TECHNICAL RISK MITIGATION FRAMEWORK FOR RAILWAY CONSTRUCTION PROJECT IN MALAYSIA

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ABSTRACT

Railway construction projects are exposed to various risks that can cause snowball effects, which also affects the national economy. Preparing a budget for a project during the initial stage is very crucial to substantiate whether its objectives are within the financial capability. The aim of this study is to appraise the project risk mitigation practice that impacts the cost of railway construction projects in Malaysia by four objectives: (1) identifying the impacts of cost overrun, (2) investigating the technical risks throughout the project phases, (3) assessing the technical risk factors that contribute to cost overrun, and (4) developing the technical risk mitigation framework for the railway construction project in Malaysia. This study gathered and analysed data from quantitative and qualitative methods. Research methods, such as the Average Index Method, Data Frequency Analysis, Standard Deviation, and Relative Importance Index (RII), were used in quantitative data analysis involving 200 respondents. For the first objective, this study found that the cost overrun in railway construction projects has also impacted other project elements, such as time and quality, which are grouped into short-term impacts. Meanwhile, the long-term impacts consist of a hike in the fare prices, lower ridership rate, difficulty in collecting maintenance funds, delay in enhancement and upgrading of the railway network, and high dependability on government operating subsidies. The risk assessment was conducted using the Fuzzy Synthetic Evaluation method. Results of the objectives two and three have ranked defective design, the additional scope of works, complex design of a system, error in design, and difficult construction of a system integration to be amongst 15 technical risks that are found critical in railway construction projects in Malaysia. Meanwhile, the qualitative data of the structured interview, which involved five (5) subject matter experts, were analysed using Code-Based Analysis. The results found that building information modelling (BIM), pre-fabrication, and the usage of software applications are amongst other risk response strategies in mitigating the technical risks that formed the conceptual framework. Finally, the framework had been developed for the fourth objective, which encompassed 15 critical technical risks of railway construction projects in Malaysia and 18 effective response strategies, which were categorised as to avoid, mitigate and escalate, and validated from three areas, namely acceptability, practicality, and effectiveness. Consequently, this study aligns with the Construction 4.0 Strategic Plan (2021-2025), Twelfth Malaysia Plan (12MP), and 2030 Agenda for Sustainable Development by United Nations (UN) in promoting resilient infrastructure, sustainable and affordable transportation, and sustainable economic growth.

ABSTRAK

Projek pembinaan keretapi terdedah dengan pelbagai risiko yang boleh menyebabkan kesan berlarutan, di mana ia juga akan memberi kesan terhadap ekonomi negara. Penyediaan belanjawan projek di peringkat awal sangat penting untuk memastikan objektif projek dicapai dalam kemampuan kewangan. Justeru, kajian ini bermatlamat untuk menilai amalan mitigasi risiko projek yang memberi kesan terhadap kos projek pembinaan keretapi di Malaysia dengan empat objektif: (1) mengenal pasti kesan lebihan kos, (2) menyiasat risiko teknikal sepanjang fasa projek, (3) menilai faktor risiko teknikal yang menyumbang kepada lebihan kos, dan (4) membangunkan kerangka kerja pengurangan risiko teknikal untuk projek pembinaan keretapi di Malaysia. Kajian ini mengumpul dan menganalisis data menerusi kaedah kuantitatif dan kualitatif. Kaedah kajian seperti Kaedah Indeks Purata, Analisis Kekerapan Data, Sisihan Piawaian, dan Kepentingan Indeks Relatif (RII) digunakan untuk menganalisa data kuantitatif yang melibatkan 200 responden. Objektif pertama mendapati bahawa lebihan kos projek pembinaan keretapi juga memberi kesan kepada elemen projek lain seperti masa dan kualiti, yang dikumpulkan dalam impak jangka pendek. Sementara itu, impak jangka panjang terdiri daripada kenaikan harga tambang, kadar penumpang yang rendah, kesukaran mengumpul dana penyelenggaraan, kelewatan menambah baik dan menaik taraf rangkaian keretapi, dan kebergantungan subsidi kerajaan yang tinggi untuk beroperasi. Penilaian risiko telah dijalankan menggunakan kaedah Penilaian Sintetik Fuzzy. Hasil kajian bagi objektif kedua dan ketiga mendapati reka bentuk cacat, skop kerja tambahan, reka bentuk sistem yang kompleks, ralat reka bentuk, dan kesukaran pembinaan dalam penyepaduan sistem sebagai antara 15 risiko teknikal yang kritikal dalam projek keretapi di Malaysia. Manakala, data kualitatif daripada temu bual berstruktur melibatkan lima (5) orang pakar subjek dianalisis menggunakan Analisis Berasaskan Kod. Penemuan kajian mendapati Model Maklumat Bangunan (BIM), pra-pembuatan, dan penggunaan aplikasi perisian adalah antara strategi tindak balas risiko dalam mengurangkan risiko teknikal yang membentuk kerangka kerja konsep. Akhir sekali, kerangka kerja bagi objektif keempat ini merangkumi 15 risiko teknikal kritikal projek pembinaan keretapi di Malaysia dan 18 strategi tindak balas berkesan yang dikategorikan sebagai menghindari, mengurangi, dan mengatasi, yang telah disahkan daripada tiga sudut, iaitu kebolehterimaan, kepraktisan, dan keberkesanan. Kajian ini selaras dengan Pelan Strategik Pembinaan 4.0 (2021-2025), Rancangan Malaysia Ke-12 (RMK-12), dan Agenda 2030 Pembangunan Mampan oleh Pertubuhan Bangsa-Bangsa Bersatu (PBB) dalam menggalakkan infrastruktur yang berdaya tahan, pengangkutan yang mampan dan mampu milik, dan pertumbuhan ekonomi yang mampan.

