3773**	**0.3560**	**0.2991**	0.2540
C_5	**0.3424**	0.1289	**0.3857**	0.2610	0.1973	**0.3516**	**0.3448**	**0.3470**	**0.3012**	0.2068
C_6	**0.3502**	0.1364	**0.4221**	**0.3185**	**0.2897**	0.2661	**0.3577**	**0.3963**	**0.2971**	0.2029
C_7	**0.3168**	0.1231	0.3816	**0.3096**	0.2786	**0.3457**	0.2503	**0.3411**	0.2757	0.2159
C_8	**0.2969**	0.1397	**0.3812**	0.2581	0.2564	**0.3197**	**0.2992**	0.2428	0.2603	0.1789
C_9	**0.2995**	0.1046	**0.3496**	0.2786	0.2311	**0.3138**	**0.2951**	**0.3199**	0.1931	0.1868
C_{10}	**0.3385**	0.1427	**0.3793**	**0.3228**	0.2574	**0.3250**	**0.3568**	**0.3319**	0.2602	0.1592

Table 7. The Causal Influence Table for The Ten Factors

	Factors	R+C	R-C
C_1	Design risk	6.4188	0.0656
C_2	Political risk	3.5784	0.9608
C_3	Financial risk	6.9906	-0.5828
C_4	Site condition risk	5.8547	0.0684
C_5	Human capital risk	5.4315	0.3017
C_6	Project management risk	6.2999	-0.2260
C_7	Health & safety risk	6.1171	-0.4404
C_8	Contract risk	6.0578	-0.7913
C_9	Technical risk	5.3444	-0.2003
C_{10}	Environmental & Force majeure risk	4.9030	0.8444

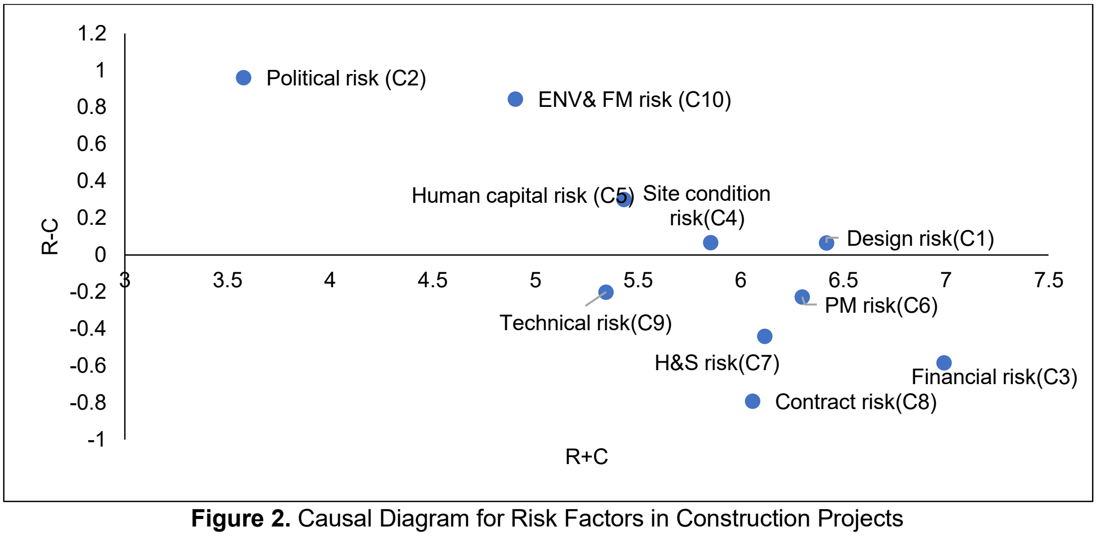

Figure 2. Causal Diagram for Risk Factors in Construction Projects

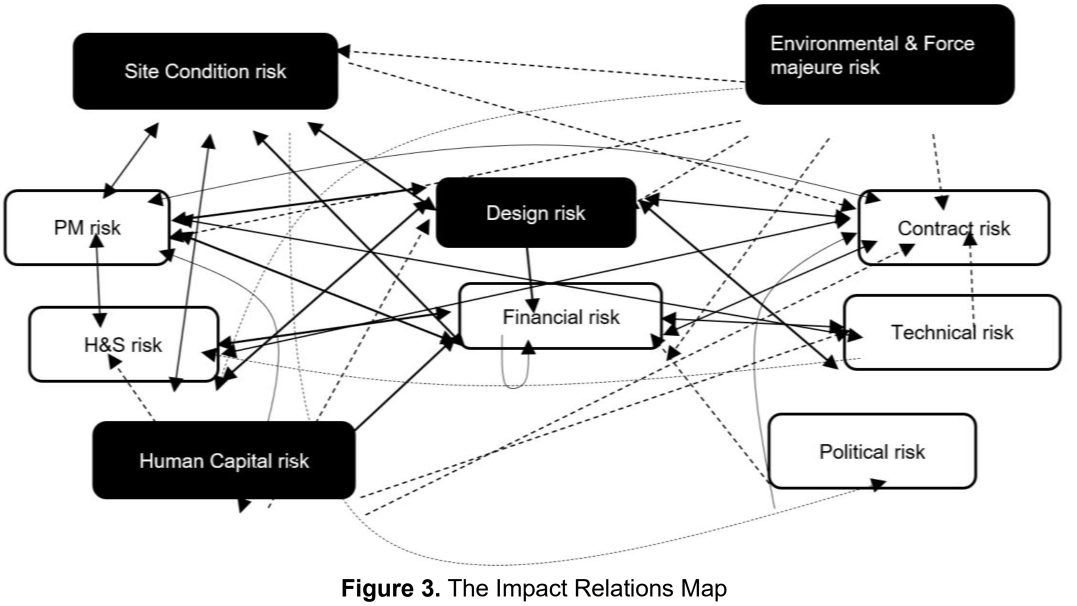

Figure 3. The Impact Relations Map

DISCUSSION

The interrelationships among the risk factors in construction projects depicted in IRM in Figure 3 illustrates that the design risk, site condition risk, human capital risk and environmental and force majeure risk have more influence over the other six risk factors. This finding shows that decision-makers should first consider these four risk factors during the implementing the risk measures.

