8. Understanding the causes and effects of low-risk management: implementation in projects using the DEMATEL algorithm

Chia-Kuang Lee, Wen-Nee Wong, Nurhaizan Mohd Zainudin and Ahmad Huzaimi Abd Jamil

1. INTRODUCTION

According to Zavadskas et al. (2010), construction projects are risky in general. In Malaysia, the construction industry can be defined as one of the most challenging and risky industries as compared to the others. The activities for construction are rife with risks and uncertainties. Oliveira (2017) stated that risk can be defined as the occurrence of possibility of either positive or negative events that happen to be recognized as uncertainties.

Risks can be categorized into either external or internal risks (PMI, 2013; Zhi, 1995; Abderisak & Lindahl, 2015). External risk can be defined as the uncertainties that exist outside of the project that will be influenced by the surrounding or environment factors, while internal risks are uncertainties that exist in the project itself. External risks include economic and political factors that may affect the risk management of construction projects (Adeleke et al., 2018). However, while negative outcomes or consequences can be associated with risks to projects, they also have the possibility of being seen as chances of positive events (Adeleke et al., 2018; Farooq et al., 2018; Goh et al., 2012). According to Adeleke et al. (2018), it is necessary to manage the possible risks in order to ensure there is no threat being brought to the project to ensure project success.

Some of the effects that might occur because of the negative risks or negative events in the construction project are project delays and cost overruns. According to Abd El-Karim, Mosa El Nawawy and Abdel-Alim (2017), the common scenario that happens among stakeholders (contractors, clients, suppliers and owners) of the project are estimations of costs and schedules that are inaccurate. In order to adapt to any circumstances or unexpected events that might occur in the project, it is important to make both budgeting and scheduling flexible.

Based on the studies by Goh et al. (2012), most of the construction firms in Malaysia only practice risk identification and qualitative risk analysis but not the risk analysis and risk response: 17.78% of organizations were willing to employ a formal risk management process in their practices or construction projects (Goh et al., 2012). One of the weaknesses of the construction industry is to cope with risks successfully. Thus, it is essential to have implementation of risk management in either projects or the companies. This could lead to improvement in profits and reputation and ensure business success.

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The causes and effects of low-risk management implementation in the construction industry need to be researched in order to intervene in the relationship between them effectively. Therefore, the objectives of this chapter are threefold:

1. To identify the causes of low-risk management implementation.
2. To determine the effects of low-risk management implementation.
3. To develop the causal relationship among causes and effects of low-risk management implementation.

2. LITERATURE REVIEW

2.1 Risk in the Construction Industry

Risk can be explained as an event that has impact on the project objectives with positive or negative outcomes that take place in the environment (Iqbal et al., 2015). According to Iqbal et al. (2015), risk can also be defined as the exposure or the probability of occurrence to gain or loss multiplied by its respective magnitude. Based on research by Bon-Gang et al. (2014) and Zavadskas et al. (2010), risk can be assessed using various types of information. The level of risks will affect the success and implementation of risk management in the construction industry. According to the Project Management Institute (PMI) (2004), because of the involvement of different contracting parties, such as contactors, clients, suppliers and owners, the projects in construction are perceived to have more inherent risks.

As construction projects involve numerous stakeholders, the possibility of risks tends to increase as they are expected to complete volatile tasks with a complex procedure and finish within a limited period (Odimabo & Oduoza, 2013). The causes of risks or uncertainties can be from different sources such as commitment from the project parties, project team performances and the condition of the environment (Abd El-Karim et al., 2017). Failure to cope with risks will cause stakeholders such as clients, contractors and the public to suffer (Zavadskas et al., 2010). Consequently, managing projects with high risks effectively remains challenging for industry practitioners (Kapliński, 2009). Therefore, it is necessary to understand the causes and effects of poor risk management that might affect the project.

2.2 Risk Management Implementation

According to the Project Management Book of Knowledge (PMBOK), risk is an uncertain event that can either be positive or negative. Olsson (2008) stated that risk is generally an event that is likely to occur and could positively or negatively affect the project outcomes in terms of the triple constraints and other relevant criteria that are related to the project performance. Additionally, risk management is considered as a process of identifying, analyzing and responding to project risks that is systematic and iterative, which helps to decrease the probability of project failure (Florio & Leoni, 2017). It consists of five steps: Risk Planning Identification, Qualitative Analysis, Quantitative Analysis, Response Planning, and Risk Monitoring and Controlling. The process helps the project team to predict the unpredictable and control the project risks. According to Carbone and Tippett (2004), it is important to have

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a supportive system to plan for and handle the risks and uncertainties of the project activities. It is a vital management instrument that helps to control construction project risks (Mills, 2001).

However, because of the uniqueness of construction projects, there is a problem of lacking enough data to refer to when managing the project risks as there are no two identical projects. Therefore, the implementation of risk management in the construction industry is different from other industries where references are available to take up as an actuarial assessment (Elshandidy et al., 2018). Based on the Association for Project Management (2004), risk management in the construction industry needs a pragmatic approach because of its variables such as technical, engineering, innovative, procurement and strategic content. Risk management has become an essential and important element of project management (Chapman & Ward, 2003), with a direct effect on project success, since risks are usually assessed by their potential impact on project objectives (Zou et al., 2007).

2.3 Causes of Low-Risk Management Implementation

While there have been many studies conducted on project risk management, the manifestation of causes to low-risk management implementation is a less-explored topic (Kutsch & Hall, 2010). The failure in identifying and eliminating the causes for risk management will affect the practices of risk management and thus lead to adverse effects such as financial losses, delay of project, loss of customer trust, loss of competitive advantage and negative press. Therefore, there is a strong need to improve project success (Yim et al., 2015).

