BUILDING INFORMATION MODELLING INTEGRATION INTO PUBLIC-PRIVATE PARTNERSHIP (PPP) RISK MANAGEMENT

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DEDICATION

I dedicate this project report to my parents who have been a source of encouragement and inspiration to me throughout my life. Without them, I will not be the person who I am now.

I also dedicate this project report to my wonderful wife, who has always been there for me and has supported me throughout the process.

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ABSTRACT

Public Private Partnership (PPP) method has been applied in numerous countries for procuring infrastructures. It focuses on the cooperative arrangement between two or more public and private sectors which endeavor towards the life cycle of its project. Most of the PPP failures are resulted from the adjoining risks in the projects. Therefore, risk management is critical to ensure the success of projects. This research investigates the risk factors in PPP projects as well as the critical risk factors that influencing the effectiveness and efficiency of PPP implementation. In addition, the relative importance of BIM n-D functions and the relative importance of beneficial factors of integrating BIM for risk management in PPP has been investigated through a comprehensive literature review and a quantitative survey. The purpose of this investigation is to propose a strategic framework for BIM-based risk management in PPP. Data of the survey are collected from 36 PPP participants with extensive BIM experience in Malaysia. Each respondent is requested to assign an agreement of one-to-five rating for each of the critical risk factors of PPP, adoptable BIM n-D functions and the benefits of integrating BIM in PPP risk management identified from the literature review. The results of priority ranking of these factors indicate that only 7 PPP risk factors, 8 BIM n-D functions and 5 benefits of BIM integration in PPP risk management are regarded by the respondents from PPP industry in Malaysia. The application of the proposed BIM-based risk management framework can be used to monitor and control PPP projects' risks and it will also enable PPP participants to consider the corresponding prevention and mitigation strategies.

ABSTRAK

Kaedah Kerjasama Awam Swasta (*Public Private Partnership*) (PPP) telah digunakan di banyak negara untuk mendapatkan infrastruktur yang memberi tumpuan kepada pengaturan kerjasama antara dua atau lebih sektor awam dan swasta yang berusaha ke arah kitaran hayat projeknya. Oleh itu, pengurusan risiko adalah penting untuk memastikan kejayaan projek. Penyelidikan ini menyiasat faktor risiko dalam projek PPP serta faktor risiko kritikal yang mempengaruhi keberkesanan dan kecekapan pelaksanaan PPP. Di samping itu, kepentingan relatif fungsi BIM n-D dan kepentingan relatif faktor-faktor bermanfaat untuk mengintegrasikan BIM untuk pengurusan risiko dalam PPP telah disiasat melalui kajian literatur komprehensif dan kaji selidik kuantitatif. Tujuan penyelidikan ini adalah untuk mencadangkan rangka kerja strategik bagi pengurusan risiko berasaskan BIM dalam PPP. Data kaji selidik dikumpulkan daripada 36 peserta PPP yang mempunyai pengalaman BIM yang luas di Malaysia. Setiap responden diminta memberikan persetujuan penarafan satu hingga lima untuk setiap faktor risiko kritikal dalam PPP, fungsi BIM n-D yang digunapakai dan manfaat mengintegrasikan BIM dalam pengurusan risiko PPP yang dikenal pasti dari kajian literatur. Keputusan penarafan keutamaan faktor-faktor ini menunjukkan bahawa hanya 7 faktor risiko PPP, 8 fungsi BIM n-D dan 5 manfaat integrasi BIM dalam pengurusan risiko PPP dianggap oleh responden dari industri PPP di Malaysia. Penggunaan rangka kerja pengurusan risiko berasaskan BIM yang dicadangkan boleh digunakan untuk memantau dan mengawal risiko projek-projek PPP dan ia juga membolehkan peserta-peserta PPP untuk mempertimbangkan strategi pencegahan dan mitigasi yang berkaitan.