The results indicate that design risks were the critical factors among other risks factors. Design risks (C_1) have the highest "R+C" value in the cause group which play the greatest influence on others. This result corresponded with the findings from previous study where the design related risks among the 14 risk items were more likely to occur (P. Wu et al., 2019). Based on previous study, the experience of architects and engineers regarding the designs were considered the most serious factors. Design risks were critical due to its difficulty in acquiring and describing the user's requirements, difficulty in the time and resources estimation required to determine the design and difficulty of tracking performance during the design process. (Choudhry et al., 2017; Zou, Zhang, & Wang, 2007). Failure to respond to the design risks can lead to design rework which influences the subsequent work, schedules and finance of projects. Therefore, it is found that companies should have knowledgeable designs to tackle the risks in the design phase of the projects.

Site condition risks (C_4) is the second most influential factors. Site condition risks exist when there is a huge number of labours, materials, equipment as well as unforeseeable situation. Besides, frequent rotations of work, changing environment and concurrent activities increase the difficulty for effective safety management and subsequently raise the accident rates (N. Tang et al., 2019). It is important that the overall construction activities should be prioritized to increase the likelihood of project success. Furthermore, the top management and employees are required to give their commitment to maintain a safe working environment. Safety policies and regulations should be revised timely and implemented by the authorities to maintain work safety in construction sites.

Based on the results of this study, human capital risks (C_5) is another influential factor in construction projects. Human capital risks not only contribute to financial loss and resources, but the knowledge and experience of the employees are also affected in which hinders the performance of the company. It is essential to ensure that the employees stay in the company, otherwise, the employer has to cover the losses when an employee quits the company (Yusof et al., 2018). Jarkas and Younes (2014) mentioned that 30% to 50% of the overall project costs are contributed by labour costs. In other words, labour costs is regarded as a significant resource to the efficiency and success of construction projects. On top of that, Mohd-Rahim et al. (2016) pointed that project performance may most likely be affected by the risks of labour shortage. This would cause schedule delays and cost overruns. Therefore, the organization should focus on employee retention and labour management strategies in order to achieve project success. The government also needs to take initiatives to solve the problem of skilled labour shortage in the country to ensure the construction industry remains sustainable.

Furthermore, it is indicated that the environmental and force majeure risks (C_{10}) have direct influence on the other six risk factors. Rahman and Esa (2014) described environmental risk as impending risk to the ecology with all sorts of influences. Environmental risks might occur during the mobilization, clearance of site and earthworks that require ground clearance for development. The risks to hazardous exposures is perhaps ten or even one thousand times higher than elsewhere in an unfavourable environmental condition (J.-H. Chang & Huynh, 2016). A number of construction development projects have reported schedule overrun or poor performance because of the explicit environmental concerns. It can be said that the project performance is also dependent on the project's environment (Malik et al., 2019). Thus, parties involved in the construction industry should give sufficient attention to ensure that fair and feasible approaches are taken to minimize the environmental and force majeure risks. Besides that, the government should be concerned on the environmental aspects to ensure that construction companies follow rules and regulations during operation in order to achieve sustainability development.

CONCLUSION AND IMPLICATIONS

The present study reveals ten risk factors in construction projects. The factors include financial risk, design risk, project management risk, health & safety risk, contract risk, site condition risk, human capital risk, technical risk, force majeure and political risk. These factors are contributed by thirteen experts who have a minimum of ten years of involvement in the construction industry. To unveil the respondents' viewpoint, DEMATEL method has been employed. DEMATEL method has been utilized in this study to determine the critical risk factors in the construction project and investigate the interrelationships among the risk factors. In addition, causal diagram and impact relations map can be interpreted by project managers, engineers, contractors and the researchers easily. Results of the present study shows that design risks are the most influential factors in construction projects. Furthermore, site condition risks, human capital risks, environmental and force majeure risks are other key risk factors to be considered as they have a significant impact on the other factors. Despite the fact that financial risks and project management risks are important, they are affected by other risk factors, hence, their effect may be intervened by addressing the key causal factors.

The parties involved in the construction industry can benefit from this study by focusing on critical risk factors while planning for risk management in construction projects. It is also suggested that the project managers should develop better risks mitigation approaches that to ensure that the quality of construction projects are on par by emphasizing on rectifying the factors in the cause group, as they have significant impact on the other factors. To this extent, the quality as a whole can be strengthened from the initial stages to the completion stages of the projects. Besides that, collaborative work between government and private parties in construction sector are required to mitigate the risks in the construction projects. Ultimately, the limitations to the DEMATEL approach employed in the present study is that the study depends on the own view of respondents and their experience in the construction industry and subjective elements may be integrated inevitably within the research. Hence, statistical validation of results in this study can be conducted in the future studies. In order to validate the results found in this study, it is recommended to conduct a case study in the future. Moreover, empirical study of a large sample can be carried out further to substantiate the results of this study.

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