2.3.1 Resistance to change (A)

According to Lundy and Morin (2013), employees' resistance to change is one of the frequently encountered causes for implementing effective risk management. It happens when there is uncertainty of change or pressure. Tummala and Burchett (1999) stated that the primary reasons that caused resistance to change among employees include lack of clarity, interference with interests and reluctance to learn. Resistance to change can be one of the most powerful causes of the organization having low implementation of risk management in projects. It has effects on both evolutionary and strategic type of changes but is believed to be generally higher in strategic changes than evolutionary ones (Pardo & Fuentes, 2003). Some of the other causes include different perceptions among employees and management, barriers in communication and gaps in capabilities in organizations. All these can cause the organization to have even stronger resistance to changing to implement risk management in construction projects.

2.3.2 Lack of managerial support and communication (B)

Another factor of low-risk management implementation stems from the lack of support from the top management of an organization (Liu et al., 2015). Repeated interactions and communication with the top management help to gain the confidence of employees and prevent project failure (Malik et al., 2019). Poor communication between top management and the project team will lead to risk avoidance as the employees are uncertain without direction (Bhoola et al., 2014; Aziz et al., 2019). This will affect the closeness of relationships and employee engagement in the project. Berger and Meng (2014) stated that communication is the cornerstone of determining the success of an organization as it is a two-way process that involves constructive feedback. Watson (2012) emphasized that it is essential for the organization to

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have a risk manager with excellent communication skills with employees and the project team pertaining to the implementation of risk management.

2.3.3 Low-risk attitude (C)

Risk attitude refers to the orientation of an individual toward taking risks where this can vary from risk-averse (very unwilling to take risks) to risk-seeking (very willing to take risks) (Winsen et al., 2014). Every individual has their own perceptions of risk and these can cause the individual to handle risks differently based on their own perceptions. An individual's positive and negative evaluation of characteristics of different types of behaviors represents the base of the attitude (Dikmen et al., 2018). However, this attitude can be improved and reinforced through knowledge acquisition. Absence of formal training in project risk management would impede the implementation of risk management. Training is an enabler of competency (Hanna et al., 2016).

2.3.4 Lack of resources (D)

Farr-Wharton (2003) suggests that inadequate resources can result in project failure, regardless of the efforts of the team. Resources include funds, manpower, equipment and machines. A lack of resources affects the implementation of risk management in any project. According to Olsson (2008), an organization requires more than having a good project plan or monitoring and control systems and should focus on implementing effective strategies for risk management. Proper risk management may incur high costs for an organization as it includes planning, estimating, costing, financing and other forms of costs control. Organizations that do not have any experts in risk management will need sufficient training and thus increase in their expenses (Ikechukwu et al., 2017).

2.3.5 Lack of knowledge in risk management implementation (E)

According to Dikmen et al. (2018), knowledge is fundamental in cultivating favorable attitudes toward project risk management. Bratianu (2018) stated that a proper risk analysis before initiating a project will help in reducing risks that may occur later in a project and this cannot be done without adequate knowledge in risk management. Besides that, it is important to understand how risk management techniques are being utilized in phases of risk management that are undertaken in a project (Dikmen et al., 2018). Organizations should also provide proper training for risk managers to ensure they are well equipped with knowledge of the project activities so that they can demonstrate and show support to the other employees. Good planning for a risk management process comes from knowledge to prevent project failure (Frese & Sauter, 2003; Zieba & Durst, 2018). Roshana and Akintoye (2005), however, stated that risk management is still rhetorical in the Malaysian construction industry due to insufficient knowledge. Therefore, it is important for the industry to reinforce both awareness and knowledge in risk management.

2.3.6 Poor risk culture in the organization (F)

As early as 1998, risk culture was defined as the perception of a manager of the organization's propensity to take risks and of the leadership of organizational propensity to either reward or punish the risk-taking (Bozeman & Kingsley, 1998). The Institute of International Finance (IIF) then referred to culture as "the norms and traditions of behavior of individuals and groups within an organization that determine the way in which they identify, understand,

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discuss and act on the risks the organization confronts and the risks it takes" (Wood & Lewis, 2018). According to Bostanci (2013), risk culture is extremely important for risk management practices in an organization. Risk culture can affect all risk management-related activities and ultimately decides whether risk management structures, methods and procedures will benefit or damage an organization (Paalanen, 2013).

2.4 Effects of Low-Risk Management Implementation

Risk management implementation is very important in the construction industry as it can reduce project failure (Wang & Moczygemba, 2015). A construction project may be defined as successful when it has satisfied the time, cost and quality constraints. A successful project should achieve satisfaction for all stakeholders (Chan & Kumaraswamy, 1998). However, many of the construction companies tend to skip this as they see it as time-consuming and increasing project cost. Failure in implementing proper effective risk management will cause more impact to the project.

2.4.1 Project delay/time overrun (G)

Project time overrun is defined as an extension of time beyond the contractual time as per agreed stage (Endut et al., 2009). According to Shi, Cheung and Arditi (2001), the impact of project delay often relates to the completion of the project. Sweis et al. (2008) mentioned that almost all types of construction projects experience delay. According to Al-Momani (2000), schedule delay has always been one of the major causes of project failure in Malaysia. Ballesteros-Perez et al. (2015) also stated that delays in construction projects are recognized as one of the most prominent in the industry. Based on Dandage, Mantha, Rane and Bhoola (2017), delays in the schedule will directly affect the project cost due to the inflation, contract termination and resulting delaying damages. This is often defined as mismanaged event(s) and is one of the project risks. Delays in the schedule will cause even more negative effects to the project stakeholders such as contractors, clients and the project team. The impact of delaying in construction projects is not just limited to contracting and consulting the clients but also extends to the national economy, especially in developing countries (Faridi & El-Sayegh, 2006; Al-Kharashi & Skitmore, 2009).

