CRITICAL SUCCESS FACTORS AND CONTRACTUAL RISKS FOR PRIVATE FINANCE 2 (PF2) PROJECTS IMPLEMENTING BUILDING INFORMATION MODELLING (BIM)

Siti Nora Haryati ABDULLAH HABIB

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TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

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‘*Blessed are those who give without remembering and take without forgetting’*

- *Elizabeth Bibesco-*

DECLARATION

This thesis is submitted under the University of Salford rules and regulations for the award of a PhD degree by research. The researcher declares that no portion of the work referred to in this thesis has been submitted in support of an application for an award of qualification of any degree at any other university or institution of learning under my name or any other individuals.

……………………………………

Siti Nora Haryati Abdullah Habib

DEDICATION

to my dearest parents, Abdullah Habib and Norani who has constantly encouraged and prayed for me from afar …. this is my little gift which can never be compared to your love and sacrifices

to my 'son'shine, Naufal Hakim, and my 'moonlight', Aesyah Humaira who always lightened my days and nights in this journey; and sacrificed their longing for mama in my absence … this is a book of remembrance for you to stay strong and never give up in achieving your dreams

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ABBREVIATIONS

AIM	Asset Information Management
BEP	BIM execution plan
BDS	Building Description System
BIM	Building Information Modelling
CAM	Computer Aided Machining
CAD	Computer Aided Design
CADD	Computer Aided Design and Drafting
CDE	Common data environment
CGU	Central Government Unit
CIC	Construction Industry Council
CSF	Critical success factor
D&B	Design and build
EIR	Employer's information requirements
FM	Facilities Management
GDL	Geometric Description Language
GLIDE	Graphical Language of Interactive Design
GIS	Geographical Information System
IFC	Industry Foundation Classes
IPD	Integrated project delivery
LOD	Level of detail
MAR	Missing at random
MCS	Manufacturing & Consulting Services Inc
MCAR	Missing completely at random
MIDP	Master Information Delivery Plan
NMAR	Not missing at random
OGC	Office of Government Commerce
O&M	Operation and maintenance
PFI	Private Finance Initiative
PFTT	Private Finance Treasury Taskforce
PF2	Private Finance 2
PPP	Public Private Partnership
SPV	Special Purpose Vehicle
TIDP	Task Information Delivery Plan
VfM	Value for money

ABSTRACT

Private Finance 2 (PF2) projects involved multiple stakeholders engaged in various contract structures, and numerous stages from initiation to operation in lengthy contract duration. Such situation cause complexity to PF2 projects, which may expose the projects to risks mainly related to collaborative networking, information integration, and contractual relationships. The emergence of Building Information Modelling (BIM) in the construction industry is an immense achievement that can potentially assist the industry players to mitigate risks in PF2 projects. Notwithstanding such benefits, BIM also exposes its users to contractual risks when the barriers in sharing information are reduced. Therefore, this study investigates the key contractual risks and the strategies to mitigate the risks for PF2 projects implementing BIM. The study also considers the critical success factors (CSFs) for PF2 projects implementing BIM as these are the aspects underlying the mitigating strategies. Subsequently, this study develops a conceptual framework of contractual risks management for PF2 projects implementing BIM.

The study is within the pragmatism philosophy; therefore it employs concurrent embedded mixed method strategy that combines qualitative and quantitative approaches. There are two stages of the study. At the first stage, data were collected through literature review, questionnaire survey and unstructured interviews with the industry experts. The results were then used to develop the preliminary conceptual framework of contractual risks management. In the second stage of the study, semi-structured interviews were carried out with the industry experts to validate the conceptual framework. Content analysis, thematic analysis, and mind mapping methods were used for the analysis of the qualitative data; whereas, descriptive and inferential statistical analyses were used for the analysis of the quantitative data. These have lead to the development of a holistic conceptual framework that illustrates the interconnection of the CSFs, contractual risks and the risks management strategies.

The study suggests fourteen CSFs for PF2 projects implementing BIM. Five CSFs are considered as the most dominant, which are: (1) systematic workflows, coordination and integration; (2) good understanding on BIM; (3) technical competence; (4) robust and clear contractual provisions; and (5) effective collaboration among the project participants. In relation to this, the study also identifies eighteen BIM risk factors that can give significant impact towards PF2 projects, most of which are related to contractual issues and BIM competency. The study reveals twenty-two contractual risks for PF2 projects implementing BIM which are related to (1) information management; (2) data reliance; (3) status of BIM model; (4) intellectual property rights; and (5) liability issues. Twenty-four strategies to manage the contractual risks were identified by the study. Based on the findings, the study implies that the PF2 projects implementing BIM require seamless and collaborative contractual instrument that is able to link all stages in the project delivery, to make the project contractually organised for a lengthy period of time, and to sustain collaborative environment throughout the project duration. The conceptual framework suggested in this study is considered relevant for implementation to meet the needs of PF2 projects implementing BIM as it would help the Clients and PF2 Contractors in the process of negotiating and drafting their contractual provisions. The study is original as it addresses the use of BIM from the contractual perspective, through the lens of PF2 projects.

CHAPTER 1

INTRODUCTION TO THE RESEARCH

1.1 Background to the Research

After more than twenty years of the United Kingdom (UK) experiencing Private Finance Initiative (PFI) in delivering public services projects, and becoming well known as the pioneer in developing the concept of Public Private Partnership (PPP); the government decided to introduce Private Finance 2 (PF2) as an alternative to PFI. Based on the criteria of PF2 spelled out in various government documents (HM Treasury, 2012a, 2012b, 2012c, 2014, 2016), PF2 is a long-term alliance between the government and the private sector with the objectives to deliver public infrastructure and services in which the private sector consortium designs, builds, finances and operates the facilities as well as deliver services to the public users. In contrast with PFI, PF2 was reformed to become less private as compared to PFI and was expected to be comprehensive to address PFI's weaknesses as identified by the Treasury Committee of the House of Commons (House of Common, 2011a, 2011b). Given that PF2 is relatively new to the construction industry, since its introduction in December 2012, only small numbers of projects have been awarded, and still under development or in procurement. These, among others, include the Priority School Building Programme (PSBP) buildings projects, Midland Metropolitan Hospital project and Royal National Orthopaedic Hospital project (Partnership Bulletin, 2017).

On the other hand, the development in information and communication technology has brought innovations to the architecture, engineering and construction (AEC) industry that transformed the way facilities and services are being delivered. Building Information Modelling (BIM) is one of the innovations that improve the industry by providing a digital platform for the AEC players to exchange, share, store, adjust and maintain project information. According to NBS (2016), BIM is a process for creating and managing information on a construction project across the project lifecycle that provides a digital description of every aspect of a facility that is being assembled collaboratively by the project team members. It can also facilitate the exchange and interoperability of the project information in a structured and intelligent way. The basic concept of BIM is to gather the soft data required to design and construct a facility in an electronic data interchange platform and the facility will be firstly constructed virtually before being constructed physically. BIM can also produce all the documentation that the team members would otherwise have to create traditionally in isolation and duplication (Hardin, 2011). Due to the vast benefits of BIM, in the UK, the Government Construction Strategy, which was published in May 2011, emphasised the requirement for all centrally-procured public projects to implement BIM at a minimum of level 2 from April 2016 (Cabinet Office, 2011). This is part of the efforts to challenge the existing industry business models and practices by driving the industry towards greater collaboration, efficiency and innovation.

In relation to PF2 procurement systems, the need to implement BIM enables some features of integrated project delivery (IPD) to be adopted in PF2 projects. The PF2 project teams can work together in an integrated environment where the relationship will become: more open in sharing information; more transparent; and therefore, achieve greater collaboration. By integrating the knowledge of all parties including the SPV, contractors, and consultants; the risks in PF2 projects can be reduced (Mustapa and Carrillo, 2008). Even though PF2 is a holistic model that provides a platform for collaborative and integrative working, these cannot be blindly achieved simply by procuring projects using PF2. Based on the research by Kamara (2012), PPP-type project does not really bridge the gap between the public and private sectors due to the lack of integration. Even though measures have been taken in the recent PF2 model in order to address the integration issue, there is still a strong need for robust information exchange and information management systems in order to support integration. This can potentially be successfully achieved through BIM.

1.2 Statement of Research Problem

Whilst the implementation of BIM in PF2 projects can enhance collaborative networks and data sharing as well as help to mitigate risks, contractual issues surrounding its implementation appear to be a serious challenge. BIM modelling may allow all stakeholders to be actively involved in the phases where they are normally absent. An example is, the appearance and influence of the contractors and facility managers during the design phase. Even though their presence is needed, BIM can create potential contractual risks when the design responsibilities and liabilities are not straightforwardly referred to the designers (Laishram, 2013). Moreover, the ownership of the BIM model may become a serious issue as it has been collaboratively developed by the stakeholders (Hurtado & O'Connor, 2008; Haynes, 2009; Chao-Duivis, 2011). Other than that, the contract also needs to properly define the designated coordinator of information for the various phases and the person liable for the faults occurring within the model. Protocols with respect to: model access; security; transmission; archiving; transmitting minimum standards with respect to software interoperability; model content; level of detail; formatting conventions; coordinating systems; and other such processes, should be developed. Risks arising after the completion of works, for example, the custody and warranty of the model also need to be considered when applying BIM (Hurtado and O'Connor, 2008). Chao-Duivis (2011) states that new contractual documents covering the relationships between the parties working in the BIM team also need to be developed.

Therefore, even though BIM has the potential to add value to PF2, it also exposes stakeholders to contractual risks that might affect the parties' businesses and working relationships. Most studies on the implementation of BIM in the construction industry have focused on construction projects procured through non-PPP procurement system (Zahrizan et al., 2008; Aranda-Mena et al., 2009; Jung and Joo, 2011; McAuley et al., 2012; Bryde et al., 2013). Studies conducted on PPP that investigate the impact of BIM implementation on PPP are very scarce (Ganah and John, 2013; Laishram, 2013). Furthermore, in the UK context, there is no contractual document, standards and guidelines that are specifically designed to support BIM implementation in PPP-type projects. Even though the benefits offered by BIM are very much highlighted by scholars (Azhar et al., 2008; Gu and London, 2010; Ganah and John, 2013) there is currently no known empirical study that critically investigates the contractual risks of BIM in the context of PPP procurement system. Considering such gaps in the literature and the need to study the connections between PPP and BIM, the present study seeks to examine the contractual risks associated with BIM implementation in PPP projects by focusing on

PF2 projects. With the new PF2 appearing in the picture of PPP implementation in the UK, the public authority has two simultaneous functions: as the facility's procurer and co-minority investor in SPV. Therefore, the relationship and information management issues amongst the stakeholders will become more challenging. Hence, the study aims to investigate the critical success factors and contractual risk in PF2 projects implementing BIM and subsequently to come up with a proposed conceptual framework for the strategic management of PF2 projects implementing BIM.

1.3 The Need for the Research

PPP and BIM are well-promoted worldwide and both are interrelated, however studies that integrate these two are very limited (Kamara, 2012; Ganah and John, 2013; Laishram, 2013). Most studies found focus on PPP and BIM separately. For example, Hardcastle et al. (2006), Chan et al. (2010), Babatunde et al. (2012), Cheung et al. (2012), and many more discuss the critical success factors of PPP. Works of Nitithamyong and Skibniewski (2003), Won and Lee (2010), and Won, Lee, Dossick, and Messner (2013) have discussed success factors for BIM and web-based management systems in construction. Studies on risks associated with PPP and BIM are also mostly addressed separately, for example in Akintoye, Taylor, & Fitzgerald (1998), Azhar et al. (2008), Jin and Doloi (2008), and Haynes (2009).

There are also a lot of studies that have been conducted on contractual risks in BIM projects such as Foster (2008), Hurtado and O'Connor (2008), Glover (2012), Golden (2015), and Winfield (2015a). However, there is no known study that empirically investigates contractual risks of BIM in the context of PPP projects. Although their studies might also be applicable in the PPP projects, there are certain contractual risks which are unique to PF2 projects implementing BIM that need to be addressed such as: the relevancy of provisions in the current BIM Protocol in the context of PF2; the duties, powers and contractual relationship between Information Manager and PF2 stakeholders; and the contractual implication if BIM is employed up until the operation stage of the PF2 facility. Current published contractual documents, guidelines and standards on BIM have also being developed without specifically matching the unique characteristics of

PPP-type procurement system. Therefore, in parallel with the UK government's effort in promoting and encouraging the use of BIM in the construction industry, the present study is considered significant to fill such gaps.

1.4 Research Questions

Based on the problem established for this research, it forwards a general question of "How to manage contractual risks in PF2 projects implementing BIM?". This question subsumes several underlying questions, which are:

1. What are the critical success factors for PF2 projects implementing BIM?
2. What are the BIM risk factors that can give significant impact to PF2 projects?
3. What are the contractual risks in PF2 projects implementing BIM?
4. What are the strategies to manage contractual risks in the PF2 projects implementing BIM?

1.5 Aim and Objectives

The aim of the research is to develop a conceptual framework of the critical success factors and contractual risk for the strategic management of PF2 projects implementing BIM. The objectives of the study are:

1. To establish the critical success factors for PF2 projects implementing BIM;
2. To investigate the potential of BIM applications in a project life-cycle and the BIM risk factors that have significant impact to PF2 projects;

3. To examine the contractual risks and the management strategies associated with PF2 projects implementing BIM;

4. To conceptualise and validate a framework that interlink the critical success factors, contractual risks and the management strategies of PF2 projects implementing BIM.

1.6 Outline Methodology of the Research

This research is based on the pragmatism philosophical stance with concurrent embedded mixed-methods as the research strategy. The present study adopts survey as the research technique with questionnaire and interviews as the tools in data collection. The research design consists of a two-stage research process. Research Stage One involves the review of the literature, questionnaire and informal interviews with experts in order to establish preliminary conceptual framework for critical success factors and contractual risks for PF2 projects implementing BIM. Research Stage Two involves semi-structured interviews with experts to validate the conceptual framework. Descriptive and inferential statistical analyses were used to analyse the quantitative data, whereas content analysis, thematic analysis, and mind mapping were used to analyse the qualitative data obtained for the study. The study triangulated the results of findings from quantitative and qualitative approaches in order to increase the validity of the findings. Table 1.1 shows the link between the research objectives, methodology, data collection and data analysis of the study.

<table>
<tr><th></th><th>Research objectives</th><th>Data collection</th><th>Data Analysis</th><th>Methodology</th></tr>
<tr><td>1.</td><td>To establish the critical success factors for PF2 projects implementing BIM</td><td>• Literature review
• Questionnaire
• Semi-structured interviews</td><td>• Content analysis
• Mean ranking
• Kruskal-Wallis H test
• Man Whitney U test</td><td rowspan="2">• Literature review was conducted to determine the possible CSFs, BIM potentials to PF2 and BIM risk factors. The information were used to synthesise PF2 and BIM in terms of how BIM can help in mitigating risks in PF2 and at the same time causing additional risks to PF2 projects.
• The information gained from the literature review were used as basis to conduct questionnaire survey in order to establish CSFs and to identify significant BIM risks to PF2 projects.
• Semi-structured interviews were used to validate the findings.</td></tr>
<tr><td>2.</td><td>To investigate the potential of BIM applications in a project life-cycle and the BIM risk factors that can give significant impact to PF2 projects</td><td>• Literature review
• Questionnaire
• Semi-structured interviews</td><td>• Content analysis
• Mean ranking
• Kruskal-Wallis H test
• Man Whitney U test</td></tr>
<tr><td>3.</td><td>To examine the contractual risks and the management strategies associated with PF2 projects implementing BIM</td><td>• Literature review
• Informal interviews
• Semi-structured interviews</td><td>• Content analysis
• Thematic analysis
• Mind mapping</td><td>• Literature review was conducted to identify the possible contractual risks associated with PF2 projects implementing BIM.
• The information from literature review were become the basis and extended to informal interviews with the experts in order to scrutinise the relevant contractual issues that need to be addressed in PF2 projects implementing BIM.
• Semi-structured interviews were used to validate the findings.</td></tr>
<tr><td>4.</td><td>To conceptualise and validate a framework that interlink the critical success factors, contractual risks and the management strategies of PF2 projects implementing BIM</td><td>• Semi-structured interviews</td><td>• Content analysis
• Thematic analysis
• Mind mapping</td><td>• The findings from objectives 1-3 were being combined and triangulated to develop the conceptual framework.
• Semi-structured interviews were used to validate all the findings and finalise the conceptual framework.</td></tr>
</table>

Table 1.1: The link between the research objectives, methodology, data collection and data analysis of the study

1.7 Unit of study

Unit of study refers to the object of study that is being analysed in a study. It may be individuals, small groups of people, organizations, process, projects, communities or industries; depending on the research focus (Hopkins, 1982; Remenyi, 1998; Baxter and Jack, 2008). The decision of the unit of study also depends on the research questions of the study (Remenyi, 1998). It is fundamentally important to identify the unit of study as it is the primary focus of the research variables, phenomena and the research problem; and it is related to which data are to be collected and analysed (Collis and Hussey, 2003). It is also to avoid ecological fallacy and exceptional fallacy from occurring due to the misunderstanding on how a conclusion is derived for the study (Trochim, 2006).

The present study is to propose a conceptual framework of the critical success factors and contractual risk for the strategic management of PF2 projects implementing BIM. Therefore, the unit of study is the PF2 projects implementing BIM. The sub-units consist of Critical Success Factors (CSFs), Contractual Risks and Management Strategies. This is because; the study seeks to investigate the critical success factors, the contractual risks and management strategies with the ultimate goal of improving PF2 projects implementing BIM in terms of the management of contractual risks. All conclusions and recommendations derived from the study are based on the opinions and perceptions of people who are experienced and knowledgeable in PPP-type of projects and BIM projects.

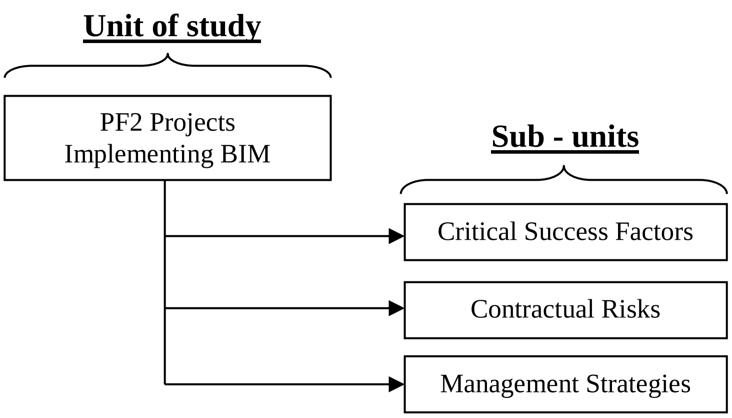


Figure 1.1: Unit and sub-units of the study

1.8 Exclusions of the Research

The study is based on the implementation of BIM and PF2 within the UK, focusing only on contractual risks. Other technical issues, for example, the interoperability of the BIM software application with other applications, the computable design data, and model building will not be part of the consideration in this research. Furthermore, the study only focuses on the contractual issues related to main project agreement and contractual relationship among the project team members in the SPV from initiation to operational stage within PF2. Other contractual structures within PF2 such as contracts with financiers and stakeholders are not the main focus of the study. This is due to the fact that the present study investigates BIM implementation in PF2 projects, in which, the application of BIM gives more impact towards the relationships of the clients, designers, builders and facilities managers.

1.9 Thesis Structure

This thesis consists of eight chapters. Figure 1.2 illustrates the interdependency of the chapters to depict the overall picture of the research conducted. A brief explanation of the chapters is as follows:

- Chapter Two discusses an overview of Public Private Partnership (PPP) and various modes of procurement systems under the umbrella of PPP schemes. This chapter also elaborates Private Finance 2 (PF2) in detail concerning aspects such as the differences between Private Finance Initiative (PFI) and PF2; the contractual structure, and the risks of PF2. This chapter also lists out the critical success factors of PF2 extracted from the review of published literature on critical success factors for PPP/PFI;
- Chapter Three discusses Building Information Modelling (BIM) in terms of its definition, applications, benefits, critical success factors and risks. It also provides an insight on the implementation of BIM in the United Kingdom to date;
- Chapter Four discusses contractual risks in PF2 projects implementing BIM by highlighting the contractual risks in PF2 projects, the potential of BIM to mitigate

such contractual risks and the contractual risks of BIM that might affect the PF2 projects;

- Chapter Five describes in detail the methodology designed for the research. It includes a detailed explanation of the research methodological framework for the study;
- Chapter Six discusses the data analyses as well as the research findings;
- Chapter Seven discusses the research findings in relation to the research questions of the present study;
- The final chapter which is Chapter Eight concludes this research from a holistic perspective including recommendations for further research.

