Review: Risk assessment of infrastructure projects on project cost

K T Liew¹, W W Low¹, K S Wong¹ and S Y Wong¹

¹Department of Civil and Construction Engineering, Curtin Malaysia, CDT 250, 98009 Miri, Sarawak, Malaysia

E-mail: low.wai.wah@curtin.edu.my

Abstract. Infrastructure projects such as highway, railway, airports, power stations and ports play an important role in the development of a country. However, past studies reported that most of the infrastructure projects experienced cost overruns with an average of more than a quarter higher than the original cost. Previous studies concluded that risks occur in the earlier project procurement stages especially tendering stage, is more likely to cause significant impact on the later stage (construction stage). From the literature review, it can be concluded that most of the studies focused on the construction stage in assessing the risk factors on the infrastructure cost. The literature review discovered that most of the research were carried out on bridges, railway and transportation, in developed city such as China, Hong Kong, and Australia, instead of Malaysia. In conclusion, risk assessment in infrastructure projects during pre-construction stage is important as it helps to provide some guidelines to the industry professionals to improve their existing risk management plan as well as their decision making. Thus, an on-going further study is conducted to identify the critical risks in infrastructure project costs during tendering stage.

1. Introduction

Infrastructure projects such as highway, railway, airports, power stations and ports play an important role in the development of a country nowadays. According to the Malaysia Budget 2018 [1], the Malaysian Government has allocated billion of ringgits funds on the infrastructure development in 2018. Among the listed projects, RM32 billion was allocated for Mass Rapid Transit Line 2 (MRT2), RM2 billion for Pan-Borneo Highway (PBH) and RM50 billion for high-speed rail (HSR) that connecting between Malaysia and Singapore [1].

However, a study of 258 infrastructures among several countries discovered that 90% of completed construction projects experienced failure in controlling the project cost averagely the actual cost was 28% higher than the estimated cost [2]. This finding implies that cost overrun is the most common phenomenon in the construction industry worldwide. For instance, the project cost of Kuala Lumpur International Airport 2 (KLLA2) increased from RM1.6 billion to RM4 billion [3, 4]. The project cost of Ipoh-Padang Besar Double Tracking Rail Project in Malaysia had increased from RM 12,900 million to RM 16,510 million, which is approximately 28% higher than original cost planned [4].

Risks that occurs in the earlier project stage such as tendering stage could bring more significant impact on the later construction stage [5]. This situation has raised the clients and other stakeholders’ awareness in conducting risk management especially during tendering stage. Previous study stated that the risks such as incomplete design drawing, specification, lack of communications among parties during the tendering stage would highly lead to an increased on project cost [6]. Therefore, it is...
recommended that risk management must be one of the essential requirements when developing infrastructure projects [7].

Generally, the process of risk management includes three major aspects: i) Risk Identification; ii) Risk Assessment; and iii) Risk Control [7]. The main objective of risk assessment is to minimise the negative risk effect to the project and meanwhile, maximise the positive risk effect to the project. Risk assessment aims to reduce the impact of cost overruns towards the projects. The impact of cost overruns including conflict, litigation and the projects can even be abandoned anytime due to shortage of funds [8]. Conflict and litigation can occur when the projects delay in progress and different parties tend to claim that they are not holding the liabilities. Therefore, the impact of cost overruns could affect the project quality.

2. Research Methodology

As shown in figure 1, the outline of the review analysis consisting of five major steps.

Step 1: Databases selection

According to Cui et al. [9], selection of the most suitable academic databases for relevant articles searching in a field is essential and important for a comprehensive review of previous research in that particular field. There are 14 popular databases subscribed by the university, namely: Business Source Complete, Ebook Central, Emerald, Informit, Medline, ProQuest, PsycInfo, ScienceDirect, SciFinder, Scopus, SpringerLink, Web of Science, Wiley Online Library and Trial databases. Among these databases, ScienceDirect, Scopus and Emerald were chosen to search for the articles related to the risk assessment of infrastructure project cost. These databases were chosen based on their comprehensive coverage in the construction risk assessment and infrastructure industry.

Step 2: Literature selection

With the determination of suitable databases, literature review was conducted by using keywords such as “risk assessment”, “infrastructure projects cost overruns” and “tendering stage”. At the initial stage, the literature was searched with the keyword of “risk assessment” to have an overview on the previous research that studied risk assessment. The literature search was then further limited to “infrastructure projects cost” and “tendering stage”. With these two keywords, it was found that there was very limited number of relevant articles, journals and books. Therefore, those articles, journals and books with the word “infrastructure project cost” in the title, abstract, and keywords are considered as meeting the requirements of this study and were adopted in the review analysis.

Step 3: Literature coding

In this study, literature coding was mainly used to filter articles by looking at the titles, keywords, and abstracts of the articles. Some information of the articles such as article title, country or region where the studies were conducted, and project types are required for further coding analysis. In a result, a total of 15 qualified articles were adopted in this study after filtering the conference articles.

Step 4: Overview of literature on infrastructure projects in risk assessment

Review results of the literature on risk assessment of infrastructure project are divided into five themes: country or region, project type and project life cycle as discussed in the Section 3.