2.4.2 Cost overrun (H)

Cost overrun can be defined as an extra cost beyond the contractual cost agreed during the tender stage (Endut et al., 2009). According to Enshassi et al. (2009) and Sweis et al. (2008), cost overruns have frequently happened in construction industries in many developed and developing countries. It is also among the most common phenomena in the construction industry (Koushki et al., 2005; Ikechukwuet al., 2017). The construction industry plays a vital role in the socio-economic growth of the country, especially in developing countries; therefore, it is important to ensure the project is completed within budget as this affects the overall development of the country. Based on a global study on construction project performance by Flyvbjerget al. (2003), cost overrun was identified as the major problem where nine out of ten projects faced overrun in the range of 50% to 100%, and this had immediate consequences for the stakeholders and country's economy (Flyvbjerg et al., 2004). Angelo and Reina (2002) stated that the problem of cost overrun is critical and needs to be further studied to alleviate

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the problem in future as it can cause a slower payout and reduce early return on the investment made.

2.4.3 Accidents (I)

According to Idris (2019), accident risk in the construction sector is higher as compared to other sectors. The accidents that happen on construction sites not only increase the fatality rates of workers but also have a huge impact on the company. Páez and Mejía (2011) mentioned that current industrial health and safety uses common corresponding standards but they are poorly applied and thus generate difficulties in project development associated with risks; if these risks are not proper evaluated, they can end up affecting the regular progress of the construction work (Alkhadim et al., 2018). The numbers of site accidents and deaths related to work are still alarmingly high despite the efforts to improve the performance of health and safety in the industry. According to Lee, Chen and Fo (2018), accidents that occur at construction sites are either caused by the negligence of the company or the workers themselves, which will affect the operation of construction. However, accidents that are caused by the human factor can be avoided by having a proper and effective risk management implementation.

2.4.4 Conflicts/disputes (J)

Conflict can be defined as “a clash between hostile or opposing elements or ideas” (Guan, 2007), while a dispute is “any contract question or controversy that must be settled beyond the jobsite management” (Diekmann & Girard, 1995). According to Verma (1998) and Rauzana (2016), conflict is inevitable and unavoidable in a project as the project stakeholders have different perceptions in the construction industry. Conflict often arises in the consecution phase of a project when the team fails to meet the stakeholders’ expectations. This issue remains a challenge in the industry as it has high potential to lead to project failure (Walton & Dutton, 1969; Kassab et al., 2010). Therefore, it is essential for the organization to be aware of the importance of implementing risk management to the projects in order to minimize any of the damages that might occur.

2.4.5 Failure to meet desired quality and requirements (K)

Ultimately, the importance of risk management is to enhance the project performance and meet the required standards for its quality (Flanagan & Norman, 1993; Malik et al., 2019). Sabariyahe et al. (2010) stated that the basic elements of project success are measured in cost, time and quality performance. As different parties have different perceptions of the term “quality”, the broadest sense of quality might change along the project’s life cycle (Chionis & Karanikas, 2018). According to Jin and Yean (2006), risk management is essential in influencing the performance of a successful project. There is a close relationship between effective risk management and project success (Wadesango & Shava, 2018). The risk identification process will help in identifying the potential risks that might influence the objectives of a project (Baloi & Price, 2003). Moreover, Sundarajan (2004) stated that there will be consequences such as cost overruns, project delay, changing capital structure and poor quality of the end product if the risk events are not handled and managed properly. Therefore, it is essential to have proper mitigation strategies against the risks to ensure the desired performance of the project can be achieved.

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3. METHODOLOGY

3.1 Systematic Review

A systematic review has been done to achieve objectives 1 and 2. It was first started by framing the research questions for review. Based on Ke et al. (2009), search keywords must be set to meet the requirements of the study. Next, the data sources were selected for this study. It is important to select a comprehensive and extensive search from relevant database and journals (Khan et al., 2003). Appropriate journals that are related to the study were obtained and the “Scopus” database was used for the whole systematic review process.

Then, a preliminary search was done using the search keywords within the defined specific elements such as the titles, keywords and abstract. This ensured the consistency of the search results. The keywords for this study included “Project Risks” and “Construction Risks” with the document type of “Article or Review”.

To assess different qualities, the articles and journals from the search results were then analyzed. They were filtered and limited to the subject areas such as “Business, Management and Accounting”, “Decision Sciences”, “Economics, Econometrics and Finance”, “Energy”, “Engineering”, “Environmental Science” and “Social Science”. The process was then continued by conducting a detailed review of the remaining filtered articles and journals related to the topics of interest.

3.2 Decision-Making Trial and Evaluation Laboratory (DEMATEL) Method

3.2.1 Introduction to the DEMATEL method

DEMATEL (Decision-Making Trial and Evaluation Laboratory)is used to achieve objective 3 of the study by developing the causal relationship among the causes and effects. DEMATEL method was first introduced in 1972 by the Science and Human Affairs Program of the Battelle Memorial Institute of Geneva. It aimed to study the complex and intertwined problematic group. According to Gabus and Fontela (1972), it has been used to assist in solving many global complex problems such as scientific, economic and political issues by considering the attitudes of experts involved. It is now widely accepted as one of the best tools to solve the cause-and-effect relationship among the evaluation criteria (Liou et al., 2007; Tzeng et al., 2007; Wu & Lee, 2007; Lin & Tzeng, 2009; Sujak et al. 2018). According to Wu and Tsai (2011), DEMATEL can help in identifying the interdependencies between the factors of the same level in a decision-making network structure using the relations of cause-and-effect between the factors. DEMATEL generates an Impact-Relation Map (IRM) effectively.

3.2.2 Procedures of the DEMATEL method

Step 1: collect experts’ opinion and calculate the average matrix Z

The opinions of the experts/targeted respondents were collected by interviewing them using the designed questionnaire. Each expert was required to give their opinion using an integer score through a pair-wise comparison. The degree to which the expert perceived factor *i* effects on factor *j* is denoted as x_{ij}. The range of the integer score is respectively from 0 (no

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impact), 1 (low impact), 2 (moderate impact), 3 (high impact) to 4 (very high impact). The integer score was automatically set to zero (0) when $i = j$. An $n\ x\ n$

$$z_{ij} = \frac{1}{m}\sum_{i=1}^{m} x_{ij}^{k} \tag{8.1}$$

The factor that has a higher integer score indicates that the greater improvement in *i* is required to improve on *j*. The average matrix is also named as initial direct-relation matrix Z. It helps to indicate the initial direct effect that each criterion exerts on and receives from other criteria.