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LIST OF ABBREVIATIONS

2D	-	2nd Dimensional
3D	-	3rd Dimensional
4D	-	4th Dimensional
5D	-	5th Dimensional
6D	-	6th Dimensional
n-D	-	Multi-dimensional
AEC	-	Architecture, Engineering and Construction
AHP	-	Analytical Hierarchy Process
BIM	-	Building Information Modelling
BLT	-	Build- Lease-Transfer
BOO	-	Build-Operate-Own
BOT	-	Build-Operate-Transfer
BOOT	-	Build-Own-Operate-Transfer
BTO	-	Build-Transfer-Operate
CAD	-	Computer Aids Design
CRF	-	Critical Risk Factor
DBFO	-	Design-Build-Finance-Operate
FM	-	Facilities Management
ICT	-	Information and Communication Technologies
IFC	-	Industry Foundation Classes
IT	-	Information Technology
IoT	-	Internet of Things
KMO	-	Kaiser–Meyer–Olkin
LCA	-	Life-cycle Analysis
LoD	-	Level of Details
ISO	-	International Organization for Standardization
MEP	-	Mechanical, Electrical and Plumbing
O&M	-	Operation and Maintenance
PMBOK	-	Project Management Body of Knowledge
PPP	-	Public Private Partnership

PtD	-	Prevention through Design
QTO	-	Quantity Take-off
SD	-	Standard Deviation
SPC/ SPV	-	Special Purpose Company/ Special Purpose Vehicle

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

PPP has emerged as a strategic instrument to improve wide range of public services in quality and effectiveness. PPP can be defined as “cooperation between public and private actors with a durable character in which actors develop mutual products and services and in which risk, costs and benefits are shared” (Klijn and Teisman, 2003). In other words, PPP is a long-term partnership between public and private for procuring a public asset or service with a substantial share of risk or risk transfer to private party. Therefore, it is important to identify the risk factors and understand how to allocate, transfer and manage those risks. The main common risks of many PPP projects are political risk, revenue risk, operation risk, demand risk and debt servicing risk (Singh and Kalidindi, 2006). Risk management is a critical process for both public and private parties to succeed in a PPP project. The strategies adopted by the public and private participants usually depend on the predictability of impact and controllability of the risk outcome (Trangkanont and Charoenngam, 2014).

World Economic Forum (WEF) promotes the application of BIM along the PPP value chain to overcome the challenge of global infrastructure development among the governments. The BIM software tools’ demand has exponentially growth in the large public project due to its infrastructure investment expanding in relatively with population growth, economic growth, urbanization and industrialization. The BIM software tool enables the following potential benefits for the PPP risk management (WEF, 2017):

i. Capture, manipulate, share and manage project preliminary data and feasibility study in an effective manner;

ii. Identify the gaps between project planning and initial preparation e.g. preliminary study stage;
iii. Provide better perspective illustration to marketing and funding resources such as lenders and sponsors; and
iv. Provide detailed information to engage market participants in a more effective way;

BIM is defined as a socio-technical technology tool and process reengineering system that involve in technical 3D modeling and dimensions of social impact (Sackey et al., 2014). The nature of Architect, Engineering and Construction (AEC) is commonly known as fragmented work processes in multi-disciplines and lack of collaboration among participants. BIM has been recently adopted by the AEC industry to enable participants from different disciplines who are working together to perform more efficiently and effectively in design and construction activity (Isikdag and Underwoood, 2010). The performance of risk management in a construction project highly depends on the degree of collaboration in construction tasks. Love et al. (2015) suggested that the use of BIM as a catalyst to ensure the PPP project's performance and risks can be monitored and evaluated throughout its life-cycle. A lot of researches have been conducted for adopting BIM in construction project's risk management (Ding et al., 2016).

Zhang et al. (2015) proposed an BIM-based framework to automatically detect site safety issues and hazards, and apply it for site's accidents prevention. Then, Zhang et al. (2016) continued the further study on the BIM-based and construction knowledge-based risk management system that able to function as follows: (1) identifying the construction processes and its potential risks; (2) analyzing the risk factors; (3) measuring the precautions and mitigations. There are wide range of benefits associated with the use of BIM integration in risk management including more accurate information, reduce conflicts, less abortive works use throughout the building life-cycle, integrated procurement and improve construction cost and time control mechanism.

1.2 Problem Statement

The challenge is the increasingly growth of the construction industry stakeholders to have a successful organizational change for BIM adoption. In Malaysia, BIM implementation is fallen behind the developed country such as US, UK, Japan and Singapore. Malaysia BIM Report that published in 2016 by Construction Industry Development Board (CIDB, 2016) indicated that there are only 45% of the 570 respondents among the construction industry players in Malaysia have knowledge of BIM and only 17% of them have experience using BIM. Despite the consecutively strong encouragement of BIM adoption among government by enforcing BIM guidelines standardization and promoting BIM techniques, it is still relatively slow due to BIM technology requires a shift in not only the technological barriers, but also in the approach of construction project's teamwork and organizational changes (Ahmad et al., 2018).