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LIST OF ABBREVIATIONS

ADB	-	Asian Development Bank
ASCE	-	American Society of Civil Engineers
AI	-	Artificial Intelligence
APAD	-	Land Public Transport Agency
BASE	-	Bielefeld Academic Search Engine
BIM	-	Building Information Modelling
BQSM	-	Board of Quantity Surveyors Malaysia
CIDB	-	Construction Industry Development Board
COVID-19	-	Coronavirus Disease 2019
CUTA	-	Canadian Urban Transit Association
DB	-	Design and Build
ECRL	-	East Coast Rail Link
EU	-	European Union
EVM	-	Earned Value Management
GDP	-	Gross Domestic Product
HSR	-	High Speed Rail
IEA	-	International Energy Agency
IRM	-	Institute of Risk Management
ISO	-	International Organization for Standardization
KLCC	-	Kuala Lumpur City Centre
KTM	-	Keretapi Tanah Melayu
LRT	-	Light Rail Transit
LRT3	-	Light Rail Transit 3
MRT	-	Mass Rapid Transit
MRT2	-	MRT Sungai Buloh-Serdang-Putrajaya (SSP) Line
MTR	-	Mass Transit Railway
NASA	-	National Aeronautics and Space Administration
PDP	-	Project Delivery Partner
PMBOK	-	Project Management Body of Knowledge
PMI	-	Project Management Institute

PPP	-	Public-Private Partnership
PWD	-	Public Works Department
RIBA	-	Royal Institute of British Architects
RICS	-	Royal Institution of Chartered Surveyors
RII	-	Relative Importance Index
SPAD	-	Land Public Transport Commission
SWOT	-	Strength, Weakness, Opportunity, and Threat
TOD	-	Transit-oriented Development
TR	-	Technical Risk
U.K.	-	United Kingdom
UN	-	United Nations
U.S.	-	United States
VO	-	Variation Order
12MP	-	The Twelfth Malaysia Plan

LIST OF SYMBOLS

RC	-	Risk Score
R^P	-	Probability of Risk Occurrence
R^I	-	Cost Risk Impact
μ	-	Mean
s	-	Standard Deviation
s^2	-	Variance
F	-	Frequency

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CHAPTER 1

INTRODUCTION

1.1 Background

Countries like the United States (U.S.), China, Japan, Germany, India, France, and United Kingdom (U.K.) always look to strengthen and expand their economies. China and U.S. make up almost 40 per cent of the world economy (Scott and Sam, 2016). Despite the world is facing the pandemic of Coronavirus Disease 2019 (COVID-19), the U.S. and China are each expected to contribute about one quarter of global growth in 2021 (The World Bank, 2021). The growth leads the global economic players to be aggressively looking for a new marketplace to expand, where the global growth is expected to accelerate to 5.6% in 2021 (The World Bank, 2021).