Step 2: create and compute the normalized initial direct-relation matrix D

The normalized initial direct-relation matrix $D = [\, d_{ij} \,]$, where all the values in the resulting matrix D are ranged between [0,1]. The formula used is shown below:

$$D = \lambda * Z \tag{8.2}$$

or

$$\left[d_{ij}\right]_{nxn} = \lambda\left[z_{ij}\right]_{nxn} \tag{8.3}$$

where

$$\lambda = Min\left[\frac{1}{\max 1 \le i \le n\sum_{j=1}^{n}\left[z_{ij}\right]}, \frac{1}{\max 1 \le i \le n\sum_{i=1}^{n}\left[z_{ij}\right]}\right] \tag{8.4}$$

All the elements in this normalized initial direct-relation matrix D will only fall within the range between zero and one.

Step 3: attain the total relation matrix T

The total-influence matrix T was obtained by utilizing the equation of $T = D\left(I - D\right)^{-1}$ in which I is an $n\ x\ n$ identity matrix. The element of t_{ij} represents the indirect effects that factor *i* had on factor *j*, and the matrix T reflects the total relationship between each pair of system factors.

$$T = D\left(I - D\right)^{-1} \tag{8.5}$$

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Step 4: compute the sums of rows and columns of matrix T
In the total-influence matrix *T*, the sum of rows and sum of columns were being computed separately using the following formulas. They are represented by vectors *r* and *c*, respectively.

$$r = [r_i]_{nx1} = \left(\sum_j^n t_{ij}\right)_{nx1} \tag{8.6}$$

$$c = \left[c_j\right]'_{lxn} = \left[\sum_j^n t_{ij}\right]'_{lxn} \tag{8.7}$$

where $\left[c_j\right]'$ is denoted as the transposition matrix.

Let r_i be the sum of i^{th} row in matrix T. The value of r_i indicates the total given both direct and indirect effects that factor i has on the other factors.

Let c_j be the sum of the j^{th} column in matrix T. The value of c_j shows the total received both direct and indirect effects that all other factors have on factor j. If j=1, the value of $(r_i + c_j)$ represents the total effects both given and received by factor i. In difference, the value of $(r_i - c_j)$ shows the net contribution by factor i on the system. In addition, when $(r_i - c_j)$ is positive, factor i will be the net cause. When $(r_i - c_j)$ is negative, factor *i* will be the net receiver (Tzeng et al., 2007).

Step 5: set a threshold value (α)
It is necessary to set up a threshold value in order to obtain the diagraph. According to Yang (2008), this calculation aims to eliminate some minor effects elements in matrix *T* as the threshold value is set to filter out some of the insignificant effects. The directed graph will then only show the effects that are greater than the threshold value as it represents the average of the elements in the matrix *T*. The formula used for the calculation is:

$$\alpha = \frac{\sum_{i=1}^n \sum_{j=1}^n [t_{ij}]}{N} \tag{8.8}$$

where N is the total number of elements in matrix *T*.

Step 6: construct a cause-and-effect relationship diagram
According to Shieh et al. (2010), the cause-and-effect diagram was constructed by mapping all coordinate sets of $(r_i + c_j \ , \ r_i - c_j)$ to visualize the complex interrelationship where $(r_i + c_j)$ represents the horizontal axis (x-axis) while $(r_i - c_j)$ represents the vertical axis (y-axis). It is also used to provide information to judge which are the most important factors and how influence affected factors. The factors that t_{ij} is greater than α are selected as shown

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in the cause-and-effect diagram (Yang, 2008). The plot graph that results clearly defines the interrelationship between the factors.

4. RESULTS AND DISCUSSION

4.1 Demographic Profile

Data were collected from 17 individuals including project managers and engineers who were considered experts in the construction industry as they all had at least 10 years' experience contributing to the industry. In order to collect the data required, a set of questionnaires was developed fitting the requirements of the DEMATEL method. The experts were then interviewed face-to-face to fill in the questionnaire. They were asked to determine the degree to which the causes and effects influence each other by answering in Likert-scale form. The background of the respondents is presented in Table 8.1.

Table 8.1 Respondents' demographic profiles

	Frequency	Percentage (%)
Gender:		
Male	11	64.70
Female	6	35.30
Type of company:		
Main contractor	9	52.94
Subcontractor	3	17.65
Consultant	4	23.53
Other	1	5.88
Experience (years):		
10–15	12	70.59
16–20	1	5.88
>20	4	23.53
Total	17	

4.2 Causes of Low-Risk Management Implementation

The causes have been labeled as follows:

- A – Resistance to change
- B – Lack of managerial support and communication
- C – Low-risk attitude
- D – Lack of resources
- E – Lack of knowledge in risk management implementation
- F – Poor risk culture in organization

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Table 8.2 Average matrix Z of causes

	A	B	C	D	E	F	Sum
A	0	2.705882	2.117647	2.705882	2.705882	2.588235	12.82353
B	2.882353	0	2.352941	2.529412	2.470588	2.470588	12.70588
C	2.352941	2.294118	0	2.411765	2.647059	2.411765	12.11765
D	2.470588	2.705882	2.411765	0	2.470588	2.470588	12.52941
E	2.705882	2.411765	2.411765	2.294118	0	2.529412	12.35294
F	2.117647	2.411765	2.470588	2.470588	2.294118	0	11.76471
Sum	12.52941	12.52941	11.76471	12.41176	12.58824	12.47059	