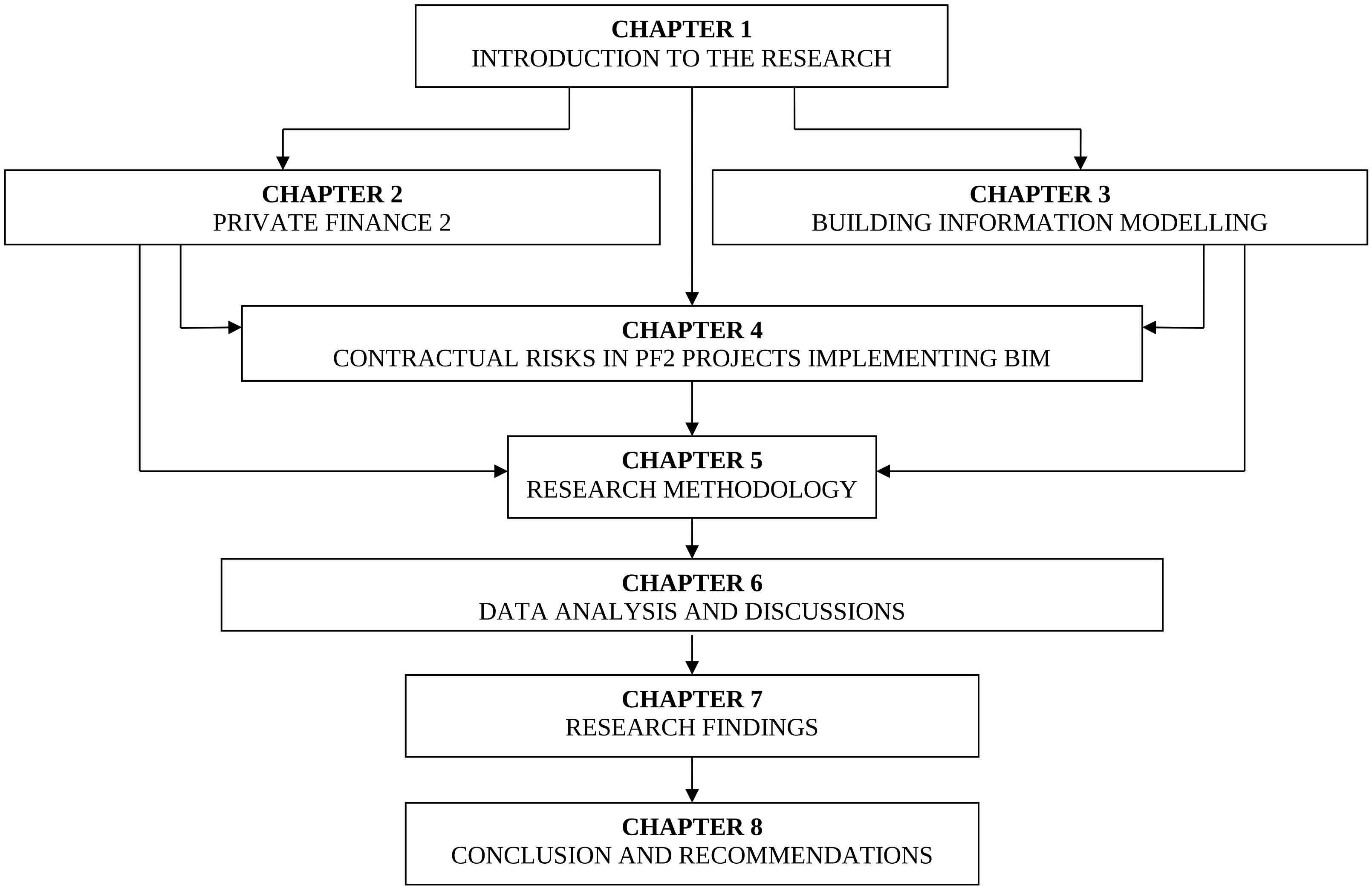


Figure 1.2: Interdependencies of the chapters

CHAPTER 2

PRIVATE FINANCE 2

2.1 Introduction

As mentioned in the previous chapter, two main areas are combined in this study, which are Private Finance 2 (PF2) and Building Information Modelling (BIM). This chapter focuses on PF2 and its context in Public Private Partnership (PPP) arrangement. The chapter is structured as follows:

- Firstly, it provides an overview of Public Private Partnership (PPP) which involves characteristics, and various modes of procurement system under the umbrella of PPP schemes;
- Secondly, it introduces PF2 and discusses the reasons for its emergence and its characteristics as compared to PFI procurement systems;
- Finally, it presents the possible critical success factors and risk factors for PF2 projects.

It is worth to note that due to the scarcity of literature concerning PF2, some of the theories developed for this study are based on or modified from PFI literatures. Justifications are given accordingly in these discussions.

2.2 Overview of Public Private Partnership

The concept of public private partnership has received worldwide attention and has been applied broadly in the development of public infrastructure and services. Despite the widespread trend and notwithstanding the literal meaning presented above, deducing a common technical definition of PPP that is globally accepted to represent the practice is said to be problematic due to the overwhelming types and practices of PPP (Li & Akintoye, 2003; Harris, 2004; Khanom, 2010; Colverson & Perera, 2012). There are various definitions of ‘public private partnership’ as defined by scholars (for example, see Maskin and Tirole (2008, p. 413), Ng, Xie, and Kumaraswamy (2010, p. 352), Chowdhury, Chen, and Tiong (2011, p. 248), Babatunde et al. (2012, p. 214), Akintoye (2009, p. 124), and Hardcastle and Boothroyd (2008, p. 31)). Forming a common definition of PPP is difficult as its practice is in response to the context of where, why and when it is applied. The practice of PPP has to respond to the institutional, legal, investment and public procurement settings of different jurisdictions (Colverson & Perera, 2012); and to the needs of its use. Furthermore, due to the trend of construction industries around the world, some portions of the practices in a country are modelled after the practices of a pioneer country or other precedent countries. This also affects the way PPP is defined. Extensive reviews by Hodge and Greve (2007) and Khanom (2010) on the definitions of PPP by scholars, generates a conclusion that PPP is defined based on its uses in practice. There are four divisions of PPP, which are:

a) a tool of governance and management – PPP is an inter-organisational arrangement where risks, costs, resources and profits are shared; and its aim is to produce better products or services;
b) a tool of financial arrangement – it either uses private finance to reduce the governments’ financial burden and to provide value for money; or both public and private sectors sharing the financial investment in a PPP project;
c) a development strategy – when partners are working towards achieving an agreed objective, the sharing of expertise, knowledge, experiences and other resources will be based on specific commitments undertaken by each party according to their strengths. Therefore, existing capacities of the partners are empowered and their weaknesses are overcome by their respective strengths;
d) a language game – being used sometimes to hide other strategies and purposes such as ‘privatisation’ and the encouragement of private providers to supply public services at the expense of public organisations.

In the United Kingdom (UK), HM Treasury (1998, p.3) has defined PPP as:

> An arrangement between two or more entities that enable them to do public service work cooperatively towards shared or compatible objectives and in which there is some degree of shared authority and responsibility, joint investment of resources, shared risk taking and mutual benefit.

This definition emphasised the allocation of shared authority and responsibility, and indicated that PPP is a ‘win-win strategy’ arrangement where parties have equal interest to one another and share almost equal power depending on their contract terms on the allocation of risks. The characteristics of PPP include: ‘bundling’ contract, which is the combination of the design, construction, finance, operation and maintenance of the facility contracted out to a private consortium therefore it involves complex contractual responsibilities, long term contract, and promotes innovation (Hart, 2003; Iossa & Martimort, 2009; Cheung, Chan & Kajewski, 2010; Colverson & Perera, 2012; De Bettignies & Ross, 2009; Athias & Saussier, 2010; Colverson & Perera, 2012; Eaton & Akbiyikli, 2009; Cheung et al., 2010).

PPP is divided into several forms, which depend on the degree of private participation in the projects. Amongst the various modes of PPP for infrastructure procurement, the Private Finance Initiative (PFI) is the most commonly used PPP variant in the United Kingdom (Li, Akintoye, Edwards & Hardcastle., 2005a). The PF2, on the other hand, is the new reformed version of PFI. This study categorises PPP modes into three broad categories, namely:

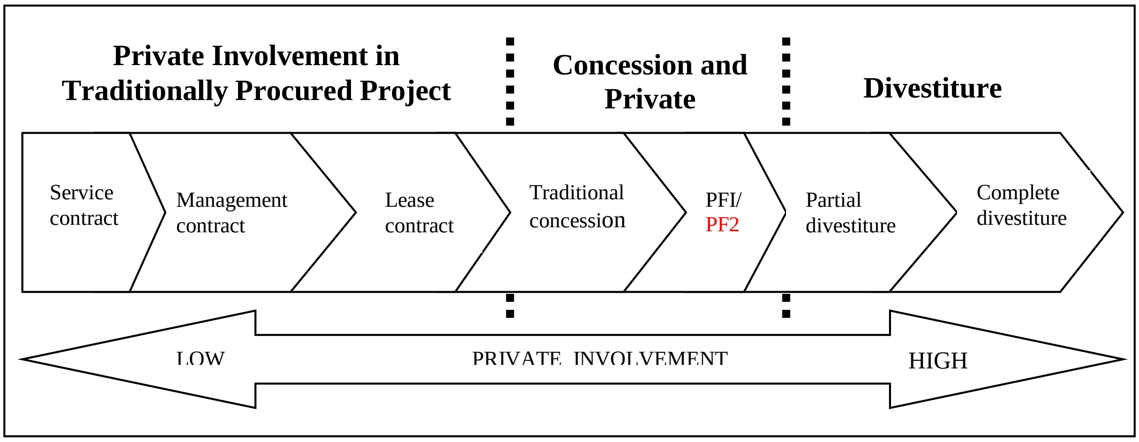
a) private involvement in traditionally procured project:
    - the private sectors participation is extended by acting as the supporting entity in the management, operation and maintenance of the public assets. In this kind of arrangement, the risk shouldered by the private sector is relatively minimal or moderate depending on the degree of their participation according to the type of contract.

b) concessions and private investment:
    - the private sector acts as the concessionaire who is responsible for constructing, financing, operating and maintaining a facility over an agreed considerable period of time, more than enough for them to collect revenues to recover their capital and gain profits, and after the concession period ends the facilities will be transferred over to the government

c) private divestiture:

- the government no longer has a direct role in determining the output specification and allows the privatised entity to pursue maximum profits

Figure 2.1 illustrates the private involvement spectrum in the PPP and Table 2.1 shows the differences of the key characteristics of the modes of projects and services delivery throughout the private involvement spectrum.



Sources: Adapted from the Asian Development Bank (2008) and Alfen et al. (2009)

Figure 2.1: Private involvement spectrum in Public Private Partnership

Although this study focuses on PF2 projects, the understanding on the concept of PPP and its variants is vital for this research due to the fact that PF2 is very new in the construction industry and there are limited studies on PF2. Therefore, in developing certain theories in the thesis, such as the identification of critical success factors, risks factors, and contractual risks for PF2 projects, the existing theories in PPP and PFI are employed and modified. Thus, the position of PF2 within PPP needs to be understood before establishing the said theories.

Key features	Private Involvement in Traditionally Procured Projects			Concession and Private Investment		Private Divestiture	
	Service Contracts	**Management Contracts**	**Lease contracts**	**Concession**	**PFI / PF2**	**Partial Private Divestiture**	**Complete Private Divestiture**
Scope	The public authority hires a private company to carry out support services task e.g. meter reading, billing, etc	The public authority hires a private company to manage and operate some or all public services e.g. utility, hospital, etc.	The private firms pay fixed lease payment to the public authority and obligation to operate, maintain, and providing quality services.	The private firm develops, operate and maintain the facility according to the performance standard set by the government.	The private firm develops, operate and maintain the facility and sell the service to the public sector.	The infrastructure is co-owned and operated by the public sector and private sector	Entire asset sold to the private sector. Public sector maintains its regulatory role.
Asset Ownership	Public	Public	Public	Private firm owns the asset and handover to the public authority after the contract ends.	Private firm owns the asset and handover to the public authority after the contract ends.	Public and Private	Private
Duration	Less than 1 year to 5 years	Approximately 2 to 5 years	Approximately 10 to 15 years	Up to 25 years or more	Up to 25 years or more	Not applicable	Not applicable
Operation and Maintenance Responsibility	Public	Private	Private	Private	Private	Private	Private
Capital Investment	Public	Public	Public	Private	Fully by private in PFI, but both public and private in PF2	Public and Private	Private
Commercial risk	Public	Public	Private	Private	Private	Public and Private	Private
Level of risk by private sector	Minimal	Minimal or moderate	Moderate	High	High	High	High
Payment terms	Predetermined fee based on lump sum fee or unit cost or etc	Fixed fee, preferably with performance incentives	Portion of tariffs revenues given to the public authority	The private firm gains income from the users charges	Unitary charges, preferably with performance incentives	Private and public sectors share profits gained from consumers	Private gain revenue from consumers

Source: Adapted and modified from Asian Development Bank (2008), European Commision (2003), Canadian Council for Public-Private Partnership (2011) and Hall et al. (2003)

Table 2.1: The key characteristics of the modes of projects and services delivery throughout the private involvement spectrum

2.3 PPP Development in the United Kingdom

The history of PPP in the United Kingdom started with the emergence of privatisation through the denationalisation of key industries such as telecommunication, gas and electricity after the Thatcher government came to power in 1979 (Gamble, 1988; Eaton & Akbiyikli, 2005). Privatisation has never been mentioned in Thatcher's 1979 manifesto; however, it resulted from the series of ad-hoc decisions based on the aim of the Thatcher government to reduce government interventions in the economy.. For example, British Telecom was privatised in 1984 due to the problem of financing the British Telecom faced by the government (Gamble, 1988; Osborne, 2013). Prior to 1977 before the Conservative party won the election, all capital expenditures of nationalised industries were measured against Public Sector Borrowing Requirement (PSBR)[1]. After 1977, PSBR was switched to External Financing Limits (EFL)[2]. The UK faced economic recession in the early 1980s which generated the public concern whether the restrictive EFL contributed to the prolongation of the economic downturn by limiting the government's investment into those which could be profitable areas that could have positive effect upon improving the economy. Resulting from these concerns, the National Economic Development Committee (NEDC) proposed the "Ryrie Rules" (Smith, 1999).

The Ryrie Rules was named after Sir William Ryrie, the Second Permanent Secretary to the Treasury, who established the said rules with the intention to define the conditions in which the private money could be used to finance the nationalised industries. These conditions are (House of Commons, 2011b):

- there should be a fair competition with private sector borrowers and no favourable risk terms such as a government guarantee;
- the projects should yield benefits in terms of improved efficiency and profit from the additional investment commensurate with the cost of raising risk capital from financial markets.

[1] PSBR was the amount of the government's budget deficit in a particular year that the government needs to borrow in order to recover the overspending money against the government's income or the government's spending plans.
[2] EFL was the limit of the amount that the industries could borrow from the government in a fiscal year.

- the use of private finance could not be additional to public finance; it has to substitute the public finance pound to pound – reducing the public expenditure due to the use of private finance

In February 1988, Ryrie Rules were revised to consider previously privatised industries and other schemes such as contracting out, opting out, mixed funding and partnership. Two fundamental guidelines were then established, as listed below (Allen, 2003):

- private finance could only be introduced where it offered cost effectiveness; and
- privately financed projects for public sector programmes have to be taken into account by the Government in its public expenditure planning.

The restriction set up in the Ryrie Rules limited the use of private funding in public sector development, hence very few attempts successfully passed through the said rules. Among them included the Channel Tunnel in 1985, Queen Elizabeth II Bridge or Dartford Crossing in 1987, and the Second Severn Crossing in 1990 (Pretorius, Chung-Hsu, Mclnnes, Lejot & Arner, 2008; Parker, 2012). The successfully approved projects were mostly concentrated on the transportation sector as there was a growing concern on the increasing traffic congestion in the UK. In 1988, the Secretary of State of Transport, Paul Channon, forwarded a proposal to extend to the private financing in road construction which included a suggestion to introduce tolls for all newly publicly financed roads, privately financed roads and congested roads with view to ease the government's financial burden. The proposal, however, raised a great concern in terms of public acceptability and enforcement (Parker, 2012). Due to the awareness that the restrictions in the Ryrie Rules were no longer relevant on the ground that urgent investment in public services was necessary, even though not from the public purse, John Major as the Chief Secretary to the Treasury, retired the Ryrie Rules in 1989. This move is to encourage more private investment in public projects (Pollitt, 2002; Eaton & Akbiyikli, 2005).

2.3.1 The emergence of Private Finance Initiative (PFI)

Following the cessation of the Ryrie Rules, the then Chancellor of the Exchequer, Norman Lamont announced the launch of Private Finance Initiative in his 1992 Autumn Statement (Allen, 2003; Pretorius et al., 2008). With PFI, the government's attitude towards private finance changed. Unlike the Ryrie Rules, private finance under PFI could be an addition to public sources; and private projects would no longer be needed to be compared to with publicly financed alternative. Any project that could be profitable was allowed to proceed (Pretorius et al., 2008; Musson, 2009). The aim of PFI was to attain closer partnership relationship between the public and the private sectors; to increase capital and management skills in public projects by utilising private sector resources; and to offer real benefits to private sector in increasing their business profit (Eaton & Akbiyikli, 2005). Amongst the first priority projects under PFI at that time include the Heathrow Express and Channel Tunnel Rail Link (Musson, 2009).

PFI experienced a slow start due to several problems in the beginning. The private sector found PFI less attractive as they need to pay high entry cost in order to invest in PFI projects; facing lengthy tendering process and complicated bureaucracy. The government also faced increased workload due to the lengthy tendering process and highly centralised regulatory mechanisms associated with PFI (Musson, 2009). Strategic changes were designed in view to improve PFI including the creation of a Private Finance Panel Executive that aimed to promote PFI to business; a Private Finance Office within HM Treasury; and Private Finance Units within individual government departments (Pollitt, 2002). Further policies were also introduced as efforts to stimulate PFI. For example, in 1993, PFI became the priority in procuring NHS projects and capital funding would not be given until the universal testing of the viability of private finance. A year later, the government put a greater emphasis on PFI for NHS project when no public finance would be approved unless PFI option testing did not approve value for money (Pollitt, 2002; Robinson, Carrillo, Anumba & Patel, 2009). Even with the greater streamlining strategies done to improve PFI, at the end of the 1996-1997 financial year, PFI projects implementation remained at a low level, with contracts worth a total of £1,096m signed across the UK in comparison to public sector gross investment which was £18,770m (Musson, 2009).

After the election in 1997, the new Labour government emphasised its strong commitment to PFI and conducted a series of reviews in order to assist the implementation and improvement of PFI. The new Paymaster General, Geoffrey Robinson, announced the appointment of Sir Malcolm Bates to conduct a speedy review of the PFI and the cessation of the universal testing of private finance potential which was considered as the reason for delay and against the priority concern of the government. The Bates Review listed out 29 recommendations to improve PFI and one of the most significant recommendations was to abolish Private Finance Panel, replace it with Private Finance Treasury Taskforce (PFTT), formed within the HM Treasury for the purpose to directly control and manage the procurement of PFI projects (Broadbent, Gill & Laughlin, 2004). PFTT was then established in September 1997, functioning as the focal point management of PFI activities across the country, supporting the 4Ps (Public Private Partnership Programme), which was established at the local authority level (Eaton & Akbiyikli, 2005). PFTT published a variety of guidance documents for PFI to spread the knowledge, assist and educate the practitioners on the undertaking of PFI projects (Broadbent et al., 2004), which eventually led to the development of a standard template for PFI transactions (Robinson et al., 2009).

Later, other reviews were also conducted and published, among which were the Second Bates Report 1999 and Gershon Report 1999. In his second report, Bates highlighted the weaknesses of the current practice in PFI and recommended Partnership UK to be formed in replacement of PFTT. The Partnership UK was then launched in June 2000, actings as a PPP developer partnering with a minority government stake, offering high-quality expertise and financial backing to the public sector. Peter Gershon (the CEO of BAE System who was invited to review government procurement policy), underlined the inefficiency related to the administration and management of government procurement. Following the Gershon Report, several agencies that were previously involved in government procurements were merged to form a new department in the Treasury, named the Office of Government Commerce (OGC) in year 2000. OGC is responsible for all contract strategies and policies regarding PFI (Pollitt, 2002; Eaton & Akbiyikli, 2005; Chinyio & Gameson, 2009). Subsequent to these efforts, PFI projects gradually increased with 450 projects worth a capital value of over £20 billion signed by September 2001 and more than 780 projects worth £53 billion capital value were recorded by the end of 2005 (Toms, Asenova & Beck, 2009). Afterwards, PFI went through moderate changes and adjustments, and remained as the most common PPP in construction procurement in the UK with the latest record of 728 projects worth £56.6 billion capital value as of March 2014 (HM Treasury, 2014).

2.3.2 The emergence of Private Finance 2

PFI has been practiced in the United Kingdom for more than twenty years. Since its birth, PFI has been echoed by the government and many commentators as offering greater benefits than other conventional procurement methods and has become the most significant PPP being practiced in the United Kingdom. The popularity of PFI creates a new wave in the construction industry in the global context when the idea of having PFI as an alternative to existing procurement methods has become widespread in other countries such as Australia, Canada, Netherland, New Zealand, Japan, China and Malaysia. These countries are emulating the UK practice, renovating it to suit their own locality factors and needs. The advanced setting of model and policies of PFI in the United Kingdom has geared up the reputation of the country in the world as the pioneer and the most matured country in PPP implementation (Eggers & Dovey, 2007).