Fortunately, Malaysia is an attractive country for foreign companies to invest into because of its strategic location and competitive position as one of Asia's emerging markets. This is further supported by PwC (2016), who claimed that Malaysia has secured USD 2.8 billion of approved foreign direct investment into global establishment in 2016. This is supported by Mahathir (2018), who said that Malaysia welcomes either domestic or foreign direct investment, which also indicates positive environment for future economy of Malaysia. In line with this, it is undeniable that infrastructure and connectivity are one of important components of development plan.

Fay et al. (2010) stated that improvement on infrastructure, either small or large-scale can provide significant economic development benefits. For example, Crossrail, the new railway of Elizabeth Line, brings significant environmental and economic benefits to the city of London and the U.K. (Pollalis and Lappas, 2019). Thus, for every investment for development, infrastructure plays a big role to support

this growth. At this juncture, transport infrastructure is seen as a major component of the fixed capital of the transport system (Ministry of Transport of New Zealand, 2014). Due to that reason, transport system, like railway, is arousing in Malaysia with the support of government and local agency, like Land Public Transport Agency (APAD) (formerly known as Land Public Transport Commission (SPAD)).

This is apparently evident as according to Arcadis (2016), the development of railway infrastructure has influenced Malaysia to be placed in the second place in Asia and fifth place globally for most attractive country for infrastructure investment in 2016. Economic Planning Unit (2015) reported that under the 11th Malaysia Plan (2016 - 2020), government has allocated a sum of RM 260 billion for development expenditure. A greater priority on public transportation is given to connect cities and the outskirts (Nathan, 2018), including Mass Rapid Transit Line (MRT) Sungai Buloh-Serdang-Putrajaya (SSP) Line, Pan-Borneo Highway, and high-speed rail (HSR) with a total value of RM 84 billion. In addition, Zakariah et al. (2017) also claimed that MRT Sungai Buloh-Kajang (SBK) Line, which has been in fully operation since 2017, is costing at RM 21 billion.

Apparently, the investment is not just focusing on Klang Valley area, but it has also widespread more to outside the area as through the phase 1 of Penang Transport Master Plan project, which costs RM 16 billion comprising of Bayan Lepas Light Rail Transit (LRT) and Pan Island Link 1 (PIL1) (Idris, 2020). Hence, based on these huge investments on the mega infrastructure project like the railway, understanding and further knowledge about the science of the railway project are seen as essential. There are various factors that can contribute to the success of railway project although it entails an amount of risks. This is apparently supported by Patil et al. (2017), who agreed that there are considerable high risks in railway project. Thus, the ability to manage risks in such construction project would benefit and bring value to the public and economic growth in a long-term.

1.2 Problem Statement

1.2.1 High Density on the Road

The population is increasing in rapid growth, where China, India, and the United States (U.S.) are among the countries that recorded the highest in increase of population with 1.09, 2.97, and 1.25 per cent respectively of population growth between year of 2015 to 2017 (Population Reference Bureau (PRB), 2017). As in Malaysia, Department of Statistic Malaysia (DOSM) (2016) recorded percentage of 1.5 of growth population from 2015 to 2016 with Selangor and Wilayah Persekutuan ranked the highest percentage of population at 25.8 per cent. SPAD (2013) also reported that population and employment in areas, such as Kuala Lumpur, Petaling Jaya, Klang, and Shah Alam, showed higher densities compared to other districts of Selangor.

Consequently, a trend where cars are proportionally increasing on the road can be also seen. World Bank (2018) estimates that Greater Kuala Lumpur residents spend more than 250 million hours a year stuck in traffic, where Malaysia has the third highest car ownership rate in the world (Gerber, 2018). Hence, SPAD (2013) claimed that without improvement of land public transport, it will further increase car usage that lead to longer travel times and significant rise in road congestion. To reduce vehicles capacity on the road and congestion, government must initiate a sustainable plan that is able to solve such issues. This seems viable as research on Customer Satisfaction Index (CSI) by SPAD (2017) has shown an increase of 3 per cent from year 2016 to 2017 of likelihood of users to continue using public transport.