Table 8.3 Normalized direct-relation matrix D

	A	B	C	D	E	F
A	0	0.211009	0.165138	0.211009	0.211009	0.201835
B	0.224771	0	0.183486	0.197248	0.192661	0.192661
C	0.183486	0.178899	0	0.188073	0.206422	0.188073
D	0.192661	0.211009	0.188073	0	0.192661	0.192661
E	0.211009	0.188073	0.188073	0.178899	0	0.197248
F	0.165138	0.188073	0.192661	0.192661	0.178899	0

Table 8.4 Total relation matrix T

	A	B	C	D	E	F
A	4.758211	4.932154	4.651193	4.892458	4.945509	4.905279
B	4.907026	4.723028	4.630708	4.848634	4.898257	4.864234
C	4.687653	4.684002	4.295732	4.652855	4.716837	4.671347
D	4.826954	4.839227	4.57948	4.626227	4.839993	4.806484
E	4.783029	4.76682	4.525881	4.722353	4.62213	4.753721
F	4.562547	4.578364	4.35124	4.545026	4.584939	4.40132

Step 1: collect experts' opinion and calculate average matrix Z

In this phase, the essential causes and influence of causes over one another were identified with the assistance of the experts using DEMATEL. As mentioned earlier in section 3.2.2, the steps involved in DEMATEL were applied. In this step, the causes identified from the literature were rated by the experts on a scale of 0–4. The ratings indicate the influence of one cause on another. From these ratings, the average matrix Z was obtained and tabulated in Table 8.2 using equation 8.1. Similarly, all the following steps were conducted as outlined in the previous section.

Step 2: create and compute normalized initial direct-relation matrix D

The direct-relation matrix D was normalized using equations 8.2, 8.3 and 8.4 and the results are tabulated in Table 8.3.

Step 3: attain total relation matrix T

From the normalized matrix, total relation matrix T was computed using equation 8.5 and the resulting matrix is shown in Table 8.4.

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Table 8.5 *Sum of influence received*

	SUM R	SUM C	R+C	R-C
A	29.0848	28.52542	57.61022	0.559385
B	28.87189	28.5236	57.39548	0.348292
C	27.70842	27.03423	54.74266	0.674191
D	28.51836	28.28755	56.80592	0.230812
E	28.17393	28.60767	56.7816	-0.43373
F	27.02344	28.40238	55.42582	-1.37895

Step 4: compute the sums of rows and columns of matrix T

The total influences received and given by each dimension were calculated using equations 8.6 and 8.7 and the results are shown in Table 8.5.

Step 5: set a threshold value (a)

The threshold value was set to filter out some of the insignificant effects. The threshold value was calculated using equation 8.8 and obtained a value of $\alpha = 4.705024$.

Step 6: construct a cause-and-effect relationship diagram

An influence diagram was created on the basis of influence of each dimension on others. It explained the role of each dimension in relation to others. The diagram is shown in Figure 8.1. The x-axis represents the degree of influence exerted by a dimension, while the y-axis represents the extent of influence experienced by a factor from others. The direction of arrows represents the influences among the factors.

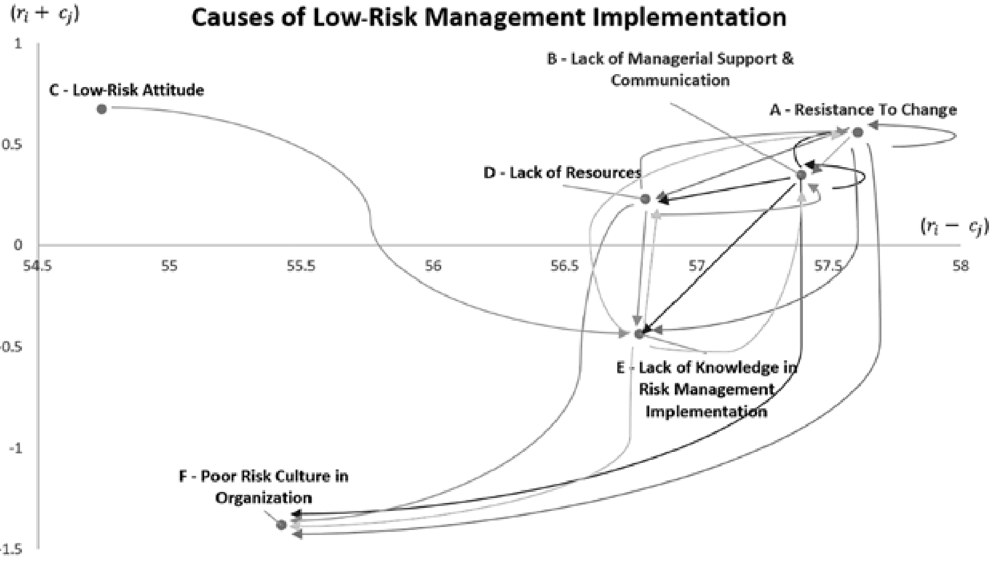

Figure 8.1 *Causes of low-risk management implementation*

The diagraph presented in Figure 8.1 reveals the relationship among the causes of low implementation of risk management. The term $+c_j$ shows how much importance a given factor

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has, while $r_i - c_j$ indicates whether the factor belongs to the causal group or effect group. The factor would appear to be in the causal group if its $r_i - c_j$ value is positive and belongs to the effect group if it is a negative value.

In Table 8.5, resistance to change (A) is the most important cause of low-risk management implementation as it has the largest value of $r_i + c_j$ ($r_1 + c_1$ = 57.61022), whereas low-risk attitude (C) is the least important cause as it has the smallest value of $r_i + c_j$ ($r_3 + c_3$ = 54.74266). Regarding the $r_i + c_j$ values, the prioritization of the importance of the causes is resistance to change (A) > lack of managerial support and communication (B) > lack of resources (D) > lack of knowledge in risk management implementation (E) > poor risk culture in organization (F) > low-risk attitude (C).