Despite the fame of PFI, critics and issues surrounding PFI were also being voiced by academics, which quite relatively tarnished the credits of PFI. Concerns were mostly expressed regarding the real fact of value for money which PFI is supposed to offer. The use of PFI inevitably causes the cost of procuring facilities to be higher than traditional means; however, in the long run, PFI is argued as providing VfM as such cost will be offset by the savings through effective allocation of risks and non-spending money in construction, operation and maintenance of the facilities. However, academics found the fact to be contrary. Shaoul (2009) criticises the VfM appraisal methodology and challenges series of NAO's reports on VfM assessment as the NAO has not carried out any assessment before financial close except one for London Underground Project, and numerous assessments after financial close by NAO were considered as not independent as the NAO collected new data. Gaffney and Pollock (1999) also found that PFI has actually raised the costs of infrastructure development in the health sector and failed to offset the higher capital costs of implementing PFI, causing the need for it to be subsidised by other NHS budgets, which in turn raises the issue of the affordability of the government to pay the private sector for PFI.

Moreover, Pollock et al. (2007) criticised the claim made by the HM Treasury (2003) that PFI has reduced the time and cost overruns, as a bias in favour of PFI due to weak evidences used by the Treasury in support of this claim. According to her, the studies referred by the Treasury were flawed in terms of sampling and measurement causing them to provide no meaningful data that are worth referring to. Therefore, it raised a concern of whether PFI is truly efficient. The issue of public accountability and transparency has also been raised, for example by Pollock and Price (2008) and Asenova and Beck (2009). Important information, especially those related to public expenditures; changes in risk allocation and risk premiums in the operational phase; and whether PFI is truly value for money to the taxpayers are being hidden from the public. In addition, Chinyio and Gameson (2009) listed out problems and issues related to PFI, among others, PFI involving high transaction cost; the pre-contract of PFI is very complex and time consuming; and the issue of profiteering by the shareholders of PFI scheme.

Considering that the dissatisfaction surrounding PFI was widely echoed, the Treasury Committee of the House of Commons convened on 18th July 2011 and produced a report on the weaknesses of PFI, which mostly reflected what had been voiced by academics and scholars (House of Commons, 2011b). The key points highlighted were:

- the use of PFI has the effect of increasing the cost of finance for public investments as the financing costs of PFI are typically 3-4% over that of government debt.
- in comparison to government's bond, the interest rate at that time was around 4%, compared to rates of around 8.5% on private borrowing.
- in the case PFI's inefficiency, for the same present value of finance-related payments, the government could have secured 71% more investment by borrowing on its own account.
- VfM assessment criteria were flawed and needed reviewing
- PFI is less suitable for services that need to change significantly following the trend over time in public service delivery, demographics or technology.

In the same year, the Committee of Public Accounts also issued a report that similarly criticised PFI with a strong statement that, *"...at present, PFI deals look better value for the private sector than for the taxpayer"* (House of Commons, 2011a, p. 3).

In response to the report, on 15th November 2011 the Chancellor of the Exchequer, George Osborne, announced the Government's intention to reassess and reform the PFI. A new model of PFI was expected to be less expensive; accessible to a wider range of financing sources; balanced between risk and reward to the private sector; more flexible; and have greater financial transparency at all levels of the project (HM Treasury, 2011; House of Commons, 2012). Resulting from the reassessment of PFI, on 5th December 2012, George Osborne confirmed in his Autumn Statement the reformation of PFI to the new scheme of PF2 with £1.75 billion Priority Schools Building Programme as the first project using PF2 (HM Treasury, 2012a).

2.4 Private Finance 2

In line with the birth of PF2, the government published a new policy document, *A New Approach to Public Private Partnership*, and a guidance document, *Standardisation of PF2 Contracts.* Generally, PF2 retained the fundamental concept of PFI specifically continuing the role of private sector investment while using private resources, innovation and skills in procuring and managing public facilities and services. However, in the new PF2, the original concept of PFI is reformed by making it less private with greater involvement of the public sector in the financing and management structure of PF2. The reformation seeks to address a number of downsides of PFI as identified in HM Treasury (2012a, p. 6):

- the PFI procurement process has often been slow and expensive for both the public and the private sectors;
- PFI contracts have been insufficiently flexible during the operational period;
- there has been insufficient transparency on the future liabilities created by PFI projects to the taxpayer and on the returns made by investors;

- inappropriate risks have been transferred to the private sector resulting in a higher risk premium being charged to the public sector; and
- equity investors in PFI projects are perceived to have made windfall gains, and this has led to concerns about the value for money of projects.

The reformation in PF2 to address the above issues is divided into seven areas as presented in Table 2.2. The most significant reformation in the new PF2 model is the change of the equity finance structure and the role of the public sector. Instead of merely being the facilities and services procurer, the public sector has now also become an equity stakeholder. In a typical PFI project, capital expenditure is structured on the basis of 90% debt against 10% equity. However, a greater proportion of equity in the financing structure of PF2 is reformed by 20-25% equity with 25 - 49% of the total equity quantum to be contributed by the public sector (House of Commons, 2014). To ensure an effective role is played by the public sector as an equity investor and to minimise the potential for conflicts of interest between the public sector acting as both investor and procurer, the equity investment will be managed by Central Government Unit (CGU) which is located within the Treasury, separate from the procuring authority and managed by individuals with the appropriate professional skills. The public sector equity will be invested on the same terms as the private sector (HM Treasury, 2012a).

No	Areas	Issues	Reformation
1	Equity Finance	• Lacking collaboration between the public and private sectors	• Public sector to act as a minority equity co-investor • Funding competition for the equity proportion in order to attract long-term investors
2	Project delivery	• Lengthy process and expensive	• Procurement improved through new centralised procurement units • Standardised and efficient approach to PF2 with standard documentation • 18-month cut-off duration for tendering • Additional Treasury check at pre-procurement stage to ensure the project is really prepared
3	Service provision	• Lack of flexibility, transparency and efficiency	• Soft services (e.g. cleaning and catering) to be removed from the project • Giving more power to procuring authorities to have discretion in determining minor maintenance activities • Additional flexibility to add or remove elective services in operational stage • Introduce gain share mechanism to facilitate the sharing of surplus lifecycle funding • Periodic reviews of service provision
4	Transparency	• Lack of transparency and accountability	• Introduce a control total for all commitments from PFI and PF2 off-balance sheet contracts signed • Require the private sector to provide equity return information for publication • Publish an annual report detailing project and financial information for projects where the government holds equity stake • Introduce a business case approval tracker on the Treasury website • Improve information provisions within the standard contractual guidance
5	Risk allocation	• Inefficient risk transfer causing profiteering by the private sector	• Public sector to retain certain risks including change in law, utilities cost, site contamination and insurance.
6	Debt finance	• Lack of competitive long term debt finance	• The financing structure to be designed to attract investment from institutional investors such as pension funds to participate
7	Value for money	• Value for money is challenged in PFI model	• The government will develop and consult for guidance to replace the existing Value for Money Assessment Guidance.

Source: Adapted from HM Treasury (2012a) and House of Commons (2014)

Table 2.2: Reformation in Private Finance 2

Equity finance is more expensive than the debt finance and the increase of the equity finance has caused PF2 to be more costly than PFI. Nevertheless, with the equity contributed by the public sector, the government is hoping that this effective cost of capital can be reduced. Apart from that, the cost can also be moderated by having funding competitions for the other private equity proportion that would increase the pressure during the bidding phase, which would consequently decrease the expected equity returns by the bidder. Cheaper debt finance from institutional investor would also be obtained due to high proportion of equity that makes the project look less risky and therefore would be more attractive for the investor to participate in (Hellowell, 2013b; House of Commons, 2014).

The higher equity proportion in PF2 gives benefits in terms of strengthening the SPV's cash flow as it will be less affected by the fluctuation caused by interest rate which impacts debt payment. Putting SPV's cash flow in the more comfortable situation would make the SPV more able to respond to the flexi changes in public sector requirements during the execution of the contract (Hellowell, 2013b). The change in the government's role as the minority equity stakeholder will also increase the transparency and accountability in PF2 project. This new arrangement gives the procuring authority a seat in the SPV; to be involved as one of the voices in the decision-making process. This, consequently, will strengthen the partnership between the public and private sector with a more collaborative approach and improved communication; giving procuring authority access to financial information; and as a preventative measure to avoid large windfall gains by the private sector. As an equity investor, the public sector can also share the profits gained from the project commensurate to the proportion of equity contributed, thereby improving the affordability of the project. Parallel with the greater involvement of public sector in PF2, certain risks which are normally transferred to the private sector are retained by the public sector including change in law, utilities cost, site contamination and insurance (HM Treasury, 2012a). This will definitely reduce the cost of PF2 projects as the private sector is no longer needed to price a contingency of the worst scenarios of such risks. Thus, this leads to more value for money if the risks are properly managed by the public sector.

The government has also been seen to seriously address the lengthy process and high cost problems, which occurred in previous private finance projects. In PF2, departmental centralised procurement unit will be established to have a more focused management system that deals specifically with procuring and supervising PF2 projects. The pre-contract process is also being improved which in that it requires the project to undergo additional Treasury checks to obtain approval to confirm that the project is completely prepared before calling for tender takes place. The tendering period is limited to an 18-month timescale, measured from project tender to appointment of a preferred bidder, otherwise funding will not be approved by the Treasury, provided that exemption is granted by the Chief Secretary. To ensure the smooth running of the procurement process, a comprehensive suite of new standard documentation will be launched including new procurement and contract guidance, a standard shareholders' agreement, a standard facilities management service output specification and a pro-forma payment mechanism for accommodation projects. Furthermore, soft services such as cleaning and catering will be removed in order to have a more flexible contract that can accommodate changes and needs throughout the lengthy contract. This kind of services will be procured separately through short-term contracts.

Another significant reform in PF2 is the introduction of control total for all commitments from PFI and PF2 off-balance sheet contracts signed. Control total is a limit set on the proportion of spending on department's expected future annual revenues to pay the unitary fee of privately financed projects (Hellowell, 2013b). The control total is set to be £70 billion over the five years from 2015–16 onwards, allowing about £1 billion of new PF2 projects a year. The control total will include payments for the ongoing maintenance of the assets, the provision of services and repayment of, and interest on, debt used to finance the project. The use of the control total mechanism will encourage prioritisation of investment to be decided and placed under the £70 billion cap, and will be more transparent in controlling future liabilities of the government in privately financed projects (House of Commons, 2014). Table 2.3 is the comparison table of the key characteristics of PFI and PF2 that shows the similarities and differences between the two.

Key features	PFI	PF2
Scope	The private firm develops, operates and maintains the facility and sells the service to the public sector.	The private firm develops, operates and maintains the facility and sells the service to the public sector.
Asset ownership	Private firm owns the asset and hands over to the public authority after the contract ends.	Private firm owns the asset and hands over to the public authority after the contract ends.
Tendering duration	Not specified, but always lengthy	18-month cut-off duration
Contract duration	Up to 25 years or more	Up to 25 years or more
Operation and maintenance responsibility	Private	Private
Service provision	All hard and soft services to be provided by the private sector	Soft services to be removed from the project
Capital structure	90% debt, 10% equity	75-80% debt, 20-25% equity
Capital investment	Private	Private is the major capital provider. Public sector contributes 25-49% of the total equity quantum
Commercial risk	Private	Private
Level of risk by private sector	High	High, but public sector retains certain risks including change in law, utilities cost, site contamination, insurance.
Payment terms	Unitary charges, preferably with performance incentives	Unitary charges, preferably with performance incentives

Sources: HM Treasury (2012a), House of Commons (2014), House of Commons Library (2015).

Table 2.3: Differences and similarities between PFI and PF2

2.4.1 The critical success factors of PF2

The concept of "success factors" was firstly introduced by D. Ronald Daniel (1961), when a discussion was made on the problems in managing information in companies due to inadequate planning in determining the relevancy of data for objectives setting, strategies shaping, decision making and measuring results against planned goals. According to Daniel (1961), as part of the planning process, subsequent to the identification of the company's weaknesses and strengths is discriminating the information to focus on the "success factors" that must be done well for the success of the company. Daniel further asserted that, by generating this kind of information, the company can eventually capitalise on the strengths and correct the weaknesses.

Inspired by Daniel's idea, the term "critical success factors" (CSFs) was introduced by John F. Rockart (1979), narrowing it to limited factors that really matter in order for a business to succeed. Rockart (1979) defined critical success factors as:

> …the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organisation. They are the few key areas where "things must go right" for the business to flourish. If results in these areas are not adequate, the organisation's efforts for the period will be less than desired. As a result, the critical success factors are areas of activity that should receive constant and careful attention from management (Rockart, 1979, p. 85).

Since its introduction, the CSFs concept then has evolved and the implementation is widely spread in many different fields, including in the area of PPP.

Based on the original idea of CSFs as stated above, numerous studies have been conducted in the attempt to apply the concept of CSFs on PPP. The identification of CSFs in PPP is viewed as part of the important steps in the development of a workable and efficient procurement procedures (Zhang, 2005). Studies on CSFs of PPP have emerged since the 1990s. For example, Tiong, Yeo, and McCarthy (1992); Tiong (1996); and Gupta and Narasimham (1998) studied the CSFs to win BOT projects; Keong, Tiong, and Alum (1997) examined the CSF or BOT projects in Malaysia; Salzmann, Mohamed, and Ogunlana (1999) studied CSFs for international BOOT projects; and Morledge and Owen (1998, 1999) examined CSFs for PFI project in the UK. After the year 2000 more research was done on CSFs of PPP due to the wide implementation of PPP across the globe.

Review on published literature on CSFs of PPP reveals that there are two types of literature: (1) studies on general PPP projects, and (2) studies on a specific type of PPP, for example PFI and BOT. However, the difference between these two types of literature is not significant. Even though these studies have developed different lists of CSFs, huge similarities among them can still be found. This is because even though the first type of literature did not specifically mention the type of PPP they are studying, it is understood from the reading that these studies are referring to concession and private investment type of PPP (refer to the discussion on PPP variants in subsection 2.2). Hence, the PPP projects under this category share many similar characteristics such as lengthy contract duration, high involvement of private sector, high risk transferred to private sector and are privately financed, therefore causing them to mostly share the same CSFs. There is no known study that has ever examined CSFs for PF2. Nevertheless, CSFs found in the literature for PPP/PFI projects are considered to be relevant to PF2 as they also rest within the concession and private investment type of PPP.

Table 2.4 provides description for each CSF. It is also worth to note that three CSFs identified from the literature are excluded from the list. These are *"value for money"* (Dulaimi et al., 2010); *"developer's profit sharing accountability"* (Abdul-Aziz & Jahn Kassim, 2011) and *"technology transfer"* (Qiao et al. 2001; Cheung, Chan, Lam, Chan & Ke, 2012). *"Value for money"* has been excluded because it is not considered as a factor for success; however, it is still considered as an element that PPP/PFI/PF2 projects try to achieve as part of the goal of the projects. *"Developer's profit sharing accountability"* is omitted because the explanation given by Abdul-Aziz & Jahn Kassim (2011) is more on the developers commitment and attitude towards giving the best facilities and services to the public users, therefore the real meaning is in question. Another factor, which is *"technology transfer"* has been eliminated from the list because the factor has been considered to be more appropriate for developing countries, and not appropriate for the UK context (Li et al., 2005b).

Table 2.5 shows the summary on analysis of literature concerning CSFs for PPP. For the purpose of the study, only recent literatures (published between year 2000-current) are being reviewed since it is observed that the 1990s studies were also analysed by these recent studies before they developed their own CSFs. Hence, other than avoiding repetition, it is also more practical to refer to the filtered sources which are more recent and tailored to the current practice of PPP. From the literature review, 57 CSFs were identified. Various repetition and overlapping features were found in the original list; therefore, the CSFs were restructured to 26 CSFs which are grouped under 5 principal categories.

Critical success factors	Description	Authors
Favourable legal framework	Acts, regulations or enforced procedures to govern the implementation of PF2. The legal model has to be independent, transparent, stable, fair and efficient accompanied with reasonable amount for the charge imposed on legal structuring and documentation required. To enhance understanding and facilitate the application in PF2 projects, appropriate governing rules and reference manuals need to be established.	Li, Akintoye, Edwards, & Hardcastle (2005b), Wen-xiong, Qi-ming, Xiao-peng, & Jing-hua (2007), Ismail & Ajija (2011), Babatunde, Opawole, & Akinsiku (2012), Cheung, Chan, Lam, Chan, & Ke (2012a), Cheung, Chan, & Kajewski (2012b), Hwang, Zhao, & Gay (2013) Dulaimi, Alhashemi, Ling, & Kumaraswamy (2010), Mladenovic, Vajdic, Wündsch, & Salaj (2013).
Stable and transparent political and social situation	Transparent and positive political attitude towards the implementation of PF2 would support the growth of PF2 as it would develop confidence for the private sector firms to participate. Stable and strong political and social situation would ensure continuity and development of PF2 projects.	Chan, Lam, Chan, Cheung, &Yongjian (2010), Abdul-Aziz & Jahn Kassim (2011), Li et al. (2005b), Wen-xiong et al. (2007), Babatunde et al. (2012), Cheung et al. (2012a), Dulaimi et al. (2010), Mladenovic et al. (2013), Qiao, Wang, Tiong, & Chan (2001).
Government guarantee	Guarantee can be in the form of subsidy guarantee and tax reduction for the private firms that participate in the PF2 projects. Government guarantee can lower the risks taken by the consortium; raise level of confidence of investors and lenders; and also support the cash flow of the consortium.	Li et al. (2005b), Babatunde et al. (2012), Cheung et al. (2012a), Helmy (2011), Hardcastle, Edwards, Akintoye, & Li (2006).
Good governance	The policymakers have dominant influence in determining the development of PF2 as they have the power to control the quality to meet the pre-agreed benchmarks. However good governance would not impose undue restrictions and constraints on the private sector and tolerable with the innovations and new the technology they introduced.	Chan et al. (2010), Ismail & Ajija (2011), Li et al. (2005b), Wen-xiong et al. (2007), Cheung et al. (2012a).
Action against errand developer	Specific rules and method of punishment need to be established in order to take action against errant developers. This is to ensure the developers are putting the utmost endeavour for the success of the project	Abdul-Aziz & Jahn Kassim (2011).
Favourable investment / economic environment	The project value is closely related to Gross Domestic Product (GDP). Therefore, the government can help to create or maintain a stable macroeconomic environment by manipulating sound economic policy and maintaining balanced budget.	Zhang (2005), Chan et al. (2010), Ismail & Ajija (2011), Li et al. (2005b), Cheung et al. (2012b), Wen-xiong et al. (2007), Babatunde et al. (2012), Dulaimi et al. (2010), Helmy (2011), Mladenovic et al. (2013), Hardcastle et al. (2006).

Table 2.4: Brief description of critical success factors for PPP obtained from published literatures

Critical success factors	Description	Authors
Available financial market	The availability of financial market with low financing costs and diversified financial products wound attract the private sector to take part in PPP/PF2 projects. One of the approaches is to get the finance provider to be part of the SPV.	Ismail & Ajija (2011), Li et al. (2005b), Zhang, (2005), Jefferies (2006), Babatunde et al. (2012), Cheung et al. (2012a), Helmy (2011), Mladenovic et al. (2013), Hardcastle et al. (2006), Qiao et al. (2001).
Sound financial package	Sound financial package includes, among others: sound financial analysis; high equity/debt ratio; low financial charges; fixed and low interest rate financing and stable currencies.	Zhang (2005), Wen-xiong et al. (2007), Hardcastle et al. (2006), Kwak, Chih, & Ibbs (2009)
Community outreach	Community outreach is important to ensure the facilities and services provided are consistent with public interest. To understand public needs and project acceptance, the developers need to have social accountability and conduct open communication and consultation with the end users.	Jacobson & Choi (2008), Abdul-Aziz & Jahn Kassim (2011), Pinder, Smith, Pottinger & Dixon (2004), Wen-xiong et al. (2007).
Communication and coordination	Myriad of parties involved with different objectives require all parties to have the willingness to compromise and collaborate. Good communication and sharing of information will contribute to good coordination of works.	Jacobson & Choi (2008), Abdul-Aziz & Jahn Kassim (2011), Li et al. (2005b), Chan et al. (2010), Wen-xiong et al. (2007), Mladenovic et al. (2013).
Shared authority between the public and private sector	Clear demarcated shared authority and responsibilities to maintain the long term alliance for the project to success.	Li et al. (2005b), Hwang, Zhao, & Gay (2013)
Good partnership relationship	PPP/PF2 partners must understand, respect each other's goals and give full commitment to the success of the project.	Jacobson & Choi (2008), Chan et al. (2010), Ismail & Ajija (2011), Li et al. (2005b), Cheung et al. (2012b).
Robust business case	The business case prepared by the awarding authority which details the need and scope of the project	Pinder et al. (2004), Zhang (2005), Jacobson & Choi (2008), Li et al. (2005b), Wen-xiong et al. (2007), Cheung et al. (2012a), Helmy (2011), Mladenovic et al. (2013), Hardcastle et al. (2006), Askar & Gab-Allah (2002), Qiao et al. (2001).
Detail project planning and evaluation	This includes robust planning to execute the project including project objectives, project schedule, budget and effective supervision mechanism and key performance indicator.	Wen-xiong et al. (2007), Mladenovic et al. (2013).