Therefore, there is no doubt that there is a demand in railway transport for urban area. Urban railway, such as Mass Rapid Transit Sungai Buloh-Kajang (MRT SBK) Line, recorded 7.5 per cent in average daily ridership year-on-year since official launched on 17 July 2017 and Light Rail Transit (LRT) Kelana Jaya Line with an increase of 7 per cent in year 2017 compared to in 2016 (SPAD, 2017). The forecast morning peak hour travel demands by all modes have been produced, which included private and public transport, where it has been found there are large radial movements

towards the central area of Kuala Lumpur (SPAD, 2013). Thus, government has a future plan in providing seamless mass transit involving railway system in urban area. Furthermore, SPAD (2013) claims that railway system can be envisaged as providing connections to the city centre, particularly through primary and secondary corridors in Klang Valley.

In 2013, the government has launched the Greater Kuala Lumpur / Klang Valley Land Public Transport Master Plan (Gerber, 2018). It includes specific plan for urban railway known as Urban Rail Development Plan (URDP), which is one of six subsidiary plans under the master plan. The objective is to investigate the broad corridors (within a 2.5 km radius) along, which any new lines might be developed and to specify measures to enhance the existing rail network. Based on the situation, railway transportation is seen as one of the keys to improve the standard of living and the infrastructure of the Klang Valley areas.

Ministry of Finance (MOF) Malaysia understands that investment on the urban railway network is important to solve issue on traffic congestion in area where railway project like Light Rail Transit Line 3 (LRT3) is critical to alleviate traffic issues along one of the most important and densely populated economic development corridors in Klang Valley, from Klang to Petaling Jaya (Zainul, 2018). Malaysia is aiming to be a fully developed and industrialised nation by sustaining its economic growth every year (SPAD, 2013). Thus, this study is believed to contribute in uplifting the standard of project management particularly in risk mitigation practice as these infrastructure plans will definitely act as a catalyst for strong economic growth.

1.2.2 High Fare Prices

A big amount of investment is being put into new railway and improvement of existing services. The capital expenditure like the construction cost of the railway holds a highest percentage of a railway fare price (Rail Delivery Group, 2017). Rail Delivery Group (2017) stated that 26 per cent of the fare price goes to the investment in the rail network, whilst National Rail Enquiries (2017) further found that 20 per cent of the fare price goes to the investment on the track and infrastructure costs. This shows

a close relationship of the fare price and the construction cost of the railway, where the percentage is the highest than other percentage distribution of fare price.

In general, price hike for railway fares is a global issue. For example, Hong Kong's Mass Transit Railway (MTR) saw fare price increased to more than 20 per cent since 2010 (Yau, 2018). The fare rise was projected to be 3.14 per cent in 2019, but it was in fact went up to 3.3 per cent until the end of the year (Yau, 2019). Kit (2018) also reported that in Singapore, maximum allowable adjustment of 4.3 per cent is implemented for the train fares starting December 2018. In addition, in Britain, Rail Delivery Group (2017) found that the train fares to go up on average 3.4 per cent for the year 2018 and spending six times more on fares than their counterparts in Europe (Khan, 2017).

As for Malaysia, Choong et al. (2015) reported that Land Public Transport Commission (SPAD) had given its approval for railway operators, such as Keretapi Tanah Melayu (KTM) Berhad and Prasarana Malaysia Berhad to set new rates which resulted in increase of fare prices. This consequently leads to increment of customer dissatisfaction of public transportation of Klang Valley from 4 to 8 per cent between 2013 to 2015 (Ipsos Loyalty, 2015). These public transports include railway, such as KTM, Light Rapid Transit (LRT) and Monorail. Therefore, with customer dissatisfaction, this automatically impacts the reduction of ridership rate and eventually, on the income revenue of the railway operator.