Based on the value of $r_i - c_j$, the causes are divided into (i) causal group and (ii) effect group.

i. The causal group contains the factors that have a positive value of $-c_j$. The highest $r_i - c_j$ value also indicates that it is the most critical factor that is influential in low-risk management implementation and has the greatest direct impact on others. In this study, resistance to change (A), lack of managerial support and communication (B), low-risk attitude (C) and lack of resources (D) are classified in the causal group as they have positive $r_i - c_j$ values of 0.559385, 0.348292, 0.674191 and 0.230812, respectively. Based on the matrix in Table 8.4, it is found that factors A, B, D and E had a mutual interaction as all their values are greater than the threshold value (α = 4.705024).
ii. The effect group contains the factors that have the negative value of $r_i - c_j$ and is largely influenced by the other factors. The lowest $r_i - c_j$ value indicates the factor to be the most influenced factor in low-risk management implementation. In this study, it shows that lack of knowledge in risk management implementation (E) and poor risk culture in organization (F) are categorized in the effect group with the values of -0.433731 and -1.378949, respectively. Poor risk culture in organization (F) is also the factor that is affected most by other factors because of its lowest $r_i - c_j$ value.

4.3 Effects of Low-Risk Management Implementation

The effects have been labeled as follows.

- G – Project delay/time overrun
- H – Cost overrun
- I – Accidents
- J – Conflicts/disputes
- K – Failure to meet desired quality and requirements

Under each perspective, the effects of low-risk management implementation were analyzed using the same DEMATEL procedures as described. Listed below are the tables and diagraph

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Table 8.6 *Average matrix Z of effects*

	G	H	I	J	K	Sum
G	0	3.411765	1.941176	3.176471	3.058824	11.58824
H	2.647059	0	2.352941	2.882353	3.058824	10.94118
I	2.294118	2.352941	0	2.176471	2.529412	9.352941
J	2.411765	2.647059	1.764706	0	2.647059	9.470588
K	2.823529	3.117647	1.941176	2.941176	0	10.82353
Sum	10.17647	11.52941	8	11.17647	11.29412	

Table 8.7 *Normalized direct-relation matrix D*

	G	H	I	J	K
G	0	0.294416	0.167513	0.274112	0.263959
H	0.228426	0	0.203046	0.248731	0.263959
I	0.19797	0.203046	0	0.187817	0.218274
J	0.208122	0.228426	0.152284	0	0.228426
K	0.243655	0.269036	0.167513	0.253807	0

Table 8.8 *Total relation matrix T*

	G	H	I	J	K
G	1.85431	2.283191	1.653441	2.225666	2.225396
H	1.949077	1.953248	1.603508	2.109564	2.125899
I	1.714367	1.884653	1.261588	1.836335	1.863109
J	1.745793	1.929322	1.413884	1.705365	1.896672
K	1.95011	2.156218	1.571968	2.104092	1.907654

Table 8.9 *Sum of influences received*

	SUM R	SUM C	R+C	R-C
G	10.242	9.213657	19.45566	1.028347
H	9.741295	10.20663	19.94793	-0.46534
I	8.560051	7.504389	16.06444	1.055662
J	8.691035	9.981022	18.67206	-1.28999
K	9.690042	10.01873	19.70877	-0.32869

Threshold value, $\pm = 1.876977$

for effects of low-risk management implementation. Table 8.6 shows the average matrix Z of effects; Table 8.7 shows the normalized direct-relation matrix D, Table 8.8 shows the total relation matrix T and Table 8.9 shows the sum of influences received. Following that, Figure 8.2 shows the causal relationship among the effects of low-risk management implementation. Based on the $r_i + c_j$ values in Table 8.9, this shows that the most important effect of low-risk management implementation is cost overrun (H) with its highest $r_i + c_j$ value of 19.94793, while the lowest $r_i + c_j$ value of 16.06444 belongs to the least important effect, which is accidents (I). The importance of the effects can be arranged in the order of cost overrun (H) > failure to meet desired quality and requirements (K) > project delay/time overrun (G) > con-

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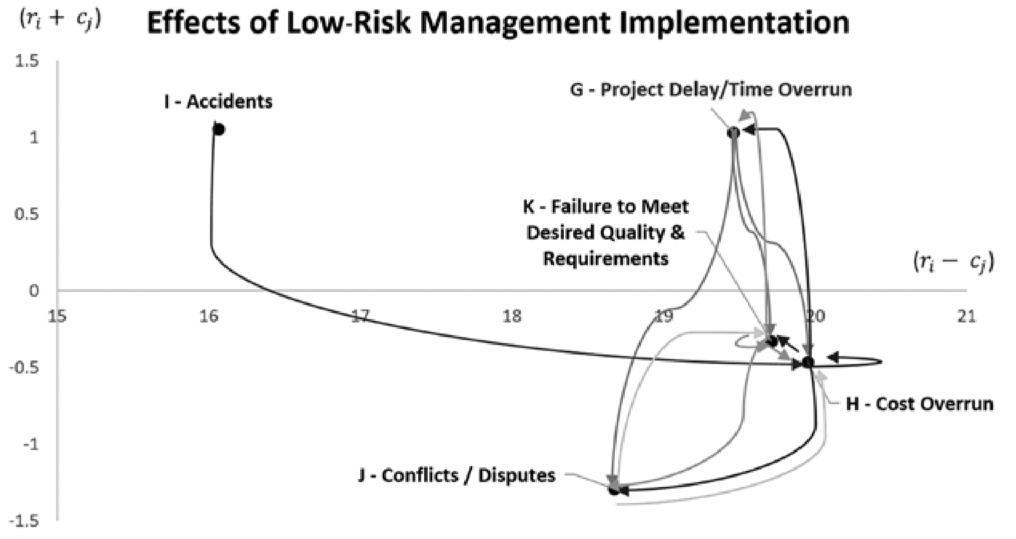

Figure 8.2 Effects of low-risk management implementation

flicts/disputes (J) > accidents (I), based on the ascending order of $r_i + c_j$ values shown in Table 8.9.