Table 2.4: Brief description of critical success factors for PPP obtained from published literatures (cont'd)

Critical success factors	Description	Authors
Thorough and realistic cost/benefits assessment	Indication on how the uncertainty is to be treated in such assessment as both costs and benefits are forecasted from three to thirty years of contract duration.	Li et al. (2005b), Babatunde et al. (2012).
Business diversification	Diversifying business operations will open up additional markets and this will increase project profitability.	Jefferies (2006), Cheung et al. (2012b).
Appropriate risk allocation	Strategic risk allocation by allocating the risks to the party best able to manage it. This would reduce individual risks premiums as such party would be able to manage the risk at the lowest price.	Zhang (2005), Jacobson & Choi (2008), Li et al. (2005b), Cheung et al. (2012b), Wen-xiong et al. (2007), Hwang et al. (2013), Cheung et al. (2012a), Dulaimi et al. (2010), Mladenovic et al. (2013), Qiao et al. (2001), Kwak et al. (2009).
Robust and clear contract agreement	Contract agreement specifies the contract objectives, obligations, rights, incentives, risks, technical specifications and etc which are vital to all contracting parties.	Zhang (2005), Jefferies (2006), Jacobson & Choi (2008), Abdul-Aziz & Jahn Kassim (2011), Hwang et al. (2013), Cheung et al. (2012a).
Competitive and transparent procurement process	This can be achieved by good communication between the public and private contractors and their advisers; the private sector openly consulting with the public sector and its adviser, while keeping responsibility for all decisions; and the private sector establishing a clear basis for making decisions	Jefferies (2006), Chan et al. (2010), Li et al. (2005b), Hwang et al. (2013), Babatunde et al. (2012), Cheung et al. (2012a), Helmy (2011), Mladenovic et al. (2013), Hardcastle et al. (2006), Pinder et al. (2004).
Effective management control	Management control includes contemporary network planning techniques and computer-based project management systems.	Wen-xiong et al. (2007), Qiao et al. (2001).
Innovation	New ideas to carry out project more efficiently and effectively.	Wen-xiong et al. (2007), Dulaimi et al. (2010), Mladenovic et al. (2013).
Development and management experience	Vast experience of the consortium will increase the possibility for the project to be successful.	Wen-xiong et al. (2007).
Strong and reliable project team	This suggests that private companies wishing to participate in PPP/PFI markets should explore other participants' strengths and weaknesses; and are capable of synergizing and exploiting their individual strengths.	Zhang (2005), Abdul-Aziz & Jahn Kassim (2011), Li et al. (2005b), Cheung et al. (2012b), Wen-xiong et al. (2007), Hwang et al. (2013), Cheung et al. (2012a), Dulaimi et al. (2010), Mladenovic et al. (2013), Qiao et al. (2001), Kwak et al. (2009).
Expert advice and review	Expert advice and review is needed to help in making practical analysis of the risk factors and fiscal implications (Jacobson & Choi, 2008)	Jacobson & Choi (2008).
The competence of the government	The government or public bodies need to be competent, well-organised and committed in the development and management of PPP/PF2 projects.	Li et al. (2005b), Hwang et al. (2013), Kwak et al. (2009).

Table 2.4: Brief description of critical success factors for PPP obtained from published literatures (cont'd)

CSF Category	Critical Success Factors	Authors																				
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	Total
Political environment and regulatory	Favourable legal framework						✓	✓	✓	✓	✓	✓	✓	✓		✓						9
	Stable and transparent political and social situation				✓	✓		✓		✓		✓	✓	✓		✓			✓			9
	Government guarantee							✓				✓	✓		✓		✓					5
	Good governance				✓		✓	✓		✓			✓									5
	Action against errant developer					✓																1
Economic factor	Favourable investment / economic environment	✓			✓		✓	✓	✓	✓		✓		✓	✓	✓	✓		✓			12
	Available financial market						✓	✓				✓	✓		✓		✓					6
	Sound financial package	✓								✓									✓		✓	4
Collaborative working relationship	Community outreach			✓		✓				✓										✓		4
	Communication and coordination			✓		✓		✓		✓						✓						5
	Shared authority between public and private sectors							✓			✓											2
	Good partnership relationship			✓	✓		✓	✓	✓				✓			✓				✓		8
	Developer’s profit sharing accountability					✓																1
Project management	Robust business case	✓		✓				✓		✓			✓		✓	✓	✓	✓	✓	✓		11
	Detailed project planning and evaluation									✓						✓						2
	Thorough and realistic cost / benefits assessment							✓				✓										2
	Business diversification		✓										✓									2

Table 2.5: CSFs of PPP from published literature

CSF Category	Critical Success Factors	Authors																				
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**	**Q**	**R**	**S**	**T**	**Total**
Project management (cont'd)	Appropriate risk allocation	✓		✓				✓	✓	✓	✓		✓	✓		✓			✓		✓	11
	Robust and clear contract agreement	✓	✓	✓		✓					✓		✓									6
	Competitive and transparent procurement process		✓		✓			✓			✓	✓	✓		✓	✓	✓			✓		10
	Effective management control									✓									✓			2
Skills, experience and competency	Innovation									✓				✓		✓						3
	Development and management experience									✓												1
	Strong and reliable project team	✓				✓		✓	✓	✓	✓		✓	✓		✓			✓		✓	11
	Expert advice and review			✓																		1
	The competence of the government							✓			✓										✓	3

References:

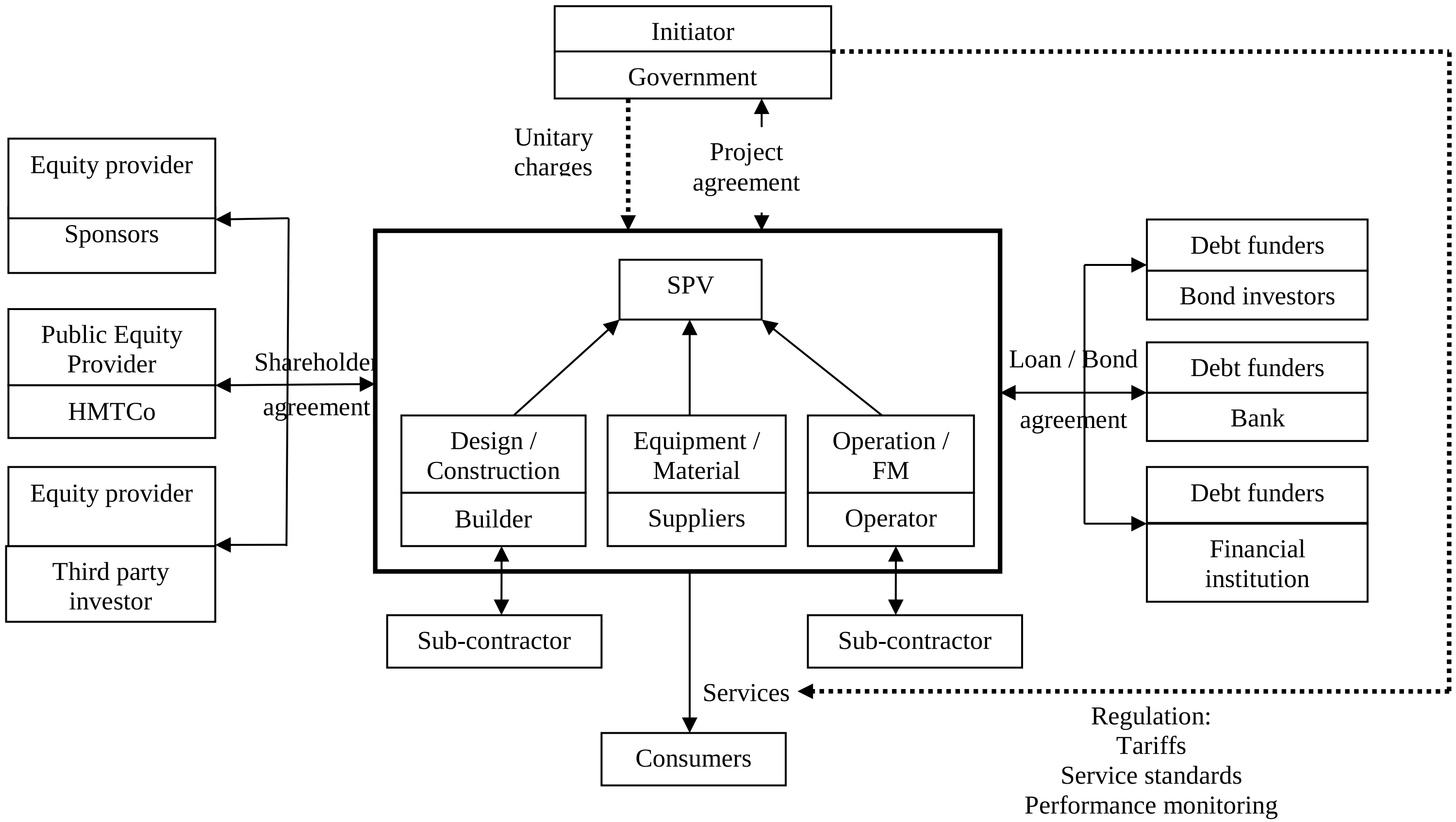
A = Zhang (2005)
B = Jefferies (2006)
C = Jacobson & Choi (2008)
D = Chan, Lam, Chan, Cheung, &Yongjian (2010)
E = Abdul-Aziz & Jahn Kassim (2011)
F = Ismail & Ajija (2011)
G = Li, Akintoye, Edwards, & Hardcastle (2005b)
H = Cheung, Chan, & Kajewski (2012b)
I = Wen-xiong, Qi-ming, Xiao-peng, & Jing-hua (2007)
J = Hwang, Zhao, & Gay (2013)
K = Babatunde, Opawole, & Akinsiku (2012)
L = Cheung, Chan, Lam, Chan, & Ke (2012a)
M= Dulaimi, Alhashemi, Ling, & Kumaraswamy (2010)
N = Helmy (2011)
O = Mladenovic, Vajdic, Wündsch, & Salaj (2013)
P = Hardcastle, Edwards, Akintoye, & Li (2006)
Q = Askar & Gab-Allah (2002)
R = Qiao, Wang, Tiong, & Chan (2001)
S = Pinder, Smith, Pottinger, & Dixon (2004)
T = Kwak, Chih, & Ibbs (2009)

Table 2.5: CSFs of PPP from published literature (cont'd)

With reference to Table 2.5, the frequency of each CSFs mentioned in the literatures is recorded. There are thirteen CSFs that are most frequently mentioned by the researchers, which are: *“favourable legal framework”; “stable and transparent political and social situation”; “favourable investment/economic environment”; “good partnership relationship”; “robust business case”; “appropriate risk allocation”; “competitive and transparent procurement process”; and “strong and reliable project team”.* Therefore, despite the varying findings and opinions by researchers on the CSFs for PPP, these thirteen factors are considered mostly agreed by the researchers as the most important factors for PPP or PF2 projects to be successful.

2.4.2 The contractual structure of PF2

PF2 is a reformed UK version of PFI, therefore the contractual structure of both methods of procurement is similar except that under PF2, the granting authority is also an equity provider of the Special Purpose Vehicle (SPV). The SPV is a shell corporation set up by a private sector consortium specifically to deliver the particular PF2 project. The SPV obtains initial funding of approximately 20-25 percent of capital expenditure and operational expenditure for the project (sometimes referred to as ‘spot finance’) which usually comes from the equity providers. Further funding is obtained from the debt funders in the form of loan or bonds. The banking sector provides finance on a ‘non-recourse’ or ‘limited recourse’ basis, which means that the repayment of the loan is totally generated by the project’s revenue and assets without having recourse to the sponsors’ non-project related assets or revenues. Therefore, it is vital for the bank to evaluate the project’s financial viability (Alfen et al., 2009; Dewulf et al., 2012). The SPV also faces penalties for late completion, poor quality of infrastructure and poor service provision (Dewulf et al., 2012). Figure 2.2 shows the basic PF2 contractual structure which portrays how the SPV is related to the other parties in PF2 project.



Source: Modified from Alfen et al. (2009) and Akintoye, Beck, Hardcastle, Chinyio, and Asenova (2001)

Figure 2.2: Basic PF2 contractual structure

2.4.2.1 The stakeholders

Various parties are involved in the execution of PF2 contract. Similar to PFI, the stakeholders comprise of the Government; Debt Funders; Equity Providers; Builders and Suppliers; and Service Operators.

The government

The public-sector party, which is labelled as the 'Government' in Figure 2.6, is a granting authority that may be a central government department, state government, regional government, local authority, public agency or any other entity that is controlled by the government (Yescombe, 2007). The public sector specifies the requirements to meet the public needs and positioned as the procurer of the facilities and services provided by the private sector throughout the contract duration. The competency of the government is critical as it plays a critical role in the development and management of a PPP/PF2 project, otherwise it may lead to project failure. Kwak, Chih, and Ibbs (2009) identify five major roles of the government in PPP projects, which are also applicable to PF2 projects, as follows:

1. Creating favourable investment environment – this is to attract private sector participation in PF2; hence the government should create a stable social, legal, economic, and financial conditions together with project-specific assistances and/or guarantees, such as guaranteed minimum revenue and tax reduction.
2. Establishing adequate legal and regulatory model – this is the pre-requisite of PF2 to ensure the project operates efficiently, to secure proper risk allocation and avoid potential corruption in the project execution.
3. Establishing a coordinating and supportive authority – the types of entities under the public sector vary; hence they have different management practices, jurisdictions and objectives. A central authority is therefore needed, for example UK Treasury Task Force that can coordinate and reconcile conflicts between these agencies or departments.
4. Selecting a suitable concessionaire - the selection of an appropriate consortium is also critical to the success of a PPP project; therefore, the government should

establish a workable procurement model to ensure a competent consortium is selected.

5. Being actively involved in the project life-cycle phases - the government need to continuously monitor the project progress and performance assessment. For PF2, as the government is one of the equity providers, access to project information throughout the contract life is quite unlimited.

The debt funders

Under PF2, the debt funders represent the financiers (for example; banks, financial institutions, bond investors), who provide 80-75 percent financial support to the SPV in the form of bank debt or bonds. Bank debt is a financial loan borrowed by the SPV from a bank or financial institution. The loan is usually syndicated between several banks to overcome the capital constraints, as sometimes, banks are limited in the size of money they can lend to any one borrower (Simons, 1993). Bank debt is the most commonly used financial instrument for financing projects. The repayment of the loan includes the principal sum borrowed with required interest applicable over the life span of the loan duration. On the other hand, a bond is a fixed income security which is issued by the SPV to the interested bond buyer where the SPV agrees to repay the amount of the bond together with the interest on a fixed future instalment arrangement. The SPV raised finance from the sale of the bonds and the bond investors enjoy good long-term return from their investment until the bond reach its maturity. There are two ways to raise finance through bonds which are either public issue – quoted on a stock exchange; or private placement – not quoted and sold to a limited number of investors (Yescombe, 2007). Basically, the size of the project, the cost of the repayment and deliverability issues are the concern before deciding to raise capital using bank debt or bonds (Yescombe, 2007; Dewulf et al., 2012). With the lower debt-equity ratio in PF2 which is hoped to improve the credit rating of the project, PF2 is expected to attract institutional investors/pension funds to participate in providing debt finance (Hellowell, 2013b).

The equity providers

Appropriate mix of equity and debt is necessary in any PPP project so as to reduce the risks resulting from taking bank debts (Kwak et al., 2009); such as fluctuations in cash-flows and the impact on SPV's ability to make scheduled debt service payments to the bank (Hellowell, 2013a). Therefore, under PF2, the remaining 20-25 percent of the project capital is gained from the equity providers with 25-49 percent of the total equity quantum provided by the public sector. The Government, through the Treasury PF2 Equity Unit, will invest a minority share together with the private sector investors and sponsors, into the SPV. The investment will be on the same terms as those agreed by the private sector and will be done through a company wholly owned by the Treasury, which is HMTCo (HM Treasury, 2013). Another proportion of private sector equity is divided between Sponsors and other third party investors. Sponsors, who are members of the consortium, are responsible for bidding, developing and managing the project, and are considered as the 'operational' investors as their investment is part of the strategy for securing their business as the contractors of the SPV (Yescombe, 2007). The funding competition for equity will force the Sponsors and the private sector investors to compete over the portion of equity that is not taken up by the Government.

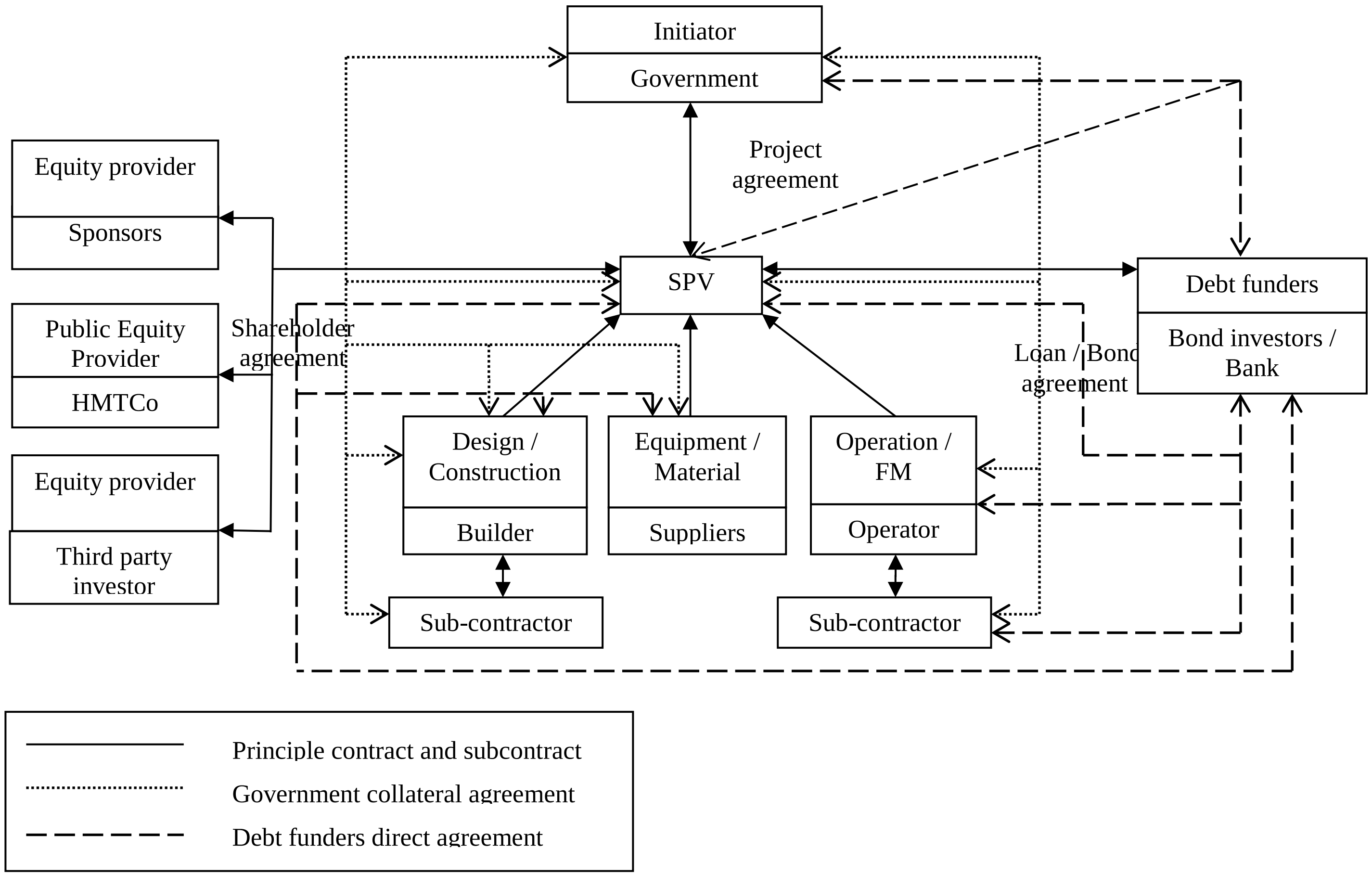
The Builders, Suppliers and Operators

The Builders, Suppliers and Operators are employed by the SPV based on fixed price contracts. The Builders are the contractors assigned to construct the PF2 facilities, whereas the Suppliers are engaged to provide necessary materials and equipments for the PF2 projects. The Operators are the service providers associated with hard facilities management which are employed to maintain the PF2 facilities during the operational stage of the contract. The Builders, Suppliers and Operators are also typically the project's Sponsors, or affiliates of the Sponsors and to whom the SPV transfers the principal risks in construction and operation (Alfen et al., 2009).