1.2.3 Railway Construction Exposal to Risk

Technical risk, management risk, financial risk, environmental risk, socio-political risk, and logistical risk are types of risks that are commonly related to the construction industry (Ehsan et al., 2010) including railway. Railway construction is a mega project that exposes to various of risks, which can be a threat to the successful project execution in terms of cost, time, and quality (Andric, Wang, and Zhong, 2019). Ana, Alvaro and Rafaela (2014) have further classified mega project risks into design risk, legal risk, political risk, contractual risk, construction risk, operation and

maintenance risk, labour risk, stakeholder (clients, users, society etc.) risk, financial risk, economic risk, and force majeure risk.

Schoonwinkel et al. (2016) claim that risk in construction project, including railway are unavoidable, impacting projects in terms of cost, time and quality. The objective of the project could adversely impact the progress and worse could forcefully end the project. In Malaysia, the impact of political risk can be seen when there was a change of government after the 14th general election in the country as the new government announced the termination of the RM45 billion third Mass Rapid Transit (MRT3) and the RM110 billion Kuala Lumpur-Singapore high-speed rail project after just two months in reign (Azman, 2018). Tipili and Ilyasu (2014) therefore pinpointed that risk can impact towards time, quality, and cost performance as these three performances provide valuable information for the shareholders to keep track on their projects in determining project success.

Regardless of how important to understand the relationship, sufficient considerations must be taken as risk can result in increased costs to the construction project (Arcadis, 2017) including railway. Somehow, the level of awareness of project stakeholders in construction industry about how the risks can affect the construction cost is found to be average (Tipili and Ilyasu, 2014). Although almost every project has its own cost consultant, almost every project also faced issues related to technical risk. Without a proper risk mitigation practice, it consequently leads to project failure in terms of cost overruns, delay in schedule, and poor quality performances (Kang et al., 2015).

However, in the perspective of railway construction project, current exercise of risk mitigation in Malaysia may not be sufficient and effective in general. Most construction companies in Malaysia have not been adopting risk mitigation practice in their organisation even though the risk level is still high in the local construction industry (Kang et al., 2015). Kang et al. (2016) also found that Malaysia has been practising risk mitigation at the very minimum level as contractors conduct a straightforward, fast and inexpensive methods for identifying risk and the analysis is only focused on events with a high likelihood of occurrence and impact level. When

the client representative ignores risk and does not make a plan to manage it from the initial phase, the cost of project can get significantly higher in later stages, where it will be more complicated to handle it (Berg and Tideholm, 2012).

1.2.4 Escalation of Cost due to Risk

Escalation of price may result in issue towards the construction project including railway, which directly will give negative effects to the stakeholders, especially the project owner. Escalation of construction project cost can complicate an overrun situation as often takes a lot of time to secure additional funding to cover it (Gbahabo and Ajuwon, 2017). When matters like these transpire, it is highly imminent that it can affect on the schedule of the railway construction project to discuss and get approval of new budget. If no agreement on the matter arising between the contractor and project owner, it exposes to contractual disputes and this can cause a serious overrun of time and cost (Kikwasi, 2013).

Therefore, it is very crucial to do thorough check and detail analysis prior to construction project award. Accuracy in estimation is a real challenge and one major challenge for cost planning and control is the uncertainty or risk (Torp and Klakegg, 2016). It is common that during design development, the information is limited and this influences level of accuracy of cost planning. Thus, a lot of assumptions and cost allowances has to be made in early stage when dealing with uncertainties. Lack of assessment during budget preparation often cause under budget and if the construction project award is based from the lowest bidder system, this would result a drop of profit of the contractor and the tendency for them to cover it with poor quality or not complying with the requirement standards (Puri and Tiwari, 2014). Due to this matter, without proper coordination and detail inspection by appointed representatives, this will frustrate expectation of project's owner and the end user.

A significant cost overrun increases the chance of the construction project to be delayed and possibility to be discontinued. Due to cost overrun factors, the impact could force the contractor to leave or stop the project (Ejaz, Ali, and Tahir, 2011). When the actual costs exceed the baseline cost, it may dismay the project owner

especially if they have constraint budget. Brunes and Lind (2014) composed their findings and found that 86 per cent of the infrastructure projects, including railway, suffered from cost overrun when compared to the budgeted cost. This study is more substantial when it has been studied that the railway projects were the highest among other infrastructure projects with cost overrun by 45 per cent (Brunes and Lind, 2014). Therefore, this can be a damaging situation to Malaysia if these issues are happening in the country.