Step 5: Discussion

The discussion was based on three main aspects as stated under step 4 (see figure 1). Research gaps and future research directions were identified accordingly based on the literature review process.
3. Overview of literature on infrastructure projects in risk assessment

3.1. Publications distributed by country or regions
As shown in the table 1, all the reviewed articles were analysed based on geographical location. The selected literatures were originated from 11 different countries, including China, Hong Kong, Australia (Sydney), Malaysia, United Kingdom, Egypt, Jordan, Saudi Arabia (Qatar), Palestine (Gaza Strip), Ghana and Afghanistan. Different significant risk factors were identified between developing countries and developed countries. For developed countries such as Australia and United Kingdom, the most common cost risk factors were government political corruption, political intervention and delay in land acquisition [10-13]. Meanwhile, compared to the developed country, developing countries such as Malaysia, China, and Afghanistan are more likely to have more significant risk factors, other than political interference. These risk factors were identified as market inflation, interest, exchange rate corruption, terrains and weather condition, and lack of communications [5, 7, 8, 11, 14-18].
3.2. Publications distributed by project types
The identified 15 studies focused on different types of infrastructure projects. For example, the researchers adopted Sydney Airport Railway Link, China Fu-De Highway Project and Sydney Cross City Tunnel as case studies to investigate the cost risk factors [13]. A research in Australia was based on the railway projects [10]. Two researches were focused on public road, drainage, building project, seaport, road and sewerage projects [16, 19]. One of the research studied on the general transportation projects in Asia while another study focused on one transportation project (i.e. Edinburgh Tram Network Project) [12, 20].

Also, many researchers focused on general construction projects type in different countries such as Egypt, Malaysia, Afghanistan, Gaza Strip and Ghana [7, 8, 15, 17, 18, 21] as there are only three studies focused on general infrastructure projects in China, Ghana, Hong Kong, and Jordan [5, 11, 14].

3.3. Publications distributed by project life cycle
From these 15 studies, 14 studies focused on construction stage and one study considered tendering stage [5]. This seems to imply that most of the studies focused on construction stage.

4. Research Gaps and Research Directions
As discussed above, most of the studies focused on the construction stage when considering the risk factors of infrastructure cost [10, 12, 19]. Furthermore, the infrastructure projects are limited to specific type of infrastructure project’s work such as bridges, railway, and transportation [10, 12, 13, 16, 19, 20].

In terms of geographical location, the regions considered by past studies are mainly in China, Hong Kong, and Australia [5, 10, 11, 13, 16, 20] with limited research focus in Malaysia [8, 15]. Research gap is identified as there are limited studies focused on the tendering stage when considering the risks of cost overruns in infrastructure projects.

5. Conclusion
There is lack of studies focused on the risk assessment of infrastructure projects cost overruns during the tendering stage based on the results of the review analysis as mentioned in section III. It is suggested for future research to be focused on the risk assessment of infrastructure project cost during other project stages (e.g. operation stage). This is because different stages of project life cycle could have different risks which can cause different level of significant impact on project cost.

Lastly, it is very important to manage risks as they are the key factors that causes cost overrun and affect the successful implementation of infrastructure project. The identified knowledge gap leads us to conduct a study about the risk assessment of infrastructure projects cost on tendering stage. In a future research which is on-going, critical risks that could cause a significant negative impact to the infrastructure project cost during tendering stage will be identified. It is expected that the critical risks will be the useful information to the industry parties involved in the infrastructure projects in managing project risks.
Table 1. List of past studies on risk assessment in construction projects’ cost

| Nos. | References | Type of Projects | Project’s Life Cycle | Geographical Location | Consideration of Project Cost? | Consideration of Tendering Stage? |
|------|------------|------------------|----------------------|-----------------------|-------------------------------|----------------------------------|
| 1.   | Abd El-Karim, Mosa El Nawawy, and Abdel-Alim (2015) | General construction projects | Lifecycle | Egypt | Yes | No |
| 2.   | Zou, Wang, and Fang (2008) | 1) Sydney Cross City Tunnel 2) Sydney Airport Railway Link 3) China Fu-De Highway Project | Lifecycle | Sydney and China | Yes | No |
| 3.   | Osei-Kyei and Chan (2017) | General infrastructure projects | Lifecycle | Ghana and Hong Kong | Yes | No |
| 4.   | Xia et al. (2017) | General infrastructure projects | Lifecycle | China | Yes | Yes |
| 5.   | Senouci, Ismail, and Eldin (2016) | Public road, drainage and building projects. | Construction stage | Qatar | Yes | No |
| 6.   | Love et al. (2017) | Railway projects | Construction stage | Australia | Yes | No |
| 7.   | Al-Hazim, Salem, and Ahmad (2017) | General infrastructure projects | Lifecycle | Jordan | Yes | No |
| 8.   | Toh et al. (2012) | General construction projects | Lifecycle | Malaysia | Yes | No |
| 9.   | Boateng, Chen, and Ogunlana (2015) | Edinburgh Tram Network Project (Transportation) | Construction stage | United Kingdom | Yes | No |
| 10.  | Niazi and Painting (2012) | General construction projects | Lifecycle | Malaysia | Yes | No |
| 11.  | Deng, Song, and Chen (2016) | Electricity, seaport, road and sewerage | Lifecycle | China | Yes | No |
| 12.  | Park and Papadopoulou (2012) | Transportation infrastructure | Lifecycle | Asia | Yes | No |
| 13.  | Famiyeh et al. (2017) | General construction projects | Lifecycle | Gaza strip | Yes | No |
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