2.4.2.2 Principal contracts and subsidiary contracts

The primary contract in PF2 is the contract between the government or the public sector and the project company who is often referred to as Special Purpose Vehicle (SPV). The SPV obtains initial funding from equity providers through shareholders' agreement. Further funding is obtained from debt funders through loan or bond agreement. The SPV then enters into a series of contracts with: builders; suppliers; and facilities management operators based on fixed price contracts. Typically, these are the project's sponsors or the subsidiaries of the sponsors (Dixon et al., 2005; Alfen et al., 2009; Dewulf et al., 2012). With this kind of arrangement, the SPV acts as a vehicle to limit the risks of the consortium members and passes the particular risks to the contractors. It is also a vehicle to act as a medium to channel the payments received from the government to the contractors.

As seen in Figure 2.3, the project agreement lies at the centre of the complex contractual networks web involving: financial; construction; and operators' contracts. Being the heart of the whole project package, the project agreement sets out the: rights; remedies; obligations; and liabilities; of both the public and private sectors. It also establishes the risk allocation between the public and private companies, therefore becoming a basis for the government to monitor and control the private sectors' activities and decisions. From the project agreement, the key provisions of other contracts will be driven at the end of which, the entire contracts in the package must interlock each other and be well-matched to the project agreement (Alfen et al., 2009).



Source: Adapted from Sundaraj (2012, p. 60)

Figure 2.3: Principal contracts and other subsidiary contracts in PF2 project

Figure 2.3 discloses other subsidiary contracts that rest behind the principal contracts. This includes the direct agreement with the debt funders and collateral agreements by the government. The debt funders' direct agreement is a three-way agreement between the government; SPV and the consortium parties; and the debt funders which provide the opportunity for the funders to step in the event the SPV or the any of the consortium parties terminated so that the funders could find another party acceptable to the government that can continue obligations under the project agreement. This is part of the approaches in risk management to facilitate the income stream by minimising the disruption resulting from such termination. The collateral agreement also shares similar principles as the debt funders' direct agreement. The government, the SPV and contractors which have contracts with the SPV, are entered into collateral agreement, with the intention of giving the authority the rights to take over relevant contracts from the SPV in the event the SPV is terminated. In addition, the government typically seeks collateral warranties from contractors appointed by the SPV in order to protect the position and the loss of the government if the project is terminated (Ramsey, 2007; Sundaraj, 2012).

2.4.3 The risks in PF2

Generally, risk is the possibility of a detrimental event to occur that could cause harm or loss to an individual or a group of people. Due to the lengthy contract duration involving a myriad of parties and affecting the public users, PF2 is obviously exposed to risks. Given the status of PF2, which is relatively very new at the moment of writing this thesis, published studies that discuss the risks associated with PF2 are very scarce. However, as PF2 is the reformation of PFI, most of the risks associated with PFI are considered to also be related with PF2. Therefore, the works of Akbiyikli and Eaton (2004), Akerele and Gidado (2003), Akintoye et al. (1998), Li, Akintoye, Edwards, and Hardcastle (2005a), and Hardcastle and Boothroyd (2008) which specify the risks of PFI are reviewed and risks they listed are combined to create the PF2 risks listing as presented in Table 2.6.

Risk Level	Risk Subgroup	Risk Factors	Authors						Total
			A	**B**	**C**	**D**	**E**	**F**	
Macro	Social	• Lack of tradition of private provision of public services				✓			1
		• Public opposition				✓			1
		• Facility gives adverse impact on society				✓	✓		2
		• Social corruption				✓			1
		• Shortage of voluntary organisation in society				✓			1
	Legal	• Change in law			✓	✓	✓		3
		• Change in tax regulation				✓			1
		• Industrial regulatory change				✓			1
	Economic	• Tariff change		✓					1
		• Market demand change	✓		✓	✓	✓		4
		• Inflation fluctuation				✓	✓		2
		• Interest rate fluctuation				✓	✓		2
		• Foreign currency exchange		✓					1
		• Poor financial market				✓			1
		• Financial attraction of project to investors				✓			1
	Environmental	• Ground conditions				✓			1
		• Site availability				✓	✓		2
		• Force majeure				✓			1
		• Weather		✓		✓			2
		• Environmental impact			✓	✓	✓		3
	Political	• Expropriation and nationalisation				✓			1
		• Political opposition				✓			1
		• Unstable government				✓			1
		• Unsupportive government policies				✓			1
		• Possible change in government			✓		✓		2
	Technological	• Availability of labour/materials				✓			1
		• Technological obsolescence					✓		1
		• Innovation risk		✓					1
Meso	Project initiation	• Planning permission			✓		✓		2
		• Tendering cost risk			✓				1
		• Delay in approval and permits				✓			1
		• Poor public decision making process				✓			1
	Project finance	• Availability of finance			✓	✓			2
		• Credit funding from sponsors/investors					✓	✓	2
		• High financial cost				✓			1
		• Cost uncertainty					✓		1
		• Increase capital cost						✓	1

Table 2.6: Categorisation of PF2 risk factors

Risk Level	Risk Subgroup	Risk Factors	Authors						Total
			A	B	C	D	E	F	
Meso (cont'd)	Residual risk	• Residual value	✓		✓	✓			3
	Design	• Organisation and coordination				✓			1
		• Improper design	✓	✓	✓	✓	✓		5
	Construction	• Site safety			✓		✓		2
		• Labour disputes and strikes		✓					1
		• Low productivity				✓			1
		• Delay in construction completion	✓	✓	✓	✓	✓		5
		• Insolvency of subcontractor/suppliers				✓			1
		• Construction cost overrun	✓	✓	✓	✓			4
		• Quality risk				✓	✓		2
		• Unproven engineering techniques				✓			1
		• Late delivery of equipment and supplies		✓					1
	Operation	• Frequency of maintenance				✓			1
		• Performance of services	✓	✓	✓		✓		4
		• Commissioning risk			✓		✓		2
		• Project life risk			✓				1
		• Availability of services					✓		1
		• Operation cost overrun	✓		✓	✓	✓		4
		• High maintenance cost			✓	✓			2
		• Operational revenues below expectation		✓		✓			2
	Contractual	• Contractual risk		✓	✓				2
		• Payment risk			✓	✓			2
		• Excessive contract variation				✓			1
Micro	Relationship	• Inadequate experience in PPP				✓			1
		• Inadequate distribution of authority				✓			1
		• Organisation and coordination				✓			1
		• Lack of commitment between parties				✓			1
		• Differences in working method				✓			1
	Third Party	• Staff crisis				✓			1
		• Third party tort liability				✓			1

References:

A = Akbiyikli and Eaton (2004)
B = Akerele and Gidado (2003)
C = Akintoye et al. (1998)
D = Li et al. (2005a)
E = Hardcastle and Boothroyd (2008)
F = Hellowell (2013a) and Hellowell (2013b)

Table 2.6: Categorisation of PF2 risk factors (cont'd)

Hellowell (2013a, 2013b), while providing critical assessment of PF2 highlights important points to consider regarding the risks in PF2. Firstly, risks related to the management of ‘soft’ facilities management services such as catering, cleaning and security will not be borne by the private sector as these services are excluded in PF2, not to be bundled together like previously in PFI. Secondly, there might be a possibility that the institutional investor (such as pension funds and insurance companies) to hesitate to participate in PF2 because of the lacking in specialists within the institutional investor to assess their project risks. Thirdly, PF2 might increase the cost of capital for the same or less risk transfer to the private sector as the government is now a minority equity stakeholder. These points are considered in listing the PF2 risks in Table 2.6. In categorising those risks, the SLEEPT taxonomy (Akbiyikli & Eaton, 2004; Eaton & Akbiyikli, 2005; Sundaraj & Eaton, 2013) was adopted. The mnemonic of S.L.E.E.P.T represents six factors, which are Social, Legal, Economic, Environmental, and Technological. This study also adapts the levelling of the risks as in Li (2003) in order to show the scale of the risks.

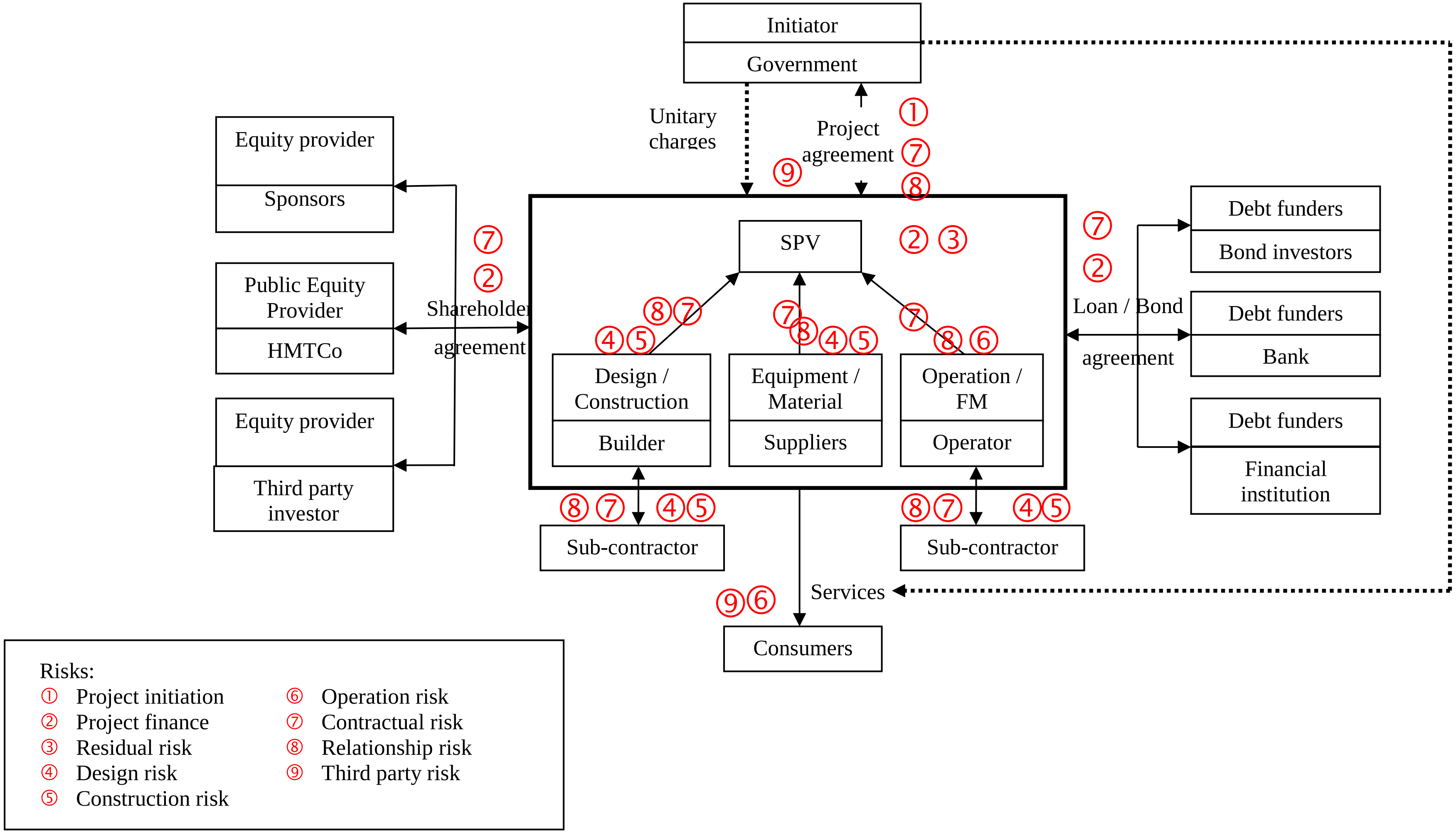


Figure 2.4: Risks in PF2 projects

2.5 The Future of PF2 with Respect to Technological Advancement

Since PPP became available in the UK, it has experienced significant evolution in response to political change, economic environment, change of policies, and improved trend in construction practice. The evolution is anticipated to continue as time passes, and further transformation would occur in the construction industry and in particular to PPP; as it adapts to meet the future demands of the industry. The transformation from PFI to PF2 is one of the examples of such evolution that gives impact to the industry's players and public users as a whole. It is observed from the literature that, generally, such evolution is rooted from the widespread paradigm to increase efficiency, quality and sustainability while at the same time to reduce the costs and time in procuring a building or a facility.

As part of the endeavour to improve the construction procurement, there is a strong interest in applying integrated and collaborative construction project arrangements in pace with information technology (IT) advancement. The integrated and collaborative project management has been the subject of much research and development due to the frustration towards the fragmentation of the construction processes which causing the relationships of the parties involved to eventually become adversarial (Lahdenperä, 2012). The issue has been echoed since the 1980s (Bynum, 1983; Fazio, Moselhi, Théberge & Revay, 1988; Cook & Hancher, 1990) and has become intense after the disintegration in the construction process as highlighted by the Latham Report (Latham, 1994) and Egan Report (Egan, 1998) as causing difficulties to coordinate the works of construction projects teams.

In support of these influential reports, various studies were conducted in relation to the issue, for example, Akintoye, McIntosh, and Fitzgerald (2000) emphasised in their study on the merits of supply chain collaboration in the construction industry to create a long term and non-adversarial relationship, and found the lack of it in the construction process. Black, Akintoye, and Fitzgerald (2000) and Bresnen and Marshall (2000) studied partnering as a way to collaborate in construction projects and identified trust, communication, commitment, clear understanding of roles, consistency and flexible attitude as factors to have a successful partnering. Love, Gunasekaran, and Li (1998) as well as Evbuomwan and Anumba (1998) examined the concept of concurrent engineering which integrates the multi-disciplinary team in three levels, namely: (1) in the design and construction planning process; (2) design tools and techniques used to support the activities in the design and construction planning process; (3) repositories of information databases for the design and construction, which includes the evolving product data. Despite the diversity of studies revolving around this issue, it is noted that strong good relationship among the construction stakeholders is the most essential factor that underpins the success of such integration and collaboration. Therefore, the formula to improve the construction industry merely relies on the improvement of the communication between the stakeholders so that it can enhance the good relationship and collaboration; and consequently, the integration of data information from various disciplines can take effect.

Realising the enormous benefits to gain from improved communication, collaboration and integration, computer and information technologies appear as a catalyst to reduce the complexity in handling these matters. Over the past 20 years, the technologies have been used and have changed the traditional practices of the construction industry players' practices, for example, generating manual designing on paper to virtual design; replacing manual taking-off of quantities to direct taking-off in computer; substituting on-paper planning and scheduling to automated planning and scheduling; and transforming the paper-intensive to paperless construction practices. The use of computer technologies in the construction industry has reduced potential errors that might happen due to human weaknesses. As the technologies continue to develop, a big wave developed in the construction industry to further adopt the technologies to reinforce the communication, collaboration and integration among the project team members (Howard, Levitt, Paulson, Pohl & Tatum, 1989; O'Brien & Al-Soufi, 1993; Ahmad, Russell & Abou-Zeid, 1995). The latest is the emergence of Building Information Modelling (BIM) which is currently gaining momentum and popularity in the construction procurement.

Generally, BIM is an intelligent modelling technology that produces, communicates and analyses building models (Eastman, Teicholz, Sacks & Liston, 2011) which provides a platform for the client, designers, surveyors, estimators and facility managers to share information during, design, construction and throughout the building lifecycle process. Through BIM, the works and knowledge of the project team members can be integrated, therefore reducing the possibility of clashes in design; and enables better and faster decisions to be made which may avoid time and cost overruns. In the operation phase, BIM can be used to obtain information on the performance and economic aspects of the project which would facilitate the project team members to take necessary action in response to it (Yan & Damian, 2008; Hergunsel, 2011). BIM is very much related to Integrated Project Delivery (IPD) approach, which attempts to create a collaborative environment within the procurement of a building, therefore coupling BIM with IPD can maximise the greatest potential of these two (Yang & Wang, 2009; Becerik-Gerber & Kent, 2010).

Within the context of PF2, the PF2 contractual structure as presented in Figure 2.3 shows that PF2 is a holistic model that provides a model for collaborative and integrative working environment. The presence of the public authority as one of the decision makers in planning and executing the project, making PF2 shares some characteristics of IPD. Hence, realising the need to harmonise the integration of various parties in PF2, BIM is considered as the appropriate tool to be used to ensure that robust information exchange and knowledge management systems can be practiced to achieve a successful PF2 project. The integration of BIM and PPP has also been discussed by Chaijani (2013); Ganah and John (2013); and Laishram (2013) which, in other words, support the idea of implementing BIM in PF2 project. In fact, the implementation of BIM has been listed as one of the strategies for the construction industry in the United Kingdom to achieve significant growth by the year 2025 (HM Government, 2013). The UK Government has also mandated that the public sector's centrally procured construction projects to be delivered using BIM by 2016 (HM Government, 2012). For this reason, BIM somehow needs to be implemented in PF2 projects. Being the latest innovation of PPP, PF2 is hoped to provide more benefits as compared to PFI and to offer solutions to problems faced by PFI. Furthermore, with the implementation of BIM within PF2, the success of PF2 projects might be the matter that can be confirmed at the pre-development stage in the future.

2.6 Summary

This chapter provides an overview of Public Private Partnership (PPP), specifically its characteristics, the reasons for its implementation, the history and various modes of procurement system under the umbrella of PPP schemes. This chapter was written with the purpose to provide the context in which the present study rests, hence, enhancing the basic understanding of PPP. Subsequently, the discussion is expanded to elaborate Private Finance 2 (PF2) in detail concerning aspects such as the differences between Private Finance Initiative (PFI) and PF2; the contractual structure, and the risks of PF2. This chapter also lists out the CSFs of PF2 extracted from the review of published literature on CSFs for PPP/PFI. The review provided in this chapter also tends to achieve the first objective of the study which is to investigate the key characteristics of PF2 model in relation to the concept, contractual structures, risk factors and critical success factors.

From the literature, it was found that there are slight differences between PFI and PF2. As compared to PFI, PF2 is designed to be more flexible, transparent and collaborative with the public sector. The PF2 arrangement illustrates the possibility of BIM to be used to enhance its potentials in providing a more successful public facilities and services. Therefore, the next chapter of this thesis discusses Building Information Modelling (BIM) and the benefits of BIM towards PF2 projects.

CHAPTER 3

BUILDING INFORMATION MODELLING

3.1 Introduction

This chapter focuses on the implementation of Building Information Modelling (BIM) within the construction industry. BIM has been seen as an opportunity to improve the traditional working culture in the industry, which subsequently can improve performance in project delivery. The state in which BIM can be used in the construction industry, its evolution over the years and its rationale on PF2 projects are also presented. This chapter also examines the functions, success factors, benefits and challenges of BIM implementation in the construction industry. The structure of this chapter is as follows:

- Firstly, it provides an overview of Building Information Modelling (BIM) which involves definition, characteristics, its potentials and benefits towards project delivery;
- Secondly, it presents the CSFs and risk factors for BIM projects;
- Thirdly, it provides information on the current state of BIM in the UK construction industry;
- Finally, it synthesises BIM with PF2 by highlighting the rationale of BIM implementation in PF2 projects.

3.2 Definition of Building Information Modelling (BIM)

Building Information Modelling is an emerging term within the Architecture, Engineering and Construction (AEC) industry, in which it is defined in various ways by professionals, practitioners and academia. Aside from the term BIM, other acronyms are also used to represent BIM, for example, Building Information Modelling and Management (BIMM), digital model, project model, virtual prototyping, integrated project database, nD modelling and so forth. Notwithstanding the variety of definitions and acronyms of BIM, its goal is to provide explicit intelligent virtual database model, which integrates all members of the design and construction team, operators and client and can be used throughout the building's life-cycle.

The features of BIM as listed out by Campbell (2007, p. 173) offered good guidelines on what is BIM, which are to:

(a) Digital – enabling simulation of design and construction;
(b) Spatial – 3D, to better represent complex construction conditions than 2D drawings;
(c) Measurable – data that is quantifiable, dimension-able, and query-able more so than visual;
(d) Comprehensive – encapsulating and communicating design intent, building performance, constructability, as well as sequential and financial aspects of means and methods;
(e) Accessible – data made available to the entire project team through an interoperable and intuitive interface, including architects, engineers, contractors, fabricators, owners, facility maintenance, and users;
(f) Durable – data that reflects as-built conditions and remains usable through all phases of a facility's life, including design and planning, fabrication and construction, and operations and maintenance.

Based on the above, it can be concluded that BIM is all about information management. It is a digital platform for the project team members to put the entire project's data, do necessary adjustment on the data to suit the project, and share the data from the inception phase onward. The key for the optimal use of BIM is the collaboration of the project team members and the working integration among them. BIM is also suitable to support integrated project delivery (IPD) method and long term projects type which requires all the project team members to interact and integrate their works from the first day until the end of the project duration. BIM can also be used in performance-based project which require the evaluation and monitoring of the project life-cycle performance such as in PPP-type of projects.