Besides, in Malaysia, Light Rail Transit 3 (LRT3) project timeline is extended from year 2020 to 2024 (Aisyah, 2018) and according to Flyvbjerg et al. (2004), the expectation percentage of infrastructure projects to escalate in cost is 4.64 percentage and this is only for the construction cost. Leung (2018) on the other hand, reported that Guangzhou-Shenzhen-Hong Kong Express Rail Link saw original project budget of HK$39.5 billion that was made in 2008 increased to HK$84.4 billion. Meanwhile, London's Crossrail project running £590 million over budget to complete the work and extra £350 million loan which caused the budget of project to increase from £14.8 billion to £15.8 billion (Plimmer and Pickard, 2018). Thus, it can be seen that cost escalation in railway project is a global issue and Malaysia should be equipped with high standard of project and risk management to tackle the problem.

There are only a few studies investigating about railway development in Malaysia and the general impacts on the national economy (Aziz, Kassim and Masirin, 2018; Yusoff, Ng and Azizan, 2021). However, it has been found that there were no studies about how cost overrun that due to risks would impact the railway construction projects in Malaysia. Flyvbjerg (2009) mentioned that the problem about mega construction projects like railway is an optimism bias in early project development, where the impact of key elements of the project such as cost have been overlooked. Therefore, this study believed that there is a need for the impacts to be aware of and understood by the stakeholders as the risk mitigation process involves awareness and collective efforts by all the stakeholders.

Additionally, although Project Management Institute (PMI) (2017) released a guideline on risk response strategies, which include mitigate. PMI (2017) has stated that the document makes no warranty that it fulfills particular purposes or needs.

Hence, there is a need to develop technical risk mitigation framework for railway construction projects in Malaysia. Currently, there is also no local study found on the technical risk mitigation process for railway construction projects in Malaysia.

Therefore, to fill the gap identified from previous literatures, the impacts of cost overrun in the railway construction project in Malaysia, the technical risks throughout the phases of railway construction project, the technical risks that contribute to the cost overrun in the railway construction project, and the effective technical risk mitigation for a railway construction project in Malaysia are substantial to be investigated. These components are important to be analysed towards developing a technical risk mitigation framework. As a result, local professionals who involve in the railway construction projects in Malaysia can effectively mitigate the technical risks and minimise the tendency of cost overrun.

1.3 Research Questions

The research questions are as per followings:

i. What are the impacts of cost overrun in the railway construction project in Malaysia?
ii. What are the technical risks in the railway construction project throughout the project phases?
iii. How can the technical risks contribute to the cost overrun in the railway construction project in Malaysia?
iv. How to develop effective procedures of technical risk mitigation for the railway construction project in Malaysia?

1.4 Aim and Research Objectives

Based from the problems highlighted in the earlier section, this study aims at appraising project risk mitigation practice that impacts to the cost of railway construction project in Malaysia. The following are research objectives:

i. To identify the impacts of cost overrun in the railway construction project in Malaysia.
ii. To investigate the technical risks in the railway construction project throughout the project phases.
iii. To assess technical risks that contribute to cost overrun in the railway construction project in Malaysia.
iv. To develop the technical risk mitigation framework for the railway construction project in Malaysia.

1.5 Scope of Research

In this study, the scope mainly focuses on Klang Valley, which includes Kuala Lumpur as well as cities and towns in the state of Selangor, Malaysia. Pemandu (2010) defined Klang Valley as the region comprises of Kuala Lumpur, Putrajaya, Klang, and all districts in Selangor with the exception of Kuala Langat, Kuala Selangor, Sabak Bernam, and Hulu Selangor. Ram (2017) reported that National Land Public Transport Master Plan (NLPTMP) established in 2013, had set ambitious goals to achieve a modal share target of 40 per cent for land public transport in urban areas by 2030 and Klang Valley with its record in delivering its recent public transport, such as railway projects as a testament to the forward development process.