The effects are then divided into (i) causal group and (ii) effect group regarding their $r_i - c_j$ values.

i. In this study, the effect factors classified under causal group are project delay/time overrun (G) and accidents (I) due to the positive $r_i - c_j$ values of 1.028347 and 1.055662. This also shows that factors G, H, J and K have mutual interactions with each other based on their values that are greater than the threshold value $(\alpha = 1.876977)$.
ii. The other factors such as cost overrun (H), conflicts/disputes (J) and failure to meet desired quality and requirements (K) are categorized under the effect group with their respective values of -0.46534, -1.28999 and -0.32869. This also shows that the factor J is affected the most by other factors as it has the lowest $r_i - c_j$ value.

4.4 Causes and Effects of Low-Risk Management Implementation

By using the same DEMATEL procedure as described earlier, the relationship between causes and effects of low-risk management implementation was also examined and is shown in Tables 8.10, 8.11, 8.12 and 8.13. The causal relationship among causes and effects of low-risk management implementation is depicted in Figure 8.3.

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Table 8.10 Average matrix Z of causes and effects

	A	B	C	D	E	F	G	H	I	J	K	Sum
A	0	2.705882	2.117647	2.705882	2.705882	2.588235	2.882353	2.882353	2.352941	2.705882	2.352941	26
B	2.882353	0	2.352941	2.529412	2.470588	2.470588	2.647059	2.647059	1.882353	2.647059	2.470588	25
C	2.352941	2.294118	0	2.411765	2.647059	2.411765	2.411765	2.411765	2.705882	2.117647	2.352941	24.11765
D	2.470588	2.705882	2.352941	0	2.470588	2.470588	3.235294	3	1.882353	2.470588	2.882353	25.94118
E	2.705882	2.411765	2.411765	2.294118	0	2.529412	2.588235	2.235294	2.411765	2.411765	2.352941	24.35294
F	2.117647	2.411765	2.470588	2.470588	2.294118	0	2.294118	2.470588	2.411765	2.411765	2.352941	23.70588
G	0	0	0	0	0	0	0	3.411765	1.941176	3.176471	3.058824	11.58824
H	0	0	0	0	0	0	2.647059	0	2.352941	2.882353	3.058824	10.94118
I	0	0	0	0	0	0	2.294118	2.352941	0	2.176471	2.529412	9.352941
J	0	0	0	0	0	0	2.411765	2.647059	1.764706	0	2.647059	9.470588
K	0	0	0	0	0	0	2.823529	3.117647	1.941176	2.941176	0	10.82353
Sum	12.52941	12.52941	11.70588	12.41176	12.58824	12.47059	26.23529	27.17647	21.64706	25.94118	26.05882	

Table 8.11 Normalized direct-relation matrix D

	A	B	C	D	E	F	G	H	I	J	K
A	0	0.103139	0.080717	0.103139	0.103139	0.098655	0.109865	0.109865	0.089686	0.103139	0.089686
B	0.109865	0	0.089686	0.096413	0.09417	0.09417	0.100897	0.100897	0.071749	0.100897	0.09417
C	0.089686	0.087444	0	0.091928	0.100897	0.091928	0.091928	0.091928	0.103139	0.080717	0.089686
D	0.09417	0.103139	0.089686	0	0.09417	0.09417	0.123318	0.11435	0.071749	0.09417	0.109865
E	0.103139	0.091928	0.091928	0.087444	0	0.096413	0.098655	0.085202	0.091928	0.091928	0.089686
F	0.080717	0.091928	0.09417	0.09417	0.087444	0	0.087444	0.09417	0.091928	0.091928	0.089686
G	0	0	0	0	0	0	0	0.130045	0.073991	0.121076	0.116592
H	0	0	0	0	0	0	0.100897	0	0.089686	0.109865	0.116592
I	0	0	0	0	0	0	0.087444	0.089686	0	0.08296	0.096413
J	0	0	0	0	0	0	0.091928	0.100897	0.067265	0	0.100897
K	0	0	0	0	0	0	0.107623	0.118834	0.073991	0.112108	0

Table 8.12 Total relation matrix T

	A	B	C	D	E	F	G	H	I	J	K
A	0.080624	0.174119	0.150403	0.173305	0.174208	0.169948	0.324178	0.336611	0.267963	0.322575	0.312134
B	0.178997	0.079949	0.157171	0.16716	0.166239	0.165576	0.311174	0.323255	0.248352	0.314864	0.309655
C	0.15869	0.156773	0.071765	0.159815	0.168329	0.160223	0.29505	0.30641	0.268436	0.288935	0.297301
D	0.164626	0.172017	0.155982	0.07777	0.164765	0.164159	0.333515	0.338954	0.25115	0.313788	0.327141
E	0.171269	0.161967	0.157161	0.157572	0.078074	0.165375	0.303306	0.303929	0.260955	0.301222	0.29989
F	0.149103	0.158458	0.155949	0.159678	0.154982	0.073947	0.287208	0.304082	0.255268	0.294202	0.293277
G	0	0	0	0	0	0	0.064978	0.188322	0.120766	0.179368	0.175866
H	0	0	0	0	0	0	0.153071	0.068844	0.131075	0.166103	0.171862
I	0	0	0	0	0	0	0.133579	0.141824	0.042477	0.134629	0.146201
J	0	0	0	0	0	0	0.138292	0.152337	0.106317	0.05923	0.151008
K	0	0	0	0	0	0	0.158194	0.174855	0.117626	0.167752	0.067097

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Table 8.13 Sum of influences received