3.3 Overview of the Benefits and Potentials of BIM

The BIM revolution is radically promoted around the globe due to the significant value-added benefits that BIM can offer to improve the quality of project delivery to the users. This is due to the capabilities of BIM in assisting various tasks in the process of acquiring a facility. A study by the Stanford University Centre for Integrated Facilities Engineering (CIFE) on 32 major projects using BIM indicates that up to 40% of unpredictable changes of budget were removed; project costs estimation has 3% more accuracy; up to 80% of preparation costs were reduced; up to 10% of contract value has been saved with the help of clash detection; and the projects have saved an average of 7% of the original time schedule (Azhar, Hein & Sketo, 2008). Other sources, such as a report by McGraw-Hill Construction (2012) on the BIM adoption in North America, tracking its development from 2007 to 2012 found a significant increase in the percentage of companies using BIM from 28% in 2007 to 71% in 2012. BIM users in North America were also reported as experiencing significant benefits from BIM implementation including higher profits, less re-work, less project duration and fewer claims. Based on the works of Azhar et al. (2008); Azhar et al. (2012); Eastman et al. (2011) and Turkan et al. (2012) the applications of BIM are identified as follows:

- **Visualisation**: generation of 3D renderings that can show the inside and outside of the facility from various angles.
- **Fabrication/shop drawings**: it is easy to generate shop drawings for various building systems, e.g., the sheet metal ductwork shop drawing can be quickly produced once the model is complete.
- **Code reviews**: fire departments and other officials may use these models for building projects review.
- **Forensic analysis**: a building information model can easily be adapted to graphically illustrate potential failures, leaks, evacuation plans, etc.
- **Facilities management**: facilities management departments can use BIM for renovations, space planning, and maintenance operations.
- **Cost estimating**: BIM software(s) have built-in cost estimating features. Material quantities are automatically extracted and changed when any changes are made in the model.

- **Construction sequencing**: a building information model can be effectively used to create material ordering, fabrication, and delivery schedules for all building components.
- **Conflict, interference and collision detection**: all major systems can be visually checked for interferences.
- **Monitoring of construction progress**: linking BIM to tablet PCs and other sensing technology to record and monitor construction progress.

Specifically, the benefits that can be attained from using BIM can be concluded in three subheadings as follows:

a) Collaboration and coordination

- BIM provides a platform for data sharing. It may allow the builders and facility managers to be involved in the early design stage, in which they can influence the design and the planning for construction. The BIM modelling also allows better exploration of space and visualisation prior to construction, hence improving the communication and understanding of the project within the design team, builders, facility managers and the project's stakeholders. The clash detection when the information of building elements enter the model can improve the integration and coordination among the designers and builders, which can help in proper planning during construction.

b) Productivity

- The BIM models have links with take-offs and costing information, which such information evolves following the changes in project design, thus reducing the misunderstanding, errors and time consumed in preparing the bills of quantities and cost estimation. Documentation from BIM models is flexible to be printed out at any time without the need to wait for necessary adjustments to be done following changes to design. The models also provide accurate construction details and fabrication information which allows more construction elements to be fabricated off-site; therefore, this can speed up the construction process. At the post construction stage, BIM can also increase the building performance, for example, evaluating the energy performance with BIM-based energy design and analysis; and more proper spaces planning with post-occupancy evaluations.

c) Efficient work flows and processes

- BIM software can be used to prepare construction sequencing planning involving ordering of materials, fabrication, and time schedules for all parts of a project. With the ability to be synchronised with the constructability reviews, the contractor can easily understand the challenges that would be faced during construction, identify the possible reasons of delays and errors which might affect the project schedules, and subsequently take necessary precaution to avoid negative effects. During the construction phase, monitoring construction progress by using BIM technology eases the contract administration tasks related to site supervision, interim payments, claims, defects checking and variations. The BIM model is also relevant to be used in the post-construction stage by the facilities manager to manage and operate the facility, for example managing renovations and maintenance.

Therefore, BIM is a very outstanding invention that can be used throughout the project life-cycle. Due to the fact that BIM is multi-functional and such functions can be extended during the operational and management stage of a facility, it can provide huge benefits if it is implemented in PPP-type projects such as PF2.

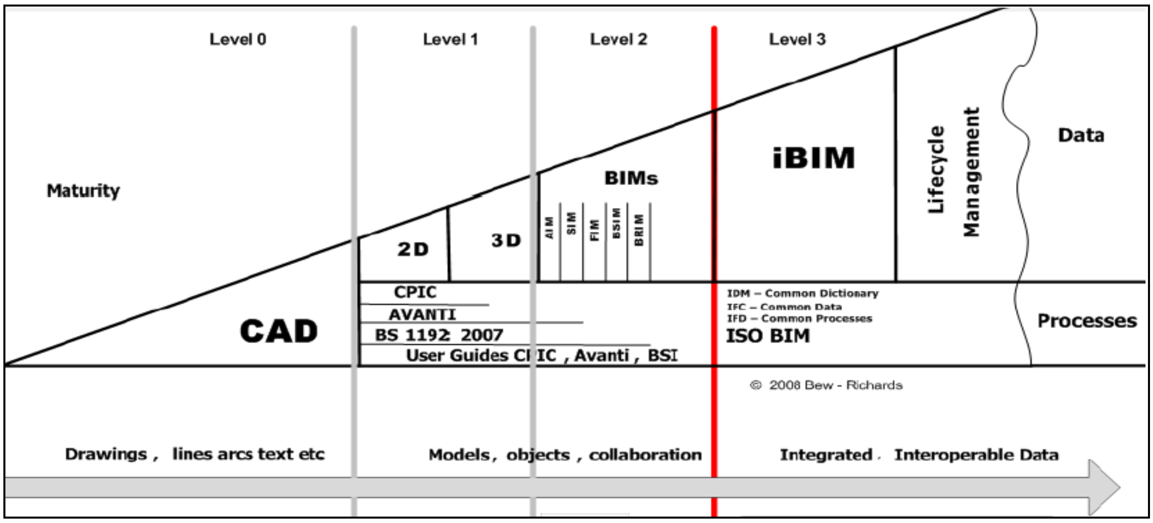
3.4 Implementation of BIM in the United Kingdom

In May 2011, the Cabinet Office published a document named the "Government Construction Strategy" with the aim to have an efficient construction industry in the UK (Cabinet Office, 2011). One of the strategy objectives lined up in the document is the requirement for all central UK Government construction procurements to be fully collaborative 3D BIM, which means the asset information and documentation are to be in the form of digital electronic data, as a minimum target by 2016. This is to realise the aim to reduce costs by up to 20% during the term of the current parliament. It is estimated that the adoption of BIM would enable to save the UK construction and its clients up to £2 billion per annum, therefore the said aim can potentially be reached (HM Government, 2012). In 2013, "2025 Construction Strategy" was published, highlighting the targets to be achieved by the year 2025, which are 33% reductions in the initial cost of construction and the whole-life cost of built assets; 50% reductions in the overall construction time; 50% reductions in greenhouse gas emissions; and 50% reductions in the trade gap between total exports and total imports for construction products and materials; with BIM being seen as a tool to help in achieving these targets (HM Government, 2013).

The requirement to use BIM was mandated following the report from the Department of Business, Innovation and Skills (BIS) from the Cabinet Office which is called the "Strategy Paper for the Government Construction Client Group". In the said report, wide implementation of BIM was recommended based on the tested hypothesis (BIM Industry Working Group, 2011, p. 15):

> Government as a client can derive significant improvements in cost, value and carbon performance through the use of open sharable asset information.

The hypothesis did not rule that using BIM is compulsory, but somehow advocated the supply chain and the client to review the benefits of BIM in improving cost, value and carbon performance due to the BIM's capability of being a platform for information sharing. Notably, there are more benefits of BIM that were not stated in the hypothesis, as other functions may be too complex to be explained and promoted for the initial widespread use of BIM, therefore it only focused on these three functions that are considered as major concerns by the construction industry players.



Source: Bew and Richard in BIM Industry Working Group (2011)

Figure 3.1: BIM maturity level

The Strategy Report divided BIM maturity levels into four milestones as presented in Figure 3.1. The purpose of levelling BIM into those levels is to define the general technical description and the level of collaborative advancement of working with BIM. The BIM maturity levels are defined as follows:

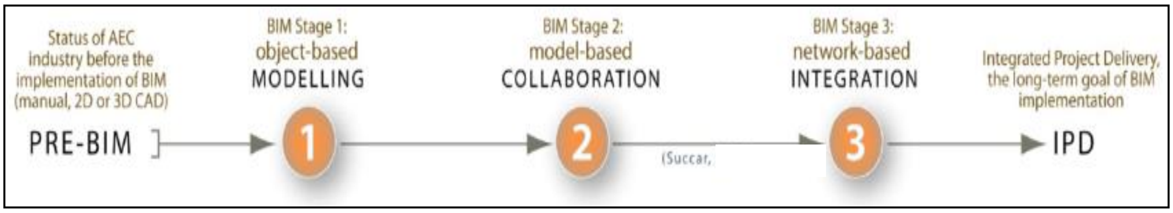
Level 0 **:** unmanaged CAD, this is not BIM as it uses 2D CAD files for data exchange mechanism for design and construction information;

Level 1 **:** managed CAD in 2D or 3D format where the company engaging industry standards such as BS1192:2007 with commercial data is managed by stand-alone finance and a cost management package with no integration;

Level 2 **:** 3D environment held in separate BIM discipline software tools with parametric data attached. During this stage, communication and the integration of data occurs when the parties agreed on the software to be used to support interoperability. The use of data drop mechanism for as-built information to be used in post construction stage by the client. This is the level that the government aims to achieve by 2016.

Level 3	**:**	is a fully open interoperable process and data integration enabled by Industry Foundation Classes (IFC). Named as integrated BIM, the data and information are managed by a collaborative model server. At this level, BIM can be used from 4D up to n-D management information which will be saved in the developed standard libraries.

This BIM maturity level is more or less similar to what has been identified by Succar (2009) as presented in Figure 3.2; except that Succar (2009) labelled it as pre-BIM status, object-based modelling, model-based collaboration, network-based integration, and integrated project delivery as the goal of BIM. The stages are defined based on their level of collaborative working. The pre-BIM status refers to the traditional practice which has no integration and is unstructured. BIM Stage 1 is where object-based modelling software tool needs to be used, but the way of working is still fragmented. BIM Stage 2 is the stage that needs multidisciplinary collaboration in order to communicate their models which are developed separately according to disciplines. BIM Stage 3 is the integration of multidisciplinary project inputs through network to produce an interdisciplinary n-D model. At this stage, integrated project delivery can be achieved and the deliverables from the model are extended to generate more important project information for its best performance, for example lean construction principles, whole life cycle costing and green building assessment and control.

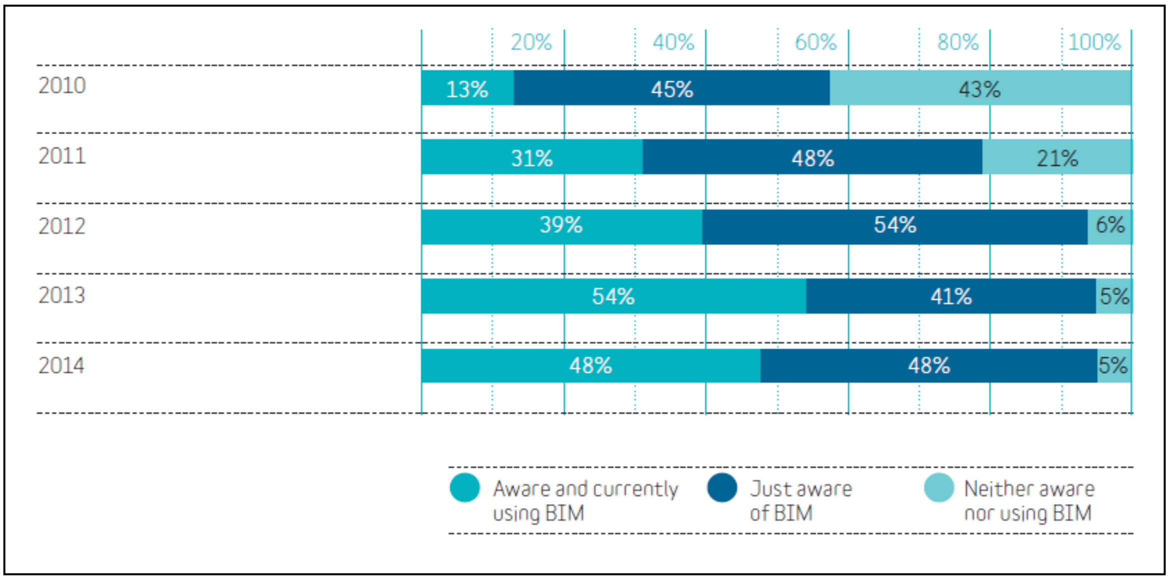


Source: Succar (2009)

Figure 3.2: BIM maturity stages

In terms of the BIM adoption by the construction industry players, the National Building Specification (NBS) reported that from year 2010 to 2013, BIM usage and awareness amongst construction professionals has increased dramatically (NBS, 2015) (see Figure 3.3). However, the adoption of BIM dropped by 6% in the 2014, which created wonders.

Among the reasons of the decrement of the percentage might be due to the economic recovery which causes increase in the demands and workload in the construction industry, which consequently decreases the time to invest in the new processes and software. However, in the recent NBS report in 2016 (NBS, 2016), the awareness and the percentage of using BIM went back up to 54% in 2015, with the reduction of 'neither aware nor using BIM' category to 4%. Therefore, from Figure 3.3, it can be seen that BIM usage and awareness in the AEC industry is unstable.



Source: NBS (2015)

Figure 3.3: BIM awareness and usage

The unstable percentage of BIM adoption poses a question that is difficult to be answered, whether the aspiration for Level 2 BIM to be fully adopted by 2016 is achievable or otherwise? The biggest barrier is said to be due to the majority of construction contracts not being collaborative, therefore not being able to support the nature of BIM which requires more collaborative environment for the usage on the projects to become successful. Allocation of risks in the current existing contract is in a binary manner and the parties' interests are not properly aligned, causing the 'true' integrated BIM hard to be practiced. Regardless of what the industry people believe, this question can only be answered explicitly when the full report on its implementation is revealed. Nevertheless, whether the target is achieved or not, it is obvious that the UK government is making serious effort for BIM to be fully implemented in the construction industry.

3.4.1 BIM standards and technical documents

Among the efforts done by the UK government in making BIM relevant to the AEC industry is by publishing BIM guidelines and standards. BIM requires massive changes in working culture, parties' relationship and processes, hence the publication of BIM guidelines and standards is integral in assisting construction practitioners in adopting BIM. The use of the published BIM guidelines and standard is also important in avoiding confusion and chaos due to various understandings on BIM, making the BIM implementation across the industry more consistent. At the time of writing this thesis, the available documents associated and applicable to BIM are as presented in Table 3.1.

Documents	Description
BS 1192:2007 Code of practice for the collaborative production of architectural, engineering and construction information	It establishes the methodology for managing the production, distribution and quality of construction information, including those generated by CAD systems.
BS 7000-4:2013 Design Management Systems: Guide to managing design in construction	Guidance on management of the construction design process at all levels, for all organizations and for all types of construction projects.
BS 8451 series Standard series of library objects for architecture, engineering and construction	Guidance on how to provide product information for inclusion in Building Information Models. It comprises: **BS 8541-1:2012** Identification and classification **BS 8541-2:2011** Symbols and other graphic conventions **BS 8451-3:2012** Shape and measurement **BS 8541-4:2012** Attributes for specification and assessment. **BS 8541-5:2015** Assemblies (on the sharing of sub-models representing combinations of components and spaces) **BS 8541-6:2015** Product and facility declarations
BS 1192-4:2014 Collaborative production of information. Fulfilling employer's information exchange requirements using COBie	Defines expectations for the exchange of information throughout the lifecycle of a Facility. The use of COBie ensures that information can be prepared and used without the need for knowledge of the sending and receiving applications or databases. It ensures that the information exchange can be reviewed and validated for compliance, continuity and completeness.
BS 8536-1:2015 Briefing for design and construction – Part 1: Code of practice for facilities management (Buildings infrastructure)	It gives recommendations for briefing for design and construction, to ensure that designers consider the expected performance of a building in use. This includes the integration of the principles of the soft landings process, combined with effective information management and the requirements for post-occupancy evaluation (POE) to strengthen the link between asset/facility owners, operators, and their facility managers and the design and construction team to assure performance of the design and the operational asset/facility in all aspects.

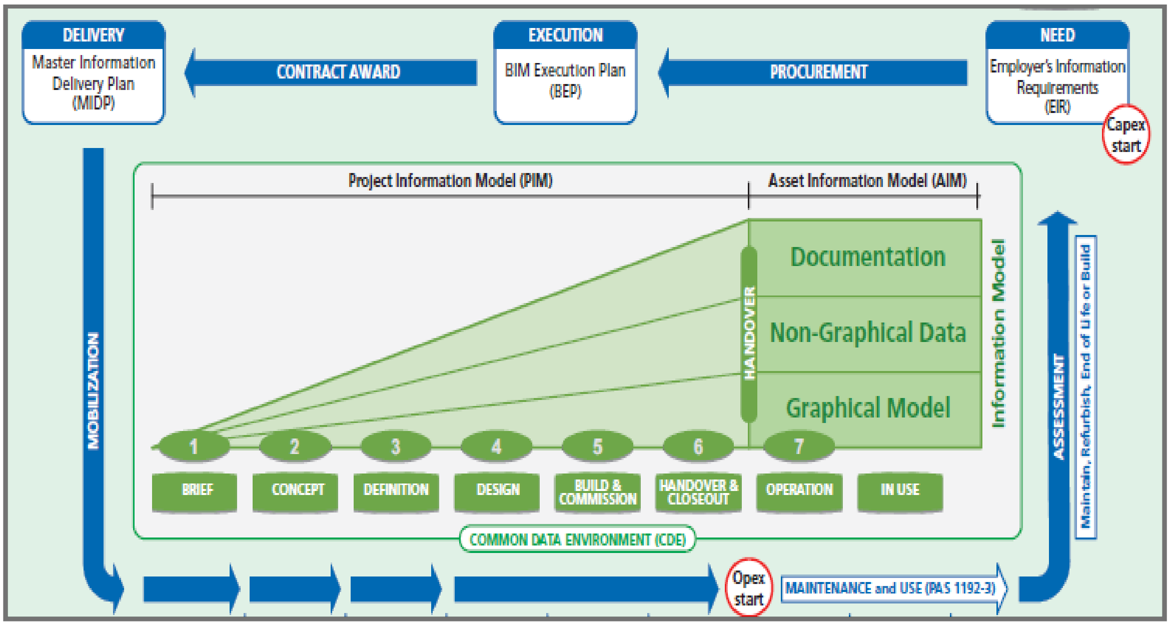
Table 3.1: BIM guidelines and standards

Documents	Description
PAS 1192-2:2013 Specification for information management for the capital/delivery phase of construction projects using building information modelling	The requirements within PAS 1192-2 build on the existing code of practice for the collaborative production of architectural, engineering and construction information, defined within BS 1192:2007. It focuses specifically on project delivery, where the majority of graphical data, non-graphical data and documents, known collectively as the Project Information Model (PIM), are accumulated from design and construction activities.
PAS 1192-3:2014 Specification for information management for the operational phase of assets using building information modelling	This is the partner to PAS 1192-2, and focuses on the operational phase of assets irrespective of whether these were commissioned through direct capital works, acquired through transfer of ownership or already existed in an asset portfolio. Like PAS 1192-2, PAS 1192-3 applies to both building and infrastructure assets.
PAS 1192-5:2015 Specification for security-minded building information modelling, digital built environments and smart asset management	This document specifies requirements for cyber-security minded BIM. It outlines the cyber-security vulnerabilities to hostile attack when using BIM and provides an assessment process to determine the levels of cyber-security for BIM collaboration which should be applied during all phases of the site and building lifecycle.
CPIx Protocol	Standard forms for BIM Execution Plan and for BIM assessment of contractors, suppliers and resources.
CPI Uniclass 2	This is the open classification system for BIM, and it will be freely available for use by all throughout the life cycle of a project and beyond.
Empoyers Information Requirements	This document is presented as a model document complete with guidance notes and core contents. It requires editing to confirm project-specific requirements for each of the sections The document then can be incorporated into other tender documentation.
Government Soft Landing	It provides structure and guidance for central government departments on how to embed and deliver GSL into central government. The policy is aligned with the principles and stages recommended by the BIM Task Group and the digital plan of work.
RIBA Plan of Work 2013	Guidance that encourages the preparation of documents that ensure that each party is aware of what they have to do. Tools proposed include schedules of services, information exchanges, and design responsibility matrix.
NBS BIM Object Standard	This standard assist in the creation of all BIM objects that operate in a common data environment. It is a clear set of guidelines to identify a quality standard for BIM objects and is the benchmark by which objects will be assessed for inclusion within the NBS National BIM Library.

Table 3.1: BIM guidelines and standards (cont'd)

3.4.2 The process of acquiring a construction project with BIM implementation

The general process of implementing BIM has also made known and available via PAS 1192 documents. Figure 3.4 shows the information delivery cycle for the implementation of BIM in a construction project.