Mega project of railway infrastructure is the main focus in this study. Flyvbjerg (2017) further defined mega project as a big-scale and complex that typically cost US$1 billion or more. The definition further elaborated as mega project is known as a project that requires many years to build and impact millions of people (Flyvbjerg,

2017). The types of railway system that are closely being investigated in this study are Light Rail Transit (LRT) and Mass Rapid Transit (MRT) because these are among forms of mass transit currently exist in major cities (Fox, 2000). Klang Valley is also chosen because currently area is strenuously developing the railway network.

Only the technical risks are investigated in this study, which are found to be significant factor to influence the project cost and controllable among the project teams. Uchenna (2017) mentioned that technical risks are the risk with highest likelihood in a construction project. The risks that involved are identified from throughout the project phases, which in general are known as inception, planning and design, tendering and procurement, manufacturing and construction, and closeout phases (Sears, Sears and Clough, 2008; Cantarelli et al., 2012; Willar et al., 2019; RIBA, 2020).

This study focuses on the effective strategy in mitigating technical risk that causing cost overrun in railway construction projects. As this study focuses on risk mitigation, by understanding the risk throughout the project phases, effective strategies can be planned as proactive measures when dealing in railway construction project. This study looks into detail relationship of the risks encountered that can contribute to the cost overrun.

The technical risks of the study are observed from the client's perspective. The client is the project owner, who is the party that holds responsibility in making final decision, operates and maintains the system when the project is handed over. The project owner of railway construction project is a crucial party in the national infrastructure development as they have a legal responsibility to public authorities and general public (Chung and Kumaraswamy, 2014). As major shareholders, they are also providing capital expenditure and usually conduct an engagement with the stakeholders, such as investors, consultants, media, and public. Therefore, the risk must be controllable to avoid any unfortunate circumstances that could potentially harm the success of the project.

The data is collected from quantity surveying firms, project management companies, contractors and clients, who are also the operator of the railway as they are accountable for the groundwork related to commercial and contractual matters, such as preparing cost estimate, controlling project cost, managing cash flow, assessing variation orders, and closing of final account. Construction project managers is part of the targeted respondents is because they evaluate and balance the competing demands of cost (Stojcetovic et al., 2014). Meanwhile, reason being quantity surveyor as a targeted respondent is because they are the cost expert (Verster, 2005) and sensitive to the influence of all cost factors.

1.6 Research Methodology

This study adopts a mixed method in gathering and analysing the data. The proposed research methodology comprises of eight phases, which are formulation of research aim and objectives, literature review, design and formation of questionnaire, pilot study, data collection via questionnaire survey and structured interview, data analysis, development of conceptual framework of technical risk mitigation for railway construction project in Malaysia, and validation of framework. Further elaborations on the research methodology can be found in Chapter 3.

1.7 Research Limitation

The distributed questionnaire is confined to investigate the responses of construction players in Klang Valley area and is limited to the scope of technical risk mitigation. This study also limited from risk identification to the response strategies as a mitigation act of railway construction projects. In this study, previous studies from researchers, who investigated risk in railway construction projects are used as a reference in identifying risks factors and further developing the research instruments for data collection purposes.

It is anticipated that the responses may be limited to only from large organisations due to the size of railway projects that often are huge and complex. Large organisations means sales turnover exceeding RM20 million or employees exceeding 75 (SME Corporation Malaysia, 2014). The main targeted groups are those involved in railway construction project only. This study also targeted range group of respondents' position and years of experience to ensure the reliability of the final outcomes.

1.8 Significance of Study

It is important for any research study to achieve its objectives that embedded with a strong purpose especially in dealing with real time issues, so it can avoid from happening sequentially. The idea behind this study is to elevate the standard of project management in regards to the mitigation of technical risk as the stability and good health of a project cost is one of key drivers in ensuring success of the project. This study also intended to broaden the knowledge of technical risk mitigation and to have a deep understanding of managing the risks that involve.

In addition, Grant and Osanloo (2014) explained that framework can aid to provide visual display showing how ideas in study being related to one another. Therefore, it is important to develop framework in mitigating technical risk of railway construction project in Malaysia, which in reality has caused massive losses and negative impact towards the stakeholders. The framework is intended to remedy the problems found in this study. It is hopeful to be beneficial for any future railway project to use this framework as a guideline and reference to make the infrastructure project more cost effective despite the arise of project risks.