	SUM R	SUM C	R+C	R-C
A	2.486068	0.90331	3.389378	1.582758
B	2.422392	0.903282	3.325674	1.51911
C	2.331726	0.848431	3.180158	1.483295
D	2.463866	0.8953	3.359166	1.568565
E	2.360721	0.906596	3.267317	1.454124
F	2.286155	0.899227	3.185382	1.386927
G	0.7293	2.502544	3.231844	-1.77324
H	0.690956	2.639424	3.330379	-1.94847
I	0.598709	2.070385	2.669095	-1.47168
J	0.607184	2.542668	3.149852	-1.93548
K	0.685524	2.551433	3.236957	-1.86591

Threshold value, $\pm = 0.145972$

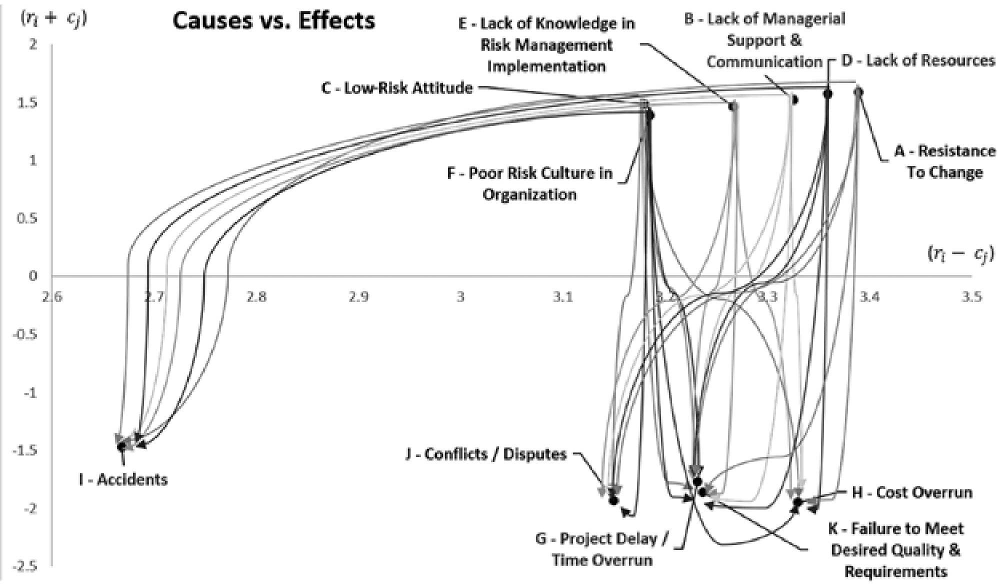

Figure 8.3 Causes vs effects

Table 8.13 shows that resistance to change (A) has the highest $r_i + c_j$ value of 3.389378 as the most important factor in low-risk management implementation with its position at the most top-right corner of the diagraph, whereas the least important factor in this study is accidents (I) due to its lowest $r_i + c_j$ value of 2.669095 and its position at the bottom-left of the diagraph. Based on the $r_i + c_j$ values, this shows that the prioritization of importance of these factors can be arranged in the order of resistance to change (A) > lack of resources (D) > cost overrun (H) > lack of managerial support and communication (B) > lack of knowledge in risk management implementation (E) > failure to meet desired quality and requirements (K) > project

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delay/time overrun (G) > poor risk culture in organization (F) > low-risk attitude (C) > conflicts/disputes (J) > accidents (I).

All the factors have been categorized into (i) causal group and (ii) effect group based on their $r_i - c_j$ values.

i. In this study, all the causes of low-risk management implementation fall within the causal group based on their positive $r_i - c_j$ values. It is found that resistance to change (A) has the greatest direct impact on the effects and has the highest correlation as it has the highest $r_i - c_j$ value $(r_1 - c_1 = 1.582758)$ among the factors. Table 8.12 also shows that all the factors in the causal group have interactions with all the factors in the effect group based on their values that are greater than the threshold value, $\alpha = 0.145972$.
ii. The effect group consists of all the effects of low-risk management implementation as they have negative $r_i - c_j$ values. The factor that is influenced the most by the other factors is cost overrun (H) based on its lowest $r_i - c_j$ value ($r_8 - c_8$ = -1.948468). It can be concluded that all the effect group factors are influenced by all the causal group factors and their interactions are shown in Table 8.12 and Figure 8.3.

5. CONCLUSION AND IMPLICATIONS

Risk management is essential in influencing project success as low-risk management implementation is detrimental to projects. Previous studies have been carried out to investigate the causes and effects that may influence project success but less has been done to draw conclusions on the risk factors to be improved. By using the DEMATEL method, this study has determined the causes and effects of low-risk management implementation and the causal relationship between them in the form of diagraphs.

The results show that the relationships among all causes and effects are significant. The results also show that the most critical cause of low-risk management implementation is resistance to change. Therefore, organizations should focus more on this issue in order to improve the use of risk management in construction projects. Change is always difficult in the beginning as it means new ways of doing things and people may fear the unknown. Therefore, it is important for organizations to provide their direction, goals and parameters to the employees in order for them to understand the need for change.

Organizations may start off in managing resistance to change by preparing courses for their employees. It helps to provide employees with insights and better understanding of the importance of implementing risk management in projects. They can also provide training programs and workshops for the employees to get proper knowledge, skills and information on risk management in construction projects. It is very important for organizations to communicate with their employees regarding the change that is going to be made. This enables the managerial team to understand the thoughts and responses that employees have to even the simplest change. They should also encourage their employees to voice their opinions on the proposed change as this helps in reducing their uncertainties.

Minimizing employees' resistance to change helps to improve communication between the managerial team and employees. Moreover, it also helps to increase the engagement

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of employees in the project by encouraging them to advocate for change. Additionally, the progress of going through changes will facilitate in gaining employees' support and go more smoothly by being open, sincere and honest. In a nutshell, the implementation of risk management in the construction industry can be improved by managing the causes carefully to minimize the impact on the project and avoid project failure.

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