Source: Bew and Richards in PAS 1192-2:2013

Figure 3.4: Information delivery cycle for BIM

The cycle starts with the Employer's Information Requirements (EIR) document which is the document that needs to be included in the tender documents for the procurement of both a design team and the builder. EIRs are an important element of Project BIM Implementation as they are used to set out clearly to the bidder what models are required and what the purposes of the models will be. These requirements will be written into the BIM Protocol and implemented through the BIM Execution Plan. The EIR define which models need to be produced at each project stage – together with the required level of detail and definition. The content of the EIR are as follows:

- Technical – details of software platforms, definitions of levels of detail etc
- Management – details of management processes to be adopted in connection with BIM on a project
- Commercial – details of BIM Model deliverables, timing of data drops and definitions of information purposes

Technical	Management	Commercial
• Software Platforms • Data Exchange Format • Co-ordinates • Level of Detail (general) • Level of Detail (components) • Training	• Standards • Stakeholder Roles and Responsibilities • Planning the Work and Data Segregation • Security • Coordination and Clash Detection Process • Collaboration Process • Model review meetings • Health and Safety and Construction Design Management • System Performance Constraints • Compliance Plan • Delivery Strategy for Asset Information	• Timing of data drops • Clients Strategic Purpose • Defined BIM/Project Deliverables • BIM-specific competence assessment

Source: BIM Task Group (2013)

Table 3.2: The content of EIR documents

In response to EIR, the BIM Execution Plan (BEP) needs to be prepared by the prospective design team and the builder that set out their proposed approach, capability, capacity and competence to meet the EIR. BEP is prepared in two stages, pre-contract BEP and post-contract BEP. The pre-contract BEP should include a project implementation plan, goals for collaboration and information modelling, project milestones and deliverable strategy. After the contract is awarded, the post-contract BEP needs to be prepared and submitted, which sets out how the information required in EIR will be provided, confirming the supply chain capability together with the Master Information Delivery Plan (MIDP). MIDP is the document that lists out when the project information is to be prepared, by whom, as well as the protocols and procedures for each stage of the project. The MIDP is developed by bringing together Task Information Delivery Plan (TIDP) data which is created by each supplier's organisation or team that is responsible for the task.

TIDP is used to show how the flow of the preparation of project documents is being transferred from one team to another and to show the sequence of model preparation. Milestones provided in the TIDPs must be aligned with the milestones produced in MIDP.

The next stage is mobilisation. This is the stage where the project delivery team makes sure all the planning to achieve the milestones works before any design work starts. This includes making sure all documents and planning have been prepared and agreed upon, the information processes are ready to be followed, the team possesses all the appropriate skills and competencies, and all of these are supported by the available technology. The selected software, IT systems and infrastructure need to be procured, and tested before being implemented. Any subsequent changes to the BEP need to be agreed on and communicated to all project members. The Project Information Model (PIM) develops over a period of time and at specific agreed points the Client will receive data in the form of Construction Operations Building information exchange (COBie) data. In BIM, these are referred to as "data drops".

At the end of the construction phase, the Client will be provided with an Asset Information Model (AIM) which can be used to manage and maintain the building for the rest of its operational life in the form of documentation, non-graphical data and graphical model.

3.5 The Critical Success Factors of BIM

Various attempts were made by different researchers to determine CSFs for BIM. For the purpose of the study, research papers which are considered recent (between year 2010 to 2016) have been reviewed to observe the CSFs for BIM as proposed by the researchers. However, there is no known study that specifically investigates the CSF for BIM between the year 2015 and 2016. As listed in Table 3.3, nine research papers which specifically discussed CSFs for BIM were selected in this review. From the review, after the various repetitive and overlapping features found in the original list were restructured, 30 CSFs were identified which were then grouped under four principal categories. Table 3.3 lists out the CSFs of BIM.

CSF Category	Critical Success Factors	Authors									Total
		A	B	C	D	E	F	G	H	I	
Business process engineering	Willingness to share information	✓	✓		✓						**3**
	Effective collaboration between project participants	✓		✓	✓			✓	✓		**5**
	Appropriate workflows, coordination and integration			✓	✓				✓		**3**
	Systematic working process			✓	✓			✓	✓		**4**
	User / Client's and stakeholders' involvement in decision making process		✓	✓	✓						**3**
	Information sharing protocols	✓		✓							**2**
	Attitude and commitment		✓						✓	✓	**3**
	Trust on completeness and accuracy		✓								**1**
Organisational structure to support BIM	Leadership of senior management	✓	✓	✓				✓	✓	✓	**6**
	BIM model team/manager	✓							✓		**2**
	Additional roles of project team members		✓					✓	✓		**3**
	Organisational strategies to adopt BIM			✓	✓	✓		✓	✓	✓	**6**
	Team base accountability								✓		**1**
	Continuous investment / good financial resources	✓		✓						✓	**3**
	Readiness to adopt BIM			✓		✓	✓				**3**
	Change in organisational culture		✓			✓		✓			**3**
Technical support and collaboration	BIM training programs and education	✓	✓		✓	✓		✓		✓	**6**
	Interoperability and data compatibility	✓	✓	✓			✓				**4**
	Standardised work procedures for BIM	✓	✓		✓						**3**
	Data security		✓				✓				**2**
	Hardware and equipment			✓						✓	**2**
	Technical supports from suppliers			✓						✓	**2**
	Technical competence			✓			✓	✓		✓	**4**
	Appropriate BIM tools and applications selected			✓	✓		✓	✓			**4**

Table 3.3: Critical success factors of BIM

CSF Category	Critical Success Factors	Authors									Total
		A	B	C	D	E	F	G	H	I	
Legal and contractual	Clear BIM standards, guidelines, codes, rules and regulations		✓			✓				✓	**3**
	Clear parties' roles, responsibilities, liabilities, and rewards in contracts		✓	✓					✓		**3**
	Allocation of risks		✓	✓							**2**
	Model and data ownership clearly defined and agreed		✓	✓			✓				**3**
	Selection of project delivery methods			✓					✓		**2**
	Establish conflict resolution process									✓	**1**

References:

A = Won, Lee, Dossick, and Messner (2013)
B = Shang and Shen (2014)
C = Mom, Tsai, and Hsieh (2014)
D = Morlhon, Pellerin, and Bourgault (2014)
E = Khosrowshahi and Arayici (2012)
F = Mason (2014)
G = Scully, Underwood, and Khosrowshahi (2012)
H = Nawi, Lee, Kamar, and Hamid (2012)
I = Miller, Sharma, Donald, and Amor (2013)

Table 3.3: Critical success factors of BIM (cont'd)

Based on Table 3.3, the four CSFs most frequently mentioned by researchers, are *"effective collaboration between project participants"*; *"leadership of senior management"*; *"organisational strategies to adopt BIM"*; and *"BIM training programs and education"*. These regular frequencies show that these four factors were consistently agreed by researchers as having major impact towards the success of BIM implementation and need to be taken into account in order to optimise the full potentials of BIM.

BIM encourages collaborative working, but at the same time requires willingness of its users to give full commitment to work collaboratively. This is why effective collaboration has always been regarded as critical to the success of BIM project. BIM is not a tool; it is a platform for collaborative working environment, therefore before deciding to embark on BIM or otherwise, the parties must evaluate their true intention as their commitment has to take precedence prior to their action to use BIM. In discussing the importance of working collaboratively, Constructing Excellence (2011) described three overriding principles to collaborative working environment, which are (i) common vision and leadership; (ii) collaborative culture and behaviours; and (iii) collaborative processes and tools. With regards to the first principle, all participants in the project need to have similar absolute focus on the end product or services that are intended to be achieved at the end of the project and to be clear on what the elements that represent values to the client and end users are. This principle is related to the *"leadership of senior management"*; as the leadership needs to establish this common vision by making it clear to the subordinate chain of people and constantly relates project progress to this vision, to see how far they are reaching the desired goal. As for the second principle, it relates to the attitude and behaviour of the people with regards to working collaboratively. The parties to be involved in BIM have to have this sincere attitude in which they have to practice the values of trust, fairness, openness, no-blame culture, honesty and transparency in their everyday working life. This is actually challenging as the parties need to balance these values with the reality that they have different interests towards the projects and have liabilities with each other. With respect to the third principle, it involves the adoption of processes and tools to support the development of collaborative culture such as information collaboration platform, open book costing, and project bank account. It is vital for the project to establish these processes and tools before the work begin, so that the collaborative culture can be naturally nurtured while the parties adhere to the processes and use the supporting tools. This is also related to the *"organisational strategies to adopt BIM"*, as the leadership should consider the supporting processes and tools in arranging the strategies to adopt BIM.

As for the *"BIM training programs and education"*, the researcher believes that this factor was mentioned by most researchers due to the fact that the knowledge and skills required by BIM in the industry are still lacking. In a recent survey done by NBS (2016), a quarter of the respondents admitted their lack of skills and knowledge required in order to use and implement BIM. A significant number of respondents also show that they are unclear about what they need to know about BIM and to whom their concern on BIM should be raised to. Thus, BIM training programmes and education needs to be continuously carried out to instil better awareness, knowledge and skills to the AEC industry players. Without such knowledge and skills, they might be reluctant to use BIM and would not consider BIM as their saviour to perform better in the project, and think of BIM as a big burden to be implemented. In a worst case scenario, forcing them to commit to BIM without adequate knowledge and skills may turn the project to be flawed, which consequently causes a huge loss in terms of money, time and opportunity.

From the discussion, it can be clearly seen that there is some correlation between the CSFs and risks factors. Having CSFs are actually to address the risks within BIM. In order to have a better picture on other risks associated with BIM, the following sub-section discusses the risks of BIM towards a project.

3.6 The Risks of BIM

Table 3.4 lists the risk factors of BIM that are extracted from recent research papers that specifically discuss the risks related to BIM (2010 to current). The list encompasses the risks for BIM from three levels of risks: macro (ecology), meso (project relative), and micro (the special arrangement of partnerships). Each group consists of several subgroups, and each subgroup has the related risk factors. BIM presents much potential and benefits to its users, however adopting BIM means the users need to be ready to adapt to the significant change in the work processes and procedures; change in roles, responsibilities and liabilities; and change in new technological environment. The risks of using it need to be identified, so that they can be managed and addressed to ensure maximum benefits can be gained from BIM. From the review of the literatures, after the various repetitive and overlapping features found in the original list were restructured, 24 risk factors were identified.

Risk Level	Risk Subgroup	Risk Factors	Authors						Total
			A	B	C	D	E	F	
Macro	Social	• Resistance to change					✓		1
		• Lack of available skilled personnel			✓		✓		2
	Legal	• Existing legal system poorly equipped to regulate multiparty, collaborative relationship		✓					1
	Political	• Change of BIM policies	✓						1
	Technological	• Lack of BIM standards and guidelines			✓		✓		2
Meso	Contractual	• Liability issues	✓				✓	✓	3
		• Ownership of information / model	✓			✓	✓		3
		• Status of BIM model	✓				✓		2
		• Unclear position, duty, responsibility and liability of Information Manager	✓			✓	✓	✓	4
		• Lack of guidelines for contractual agreements	✓				✓		2
		• Intellectual property rights						✓	1
		• Unclear allocation of risks				✓	✓		2
		• Privity of contract and third party reliance				✓	✓	✓	3
		• Integrity of BIM model				✓		✓	2
		• Data security					✓	✓	2
	Financial	• High initial cost to implement	✓		✓		✓		3
		• Time consuming to be proficient	✓				✓		2
Micro	Process	• Increase short-term work load			✓				1
		• Lack of collaborative work processes					✓		1
		• Inadequate top management commitment			✓				1
	Technical	• Defective integration between software tools/ Interoperability not guaranteed	✓		✓		✓		3
		• Errors in the model	✓	✓			✓		3
		• Little knowledge and experience	✓		✓				2
		• Model management difficulties	✓		✓				2

References:

A = Talebi (2014)
B = Ness (2011)
C = Chien, Wu, and Huang (2014)
D = Simonian and Korman (2010)
E = Azhar et al. (2012)
F = Boyes (2014)

Table 3.4: BIM risks factors

Based on the list of risks above, there are few factors considered as dominant risks factors as they were found to be mentioned regularly in the literatures. These are *"liability issues"*; *"ownership of information/model"*; *"unclear position, duty, responsibility and liability of Information Manager"*; *"privity of contract" and third party reliance"*; *"high initial cost to implement"*; *"interoperability issue"* and *"errors in the model".* From these dominant factors, a majority of the risk factors considered to be dominant are related to contractual risks subgroup. This shows that most of the risk factors are coming from weak contractual provisions. This also signifies that having robust contractual provisions is vital to manage risks in BIM projects. *"High initial cost to implement"* is due to the fact that the parties who want to embark into BIM have to spend an upfront cost in developing the knowledge, the skills and also the hardware and software to support the implementation. These sometimes do not only involve money to be spent but also time and courage. It is also time consuming to put everything necessary for BIM implementation in place before it can be used effectively for the project.

"Interoperability issue" is related to the ability of different technologies or software applications to be synchronised for communication and data exchange. With a myriad of parties involved in a project, there might be different technologies or applications being used by the parties. If the technology and software applications cannot support each other, problems such as loss of data or errors might occur. This can cause *"errors in the model"* to happen, and worst case scenario, it can give adverse effect to the project as a whole.

All of the benefits, risks and CSFs have been discussed. As much as the advantages that can be gained from BIM, attention should also be given to the risks that are attached to it. The next sub-section of this chapter discusses the state of the implementation of BIM in the United Kingdom as well as the legal and technical documents produced to support its implementation.

3.7 Rationale of the Implementation of BIM in PF2 Projects

BIM potentials and benefits as presented earlier have shown how BIM can be a powerful assistant in increasing the chance for a construction project to be successful. This has also generated the idea of using BIM in procuring PPP projects. With some published case studies showing the use of BIM in PPP projects and several articles that discuss and encourage the use of BIM in PPP projects, it is worth to investigate how BIM could bring benefits to PF2 projects, as intended by the present study. It is noted from the literature that the main challenge in PPP-type projects is to cope with the uncertainty and complexity of the project (Construction Industry Council, 2000; Froud, 2003; Carrillo, Robinson, Foale, Anumba & Bouchlaghem, 2008; Laishram, 2013). This is due to the nature of PPP that involves a myriad of parties in its supply chain; has lengthy contract duration; unpredictable future changes and demand; and high expectations on the ability to deliver the project within time and budget. Therefore, if BIM comes into the picture, even though its use is not expected to overcome the uncertainty and complexity of the PF2 projects completely, it is seen as a great tool to aid the effort of delivering the project efficiently. This is achieved by providing a platform for the parties to closely collaborate; to project future cost and constraints; and also to facilitate possible changes that might happen during the course of the project life span.

Quinn (2014) envisages that the use of BIM in PFI project will reduce the possibility of disputes. Lack of detailed output specification from the client has caused many PFI disputes in the past. Therefore, within the context of PF2 projects implementing BIM, BIM can be used to help the Employer to present a more comprehensive output specification required, which will reduce the possibility of the project from going astray from the expectation. Quinn (2014) further clarifies that PPP-type projects require effective collaboration between project team members and client from the initial stage to its operation, coordinated project information and workflows, and uniform understanding about the project among the stakeholders. With the use of BIM in PF2 projects, access to comprehensive and coordinated project information can be achieved as a whole and will be equally distributed among the project team members. The parties can be more aware of each other's inputs towards the project and any issues can be solved before the facility is being constructed physically on the ground, thus decreasing the possibility of a dispute to happen. The potentials of BIM to support the collaboration and information exchange among the project stakeholders were also raised by Kamara (2012) and Laishram (2013). Kamara (2012) highlighted the benefits of BIM in terms of supporting IPD; thus, having BIM in PF2 projects may encourage IPD elements to be infused in PF2 project, which can improve the smooth running of the project. Laishram (2013) further added that the use of BIM can improve the financial viability of the project as the adoption of BIM during the construction, operation and maintenance of the facility would help to avoid costly errors and saving reworks.

St Helens and Knowsley Hospitals Project is one example of a PFI-BIM project that confirms the benefits of BIM in PPP-type projects. Even though the collaborative working by using BIM was decided after the design work of the project had already begun, which consequently caused some reworking, BIM has facilitated the project to be delivered three months ahead of the original schedule. The project needs to be done in a situation where the adjacent hospitals' buildings need to stay operational throughout the construction period. This is where BIM enables major off-site construction to be carried out to minimise the disruption. It was reported that waste was reduced with 60–70% saving in time to find documents and a 75–80% saving in design coordination (BuildingSMART, 2010). Another PFI-BIM project, Barts and Royal London Hospitals Project, also experienced the benefits of BIM by 10% estimated project total cost reduction. This £1 billion project used BIM in variety of ways including design coordination, construction monitoring and planning especially in installing large medical equipment, cost planning and recording progress with tablet PCs issued to all construction managers and supervisors (Harty, Throssell, Jeffrey & Stagg, 2010).

These examples give some hints that PF2 projects will become better with the implementation of BIM. PF2 is the 'son' of PFI under the umbrella of PPP, therefore it is presumed that BIM could also benefit PF2 in areas it benefited PFI and other PPP variants as well. Indeed, the gist of the implementation of BIM in PPP-type projects is to improve project delivery and performance by reducing the risks in the projects with the values that can be provided by BIM. Synchronising the benefits of BIM as presented in sub-section 3.3 with the PF2 risks factors as mentioned in sub-section 2.4.3, the researcher found that there is indeed huge potential benefits that BIM can bring towards PF2 projects. However, not all risks can be reduced with the implementation of BIM. It is contended that risks which could be mitigated by BIM are mostly risks categorised under Meso and Micro level only. Based on the applications of BIM that have been identified by Azhar et al., (2008), such applications were synchronised with the risk factors of PF2 to show the benefits that BIM may bring to PF2 projects. Figure 3.5 presents the synchronisation of these two.

Risk Level	Risk Subgroup	Risk Factors
Meso	Project initiation	• Planning permission
		• Tendering cost risk
		• Delay in approval and permits
		• Poor public decision making process
	Project finance	• Availability of finance
		• Credit funding from sponsors/investors
		• High financial cost
		• Cost uncertainty
		• Increase capital cost
	Residual risk	• Residual value
	Design	• Organisation and coordination
		• Improper design
	Construction	• Site safety
		• Labour disputes and strikes
		• Low productivity
		• Delay in construction completion
		• Insolvency of subcontractor/suppliers
		• Construction cost overrun
		• Quality risk
		• Unproven engineering techniques
		• Late delivery of equipment and supplies
	Operation	• Frequency of maintenance
		• Performance of services
		• Commissioning risk
		• Project life risk
		• Availability of services
		• Operation cost overrun
		• High maintenance cost
		• Operational revenues below expectation
	Contractual	• Contractual risk
		• Payment risk
		• Excessive contract variation
Micro	Relationship	• Inadequate experience in PPP
		• Inadequate distribution of authority
		• Communication
		• Lack of commitment between parties
		• Differences in working method
	Third Party	• Staff crisis
		• Third party tort liability

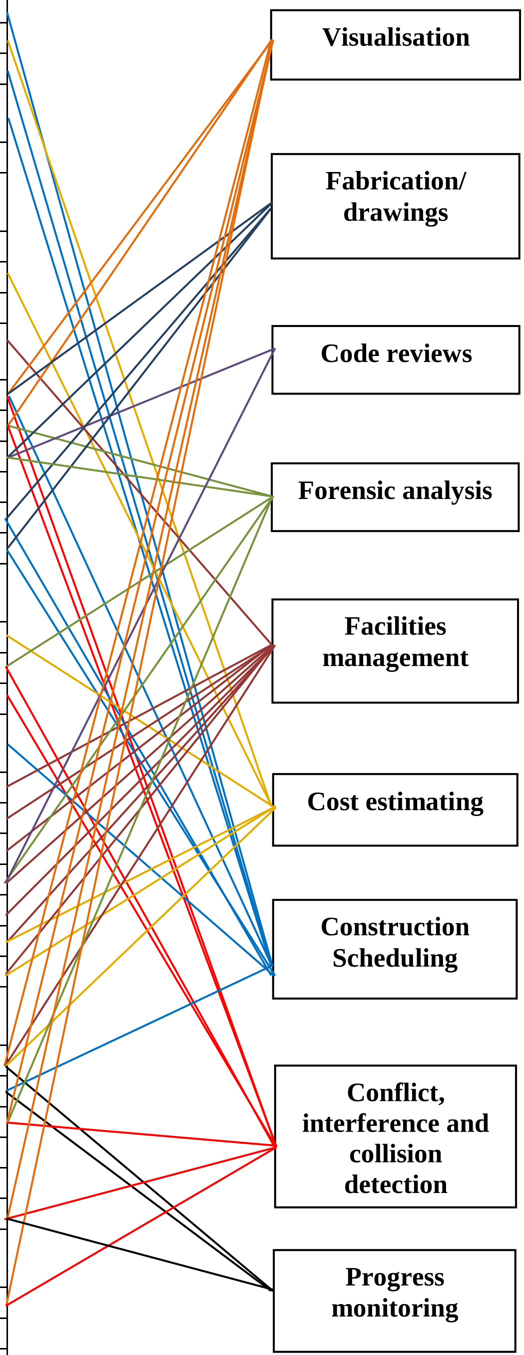


Figure 3.5: BIM potentials to reduce PF2 risks

As presented in Figure 3.5 there are various PF2 risks that can potentially be mitigated by using BIM. A few PF2 risks which might not be possibly addressed by BIM are mostly related to attitude, commitment, conflicts, knowledge and capital cost to implement BIM. These risks are identified as *"availability of finance"*; *"credit funding from sponsors/investors"*; *"high financial cost"*; *"increase capital cost"*; *"labour disputes and strikes"*; *"insolvency of sub-contractors/suppliers"*; *"operational revenues below expectation"*; *"inadequate experience in PPP"*; *"inadequate distribution of authority"*; *"lack of commitment between parties"*; *"staff crisis"*; *"third party tort liability"*. The huge potential of BIM in mitigating PF2 risks justifies its significance in improving PF2 project delivery and project performance, thus showing the relevancy of its implementation in PF2 projects. Nevertheless, it is worth to acknowledge that the success of PF2 projects implementing BIM does not only depend on BIM, but more importantly it depends on other soft factors as well such as parties' attitude, commitment, knowledge and financial capability.