Subsequently, through this study, it is hoped that it can assist to mitigate the technical risk of railway construction project, which contributes to the negative cost impact including the fare prices of the railway when it is in operation. The hike of railway fare prices is a global issue and Malaysia is not excluded. Therefore, it is very important in this study to investigate and assess the critical technical risks in railway

construction projects. The establishment of the framework is part of the initiative to smoothen the process of handling the budget of the project which potentially can give a cost saving when it is done.

As it is also aware that every construction project is susceptible to the risks, the results of this study can help the railway construction project members to mitigate the technical risk so it will reduce the likelihood and minimise the cost impact that potentially can harm the progress of the project. Apart from that, this study can also increase the awareness of the project shareholders about the risk that they are exposed to. However, when the risk occurs, the framework from this study can also attenuate the negative cost impact towards the project.

It is very common for the mega project to have a cost overrun of 50 to 100 per cent (Flyvbjerg, 2011). That would cost a huge additional amount of money in the project and it may have severe impacts in the long-term, while the railway projects supposed to benefit to the society. Nonetheless, this seemed to be a big amount for the shareholder and more research and development in mitigating this problem must be engaged. The framework developed from this study able to minimise the tendency of cost overrun in a construction railway project through careful planning and proper execution.

This study hopes to align itself with the 2030 Agenda for Sustainable Development by United Nations (UN) in promoting resilient infrastructure, sustainable and affordable transportation, and sustainable economic growth. This also in support with the Construction 4.0 Strategic Plan (2021-2025) in facilitating the development of socioeconomics of the society through construction industry, and the Twelfth Malaysia Plan (12MP) in promoting sustainability and economic empowerment.

1.9 Structure of Thesis

This study consists of six chapters, which encompass the combination of theoretical and empirical studies of risk management in construction project, particularly factors affecting the cost in railway construction project. Chapter 1 discussed the overview of the study with the brief introduction of current situation of the industry and matters related to the railway construction projects. This chapter also explained the problem statement, research objectives, research question, limitation of the study, and research methodology, which finally led to the achievement of the study aim.

Chapter 2 elaborated in detail matters related to the study, which include the evolution of risk management, overview of risk management concepts, risk management in Malaysia construction industry, importance of railway construction project in society and economic growth, impact of risk on project cost, impacts of cost overrun in railway construction projects, risks involve in railway construction projects, phases of railway construction project, effective risk response strategies in dealing with technical risk of railway construction project, theoretical framework of technical risk mitigation, and conceptual frameworks of technical risk mitigation strategies of railway construction project in Malaysia. By understanding the matters related to the studies and established ideas, this study is able to strengthen the knowledge area, analyse the concerns in the industry, and be confident in creating a new ideology that can enhance the effectiveness and productivity of the key areas.

The contents in Chapter 3 are focused on the research methodology that assisted the process of the research from the beginning towards the end. The types of data used in research are explained, which are mainly on primary and secondary data. The research methodology phases are also described from literature review phase, formation of research questionnaires, collection and analysis of data, and finally, the development and validation of framework. All these phases are discussed in depth to ensure the clarity and validity of the study.

In Chapter 4, the data collected from the targeted respondents are being tabulated, reported, and then analysed. In this chapter, the risks are being investigated and the relationship to the cost are being studied carefully to maintain its relevance and importance towards the research. Apart from that, related feedbacks that are out of the research questions by the respondents are also being considered. In that sense, this study is able to realise and understand further if there is any concern in the research area. Finally, the validation of framework is analysed to ensure its effectiveness.

In the penultimate chapter, Chapter 5, the analysis and discussion are carried out. The data received are screened, tabulated, and prepared to be analysed. The purpose of analysing the data is to determine the most important technical risks that negatively influence on the cost of project and the most effective way to mitigate the setbacks. Apart from that, the analysis able to contain the feedbacks from the respondents, which are expectedly to introduce a groundbreaking information related to the research studies.

At the of final chapter, Chapter 6, the findings are summarised in accordance with the research objectives. The recommendations of the research are concluded based from the findings. This chapter presented the conclusion, recommendation, and limitation of the research based from the discussion in the previous chapters.

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