Lack of awareness of BIM adoption in PPP projects made both public and private actors unable to enjoy full benefits of PPP implementation (WEF, 2017). The risk management in PPP projects can be improved by exploration of the BIM adoption in PPP processes. An effective application framework of BIM functions among the PPP participants from different sectors and disciplines will enable the optimization of the advantages of BIM and initiate the use of BIM in construction industry. Wide range of studies exploited the interoperability of BIM technology to improve information exchange and communication among PPP participants. There is still a shortcoming of the literature regarding identifying the best practices and functional framework to succeed BIM adoption in PPP risk management.

1.3 Research Aim and Objectives

The aim of this research is to explore the extent levels of BIM adoption in PPP industry by proposing a strategy framework of BIM-based risk management for PPP projects. The objectives of this paper are:

i. To identify the critical risk factors in PPP projects from perspective of stakeholder relationship, financial aspect, project governance and management, operation and facility management;
ii. To determine the BIM functions for PPP risk management;
iii. To recognize the benefits of integrating BIM initiatives and practices in PPP risk management;
iv. To develop framework for integrating BIM in PPP risk management.

1.4 Scope of Study

This research focuses on the integration of BIM functions in PPP to achieve successful PPP risk management. Unlike the conventional project delivery process, PPP project participants and stakeholders such as government authority, SPV and consultants work together in extraordinary long term as a team to deliver the project. Hence, collaboration among team members is important to resolve the issues of integrated working arrangement, information exchange mechanism, project processes and relationship management in PPP projects. A functional framework of BIM integration for PPP risk management projects requires a well strategic plan to mitigate risks efficiently. The literature review and quantitative questionnaire survey will be conducted in Malaysia and the data is derived mainly from the Malaysia construction industry. Therefore, the research outcomes are expected to be applicable to Malaysia and as a comparative study for other regions. The targeted sample of this study includes the professionals with PPP experiences and BIM knowledge in the construction industry of Malaysia.

1.5 Significant Studies and Researches

In this project report, it can be explained with the following main significant studies and researches:

i. Various types of PPP risk factors have been reviewed from existing literatures and re-classified the identified PPP risk factors in this research;
ii. The current risk management practices in the PPP projects have been reviewed and examined for identifying the existing problems, needs of improvement;
iii. Types of BIM functions in multi-dimensional BIM environment have identified for the uses of better managing complex risk factors in PPP projects;
iv. This research studied the valuable insights of the benefits of integrating BIM functions in PPP risk management;
v. A framework of BIM-based risk management for PPP practices has been developed for helping key stakeholders from both public sector and private sectors to drive the PPP projects towards better performance.

1.6 Organization of the Project Report

This project report consists of six chapters and the outline of the chapters is presented as follows:

Chapter 1: Introduction – Introduces the problem statement, motivation, goal and knowledge gaps that addressed in this research, and presents the research objectives, methods and scope of this study.

Chapter 2: Literature Review – Presents a comprehensive literature reviews on the existing BIM definitions, concepts and knowledge, BIM tools and technologies, definitions and modes of PPP, PPP risk factors, PPP risk management methods and processes, the current relevant principles and guidelines for BIM-based risk management and the beneficial factors of integrating BIM in PPP risk management. Concludes the research problems and knowledge gaps from the findings of this literature reviews.

Chapter 3: Research Methodology – Discusses and illustrate the methodology of this research by presenting the research methods, research workflows and strategies, research framework to determine the research questions.

Chapter 4: Data Collection and Analysis – Presents the quantitative data collection and analyses the questionnaire survey, which aims to identify the critical risk factors in PPP, BIM n-D functions for PPP risk management and the beneficial factors of integrating BIM in PPP risk management.

Chapter 5: A Strategic Framework for BIM-based Risk Management in PPP – Discusses the conceptual ideas in developing a strategic framework for BIM-based risk management in PPP. Describe the structures and design methods of the strategic framework and presents its applications.

Chapter 6: Conclusions and Recommendation – Concludes the project by providing a summary of the work done in this research that involving the review of the achievements in the research objectives, theoretical and practical contributions, limitations and future research suggestion.

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