3.8 Summary

This chapter provides an overview of Building Information Modelling (BIM) in terms of its definition, applications, benefits, CSFs and risks. It also provides an insight on the implementation of BIM in the United Kingdom to date. This chapter was written with the purpose to provide understanding on BIM, which subsequently justifies the relevance of BIM implementation in PF2 projects. These pieces of information are important as they relate to contractual risks that might occur which will be discussed in the subsequent chapter. From the literature review, it was found that there is a huge potential of benefits that BIM can offer toPF2 projects mostly in terms of facilitating the minimisation of numerous PF2 risks. However, implementing BIM is not completely as simple as it seems as there are also BIM risks attached to it that need to be considered and to be managed in order to have the optimum advantages of BIM implementation.

Having the understanding of BIM and its relevance to PF2 projects, this chapter provides answers to objective 2 and 3 of the present study, which are to investigate the BIM applications potentials in a project life-cycle, including the risk factors and the CSFs of

BIM; and to critically synthesise PF2 and BIM in terms of the benefits BIM can offer to PF2 projects. As the understanding of PF2 and BIM has been addressed, the next chapter focuses on the core subject of the present research, which are contractual risks in both PF2 projects and BIM projects.

CHAPTER 4

CONTRACTUAL RISK IN PF2 PROJECTS IMPLEMENTING BIM

4.1 Introduction

This chapter concerns the contractual risks associated with PF2 projects and BIM implementation. The purpose of this chapter is to provide the definition of contractual risk as being used for the present study and to provide understanding on the contractual risks within PF2 projects and BIM projects. This chapter also explains how BIM can be used to mitigate contractual risks in PF2 projects. This chapter is structured as follows:

- Firstly, it defines what contractual risks are from the perspective of the present study, which is also the focus of the study;
- Secondly, it elaborates the contractual risks in PF2 projects and the potentials of BIM to mitigate those risks;
- Thirdly, it discusses the contractual risks in BIM by highlighting the possibility of the risks to occur in PF2 projects implementing BIM

The understanding of contractual risk in PF2 and BIM is important as it is the basis to conduct the fieldwork of the research.

4.2 Definition of Contractual Risk

The term ‘contractual risk’ has been mentioned in many research works; however most of them do not exactly define the term. For example, Kangari and Riggs (1989) pointed out that contractual risk is one of the components of project risk. The term is not defined but they provided examples of contractual risk such as lack of contract clarity, absence of communication between the parties, and problems of timeliness in contract administration. In Charoenngam and Yeh (1999), contractual risk is described as one of the types of construction risks. Even though Charoenngam and Yeh (1999) explained contractual relationship as one of the factors contributing to construction risks, they do not mention its link to contractual risk. On the other hand, when Loosemore and McCarthy (2008) explored the differences in perceptions of risk allocation within the traditional construction supply chain, the term 'contractual risk' was not used. However, the authors explained the risks associated with the unclear provisos in a contract and the problem in synchronising express terms and implied terms in practicing contract provisions.

Literally, 'contract' is defined by the Oxford English Dictionary (2017) as, "*a mutual agreement between two or more parties that something shall be done or forborne by one or both*." Rooted from this word, 'contractual' is defined as, "*pertaining or relating to a contract*." Therefore, everything that has a link, correlation, or association with 'contract' is 'contractual'. The term 'risk' is defined by the dictionary as, "*the possibility of loss, injury, or other adverse or unwelcome circumstance; a chance or situation involving such a possibility*." Hence, contractual risk is the probability of an unwanted event to happen arising from matters related to a contract that give bad implication(s) to the contracting parties and the contracting subject.

Some research relate contractual risk with the negative human attitude factor such as in Lyons and Mehta (1997), who opined that contractual risk is the possibility for an agreement to be violated. The examples given include failure to make payment within the agreed time, failure to keep a commercial secret, and failure to conduct the transaction according to agreed rules. Fafchamps, Gunning, and Oostendorp (1998) have explained contractual risk from the view point of the manufacturing environment as imperfect contract compliance by clients and suppliers. This kind of view opens a wider horizon in determining the risky 'matters that related to a contract', making them more subjective as the matters are not only technical in nature as mentioned in most examples given earlier by Kangari and Riggs (1989) and Loosemore and McCarthy (2008), but also involve human behavioural issues which are unpredictable and flexible.

In defining the term 'contractual risk', it is important to understand the relationship between contracts and risks. Keskitalo (2006) gives an interesting view on the relationship between contracts and risks. According to him, their relationship depends on the approaches from different perspectives. From the perspective of legal risks, contracts can be regarded as the sources of risks as contracts create a contractual relationship full of rights and liabilities that can be challenged in court. From the perspective of contract risk, contracts are the tools to deal and solve issues with regards to the risks these contracts are embedded with; therefore, contracts act as an instrument to manage the risks. Finally, from the perspective of business risk where the contracting activity is another branch of the organisations activities, contracts are seen as tools for the management of not only contract and liability of legal risks but also business risks. Hence, with such clarity, the term 'contractual risks' in the context of this study is more inclined towards the perspective of legal risks as the term appears to refer to the risks arising from contracts, not the risks in relation with the contracts dealing, or even the business risks where the contracts manage.

Based on the above discussion, the present study prefers to exclude negative human attitude, which is non-compliance of contract from the term 'contractual risk'. It is important to note that human attitude is a never-ending issue that not only affects contractual dealings but can also be the factor that stains other business dealings, managements, administrations and operations. There is no other way to unravel it, except by only having awareness, working honestly and acting professionally. However, problems arise from practical matters in contracts require specific strategies to be planned in order to overcome or mitigate the problems or alleviate the constraints that cause such problems. Therefore, assuming all contracting parties are working professionally and honestly, contractual risks are those associated with flaws in contract documents, inappropriate documents, or improper contractual relationships which cause the occurrence of risks such as claims and disputes, disruption of work, stoppages of work, lack of co-ordination, delays, and inflated costs (Bufaied, 1987; Akintoye & MacLeod, 1997). These will be the focus throughout this study.

By referring to the above established definition of contractual risks, the next sub-section of this chapter will be discussing the contractual risks in PF2 projects and BIM.

4.3 Contractual Risk in PF2 Projects

PPP/PFI is echoed by many as offering far more benefits than conventional construction procurement methods. However, after a number of projects showing unexpected performances mostly on providing ‘value for money’ as what it is intended to, concerns whether PPP/PFI is truly the way out to ease the financial burden of the government are spreading. Media and many academics have claimed that the PPP/PFI is actually expensive and the taxpayers are eventually paying billions of pounds more than the cost of the project if it is procured conventionally, upon the end of the contract (Gaffney & Pollock, 1999; Shaoul, 2005; Parker, 2009; Skidmore, 2012). Such concerns gradually lead to the reformation of PFI to PF2.

Similar to PFI, PF2 is a risk sharing relationship generated from a partnership arrangement between the public and private sector agents to deliver an agreed-upon infrastructure or services to public users. Such relationship is bound by a contract that specifies the rights, responsibilities, obligations, and liabilities of the parties and also specifies how the risks are allocated among the parties. Regardless of how heavy the critics are towards PFI as an approach to procure public facilities, according to Palmer (2000), the outcome of PFI project whether it presents ‘value for money’ or otherwise, depends on the precise terms of the contract, how the contract is awarded and how it works in practice over the contract life. Contract is actually the heart of any PPP-type projects. Thus, it is important for PF2 projects to have robust and reliable contracts that bind the parties involved in it.

Generally, PPP-type projects involve long term contracts up to usually 25 years or more and involve a myriad of parties to undertake the project. Therefore, the long duration of contracts causes them to be risky due to many known and unknown uncertainties that might happen in future as the time passes. Thus, the PPP contracts are inevitably complicated and incomplete (Iseki & Houtman, 2012). PPP contracts are considered as ‘incomplete’ due to insufficient precision in detailing some circumstances and contingencies during contracting as they are either unforeseen or too complex to be detailed out. The greater the completeness of the contracts, the lower the potential for dispute and abuse (Robinson & Scott, 2009). Therefore, incomplete contract is considered as the contractual risk of PPP/PFI contract. Furthermore, because PF2 is not really different from PFI, the contractual risk of PF2 projects is considered similar. The following are the key areas in the PF2 contracts that are usually incomplete (see Table 4.1).

Key Areas	Description
Concession charges	Difficulties to estimate the concession charges due to the unknown demand and number of users that will use the facility (Clifton & Duffield, 2006).
Services output specification	The use of subjective or ambiguous terminologies in the output specification as it is difficult to specify the services delivery in detail which leaves it open to different interpretations (Robinson & Scott, 2009).
Design output specification	Difficulties in specifying the design output as not all future circumstances can be predicted during contracting (Robinson & Scott, 2009).
Variation	Changes throughout the contract duration to suit the new demand of the users and to resolve future contingencies (Li et al., 2005a). In PF2, the procuring authorities will have the flexibility to add or remove certain elective services once a contract is in operation (HM Treasury, 2012c).
Quality	Difficulties in specifying the quality of the design and services in words. In terms of design, the quality can only be evaluated during construction and after the facility is constructed to see whether it serves the functions intended. In terms of services, the quality can only be appraised after the facility operates through the use of performance appraisal indicator (Akintoye et al., 2003).

Table 4.1: Key areas of incomplete contract in PF2 projects

A document entitled "*Standardisation of PF2 Contracts*" was published by the HM Treasury in December 2012 with the purpose of acting as guidance for the drafting of provisions in PF2 contracts by construction industry players. The document provides a standard form of PF2 contracts template and a pro forma for payment mechanism. This is an effort done by the government to standardise the PF2 service contracts to enable PF2 projects to be procured efficiently with reduced time and cost. At the time of writing, this was the only contractual document available for PF2 in the UK. The compatibility of this document to support BIM implementation was doubted. Even though relevant BIM Protocol can be used as supplementary contract to be attached to the PF2 contracts, a proper review of the document needs to be undertaken to ensure that it is suitable to be used in the PF2 environment.

In comparison to other procurement systems, drafting a PF2 contract is considered to be more challenging. Elements of the project such as the technology used, procurement processes and procedures, facilities management, life cycle costing, the myriad of parties involved, payment mechanisms, concessions, etc.; all need to be clearly expressed by considering that this is a long term contract and ensuring that the targeted VfM for the project as well as, the win-win situation between the private and public sectors are achieved. With the nature of PF2 contracts, which needs them to be sustained for a long period of time, the 'living' or incomplete contracts are also needed in order to manage the unexpected situations that might happen throughout the construction and operation periods. These includes new incoming technologies that substantially users' needs, price variation during construction, service price variation during operation, inflation, and changes in law (Iossa et al., 2007; Habets, 2010). Furthermore, Iossa et al. (2007) identifies reasons why PPP-type projects contracts require flexibility. Among others, this is because some circumstances that may affect the contract terms are not predictable and cannot be incorporated in the initial contract, to reduce transaction costs by including only selected contingencies in the contract, and to correct past decisions which turned out to be wrong as the projects are running.

The use of BIM in PF2 projects will not fully and completely resolve the incomplete contract issues in PF2 projects. In spite of that, BIM will help bring a new perspective to deal with such issues. Difficulties in estimating the concession charges might not be able to be resolved through BIM implementation; nevertheless, if the project team members are able to use BIM wisely, the project total cost in construction and operation can be significantly reduced, which would consequently help to expand the profit margin. The surplus profits, other than can being able to be enjoyed by both the public and private sectors (as the public sector is also a co-investor in the SPV), can also be used to cover any uncertain additional operating cost that may occur due the unknown demands of the facility that cannot be determined during the initial stage of the project.

Certain parts in the issue of incomplete design and output specifications can be solved via BIM. The use of BIM in PF2 projects forces the builders, facilities managers and operation and maintenance managers to be present as well as to be actively involved in the decision-making process from the early stage of the design. This, consequently, may address the initiation-design-construction-operation timescale loops problem as the knowledge and needs of the parties involved can be exchanged across organisational boundaries. Hence, rigorous discussion between all the project team members with the client can be done, and this may lessen possibilities of inconsistency of understanding among the parties involved. In PF2 projects, the presence of the government's representative in this important stage of decision making can greatly bridge the gap between the public and private entities. Accompanied simultaneously with BIM's capabilities of providing visualisation, forensic analysis of the design, cost estimating and clash detection throughout the process, constraints and issues related to incomplete design and output specifications can be significantly alleviated provided that the FM and Operations and Maintenance (O&M) inputs are smoothly permeated without any drop-off along the process. Commitment and collaboration are critical for the success of this process.

Not much might be able to be done by BIM in the issue of difficulties in specifying the quality of the design and services; but due to close discussion, integration and collaboration among the parties involved in PF2 projects, the risk of having poor quality facility and services might be fairly reduced. In the case of variations, changes in the design due to clashing building elements should not happen under BIM because this kind of problem would have been settled in the pre-construction stage. Nevertheless, other reasons for variation such as changes in the client's requirement to cope with the users' new demand and the addition or removal of elective services might happen in the future. In these situations, BIM would be able to assist the FM and O&M Managers in the planning of the building spaces to manage the variation, providing quick and accurate costing for such variation and spreading the information to all relevant parties involved including the client. Thus, with BIM there will be more systematic workflows and efficient processes in managing variations.

4.4 Contractual Risk in BIM which Needs to be Considered in PF2 Projects Implementing BIM

The potentials and benefits of BIM are much discussed by scholars and construction practitioners. However, within BIM, there are contractual risks that need to be addressed to ensure the smooth-running of its implementation in a project. At the time of writing this thesis, there is no known recorded legal case with regards to BIM in the United Kingdom or elsewhere, except for, in the United States, where one legal case on BIM was reported by many (Matthews, 2011; Eadie, 2014; Sabo, 2014). The case was on the construction of a life sciences building using BIM in the United States, where the architect who worked with the M&E engineer failed to inform the contractor on the specific installation sequence of mechanical and electrical ducting into the ceiling plenum, causing the space to run out when 70% of the building was almost completed. BIM was used to design the ducting system, but the contractor was provided with 2D documents for construction. The contractor and the architect sued each other; however, they finally managed to settle the case out of court with both parties agreeing to stay anonymous to protect their commercial interest.

The above US case is an example of the consequences when there is a lacking of communication and coordination in a BIM project that might happen in other projects elsewhere as well. Although at the moment no other legal cases have been reported in the United Kingdom, the risk of disputes on BIM occurring cannot be underestimated. The key for a successful BIM implementation does not mainly depend on the contractual framework, but on the effective collaboration and good communication among the client, contractors, consultants and suppliers. Nonetheless, a robust contractual framework is needed to support BIM implementation in providing clear contractual procedures and clear roles, duties, liabilities and rights of the parties involved. In the situation where BIM is implemented in PF2 projects, the contracts need to be sustained for a lengthy period of time, hence it is indeed critical for the contractual risks to be noted and addressed from the early stage of the projects. Based on the review of literature, scholars have listed many contractual risks of BIM. After scrutinising these said risks, the researcher concluded that there are five key contractual risks related to BIM that need to be considered in PF2 projects implementing BIM, which will be discussed in sub-section 4.4.1 to 4.4.5 hereinafter.

The integration of BIM into the process of project delivery will give substantial impact to the working environment, working methods and the relationships of parties involved in the project. The use of BIM will definitely require changes in the way the project team members normally bind their contract. Additional contractual risks due to BIM implementation are inevitable and need to be adequately addressed in their conditions of contract in order to obtain the full benefits of BIM. Many recognised that BIM is closely related to collaborative working, which therefore requires collaborative contractual model to address contractual issues unique to its use (Hurtado & O'Connor, 2009; Winfield, 2015a; Manderson, Jefferies & Brewer, 2015; Klein, 2015). Even though radical changes to the current legal model may not be required in Level 2 BIM (Glover, 2012; Currie, 2014), as it is not supposed to alter the original roles and responsibilities of the project team members and client, most legal commentators agreed that Level 3 BIM requires far greater changes to cater to the need of extensive sharing of information as well as horizontal cooperation and collaboration in a project delivery (Sinclair, 2012; Claremont, 2014; Savage, 2014; Golden, 2015). Considering the legal and contractual implications of BIM, some efforts have been done to revolutionise the existing standard contractual documentation and practice in order to make them BIM-enabled. Some examples of the contractual documents are Joint Contracts Tribunal (JCT) Public Sector Supplement; NEC Guidelines: How to Use BIM with NEC3 Contracts; CIOB Complex Project Contract 2013; and CIC BIM Protocol. At the time of writing this thesis, all of the current contractual documents were mostly designed for design and build project. However, only CIC BIM Protocol was claimed to be suitable for use on all Level 2 BIM projects.

Despite the presence of the CIC BIM Protocol in the UK construction industry, criticisms regarding its comprehensiveness and the relevancy of the clauses contained in it were found in some of the literatures. Al-Shammari (2014) has highlighted the weaknesses of the Protocol in addressing information management issues and intellectual property issues. The Protocol was also said to be unsupportive of collaborative working. Klien (2015) has criticised the Protocol as it only includes consultants and tier-one contractors; therefore, not covering the whole parties involved in the BIM project. Moreover, Klien (2015) also questioned the ability of the Protocol to address common data environment (CDE) issues. In a research conducted by the Centre of Construction Law and Dispute Resolution, King's College London (2016), several weaknesses of the Protocol were highlighted and proposed to be reviewed. These are:

1. The overriding effect of the Protocol that has a significant impact to each of the existing contracts annexed to the Protocol, which may cause problems in interpretation of the clause;
2. No warranty of the integrity of the electronic data which affects the data reliance;
3. Unclear integration of the Protocol's appendices of practical documents (Model Production and Delivery Table, Levels of Detail, Employer's Information Requirements, Common Data Environment, BIM Execution Plan) with the consultant services schedules, the project brief, and the project programme.
4. The Protocol using the term "reasonable endeavours" in setting the expectation of the duty of care. Such term is unclear, lower and less clear "duty of care" than the accepted standard of reasonable skill and care.

In the context of PF2 projects, the use of the CIC BIM Protocol might not be relevant as PPP-type projects normally used in bespoke contracts. The use of a single standard contract might not be appropriate as it may cause some parties not being well-served in a different situation. However, the Protocol is seen as a general illustration of how contractual risks of BIM are being addressed in a contract, therefore it can be a great lesson to be learnt for people involved in the drafting of PF2 projects implementing BIM. The following sub-sections discuss the five key contractual risks of BIM as identified from the literature together with the discussion of how these risks are being positioned in the CIC BIM Protocol. This may in turn inspire the way such contractual risks to be addressed in the contracts of PF2 projects implementing BIM.

4.4.1 Information management

Coordinating and integrating project data together with the sharing and exchange of the data among multiple parties in the course of building and operating a facility require a person or an entity to act as the Information Manager. Although such a role is not new in the construction industry as, traditionally, the project manager or contractor acts as the information provider and manager for the construction project; in the case of projects implementing BIM, where coordinating, integrating, sharing and exchanging data are more complex; such role is becoming more vital. Several issues have been raised by construction lawyers with regards to the role and position of the Information Manager.

Hurtado and O’Connor (2008) and Winfield (2015) were concerned on the duties and powers of the Information Manager due to the impact to the project workflows and to ensure the contracts oblige parties to comply with the directions and instruction given by the Information Manager in regards to data-related matters. Udom (2012) highlighted the procedures on the appointment of the Information Manager with regards to issues such as who appoints the information manager, how is the manager to be replaced and who bears the cost arising from this role.

The CIC BIM Protocol mentioned the need to appoint the Information Manager by giving two options, which are by appointing a stand-alone Information Manager or by forming the duties under an existing appointment of Design Lead or Project Lead. It is noted that there is inconsistency between the CIC BIM Protocol and PAS 1192:2013 (Note 3, Sub-clause 7.5.1) as the latter document states that the Information Manager is not a stand-alone role:

> The information manager is not a stand-alone role and is expected to shift from design team to contractor prior to start on site. Under the BIM Protocol, a client is obliged to appoint an information manager at all project stages (BSI, 2013, p.17).

The duties of the Information Manager have been prepared by the CIC in the *“Scope of Services for the Role of Information Management”* document. However, there are still unclear procedures on the appointment of the Information Manager, how the role is going to pass on to the relevant project team members, the contractual relationship between the Information Manager and other project team members, and the powers to issue instructions regarding project data.

In the context of PF2 project, it is also unclear how the Information Manager is to be positioned within the PF2 contractual structures, how the transition from construction stage to operation stage affects such role, and if the role of the Information Manager needs to be sustained during the operational stage, specific responsibilities, duties and powers need to be expressly provided in the contract or in the BIM Protocol. As the PF2 project involves complex and lengthy contracts, it might also be relevant to recommend one ideal way of appointing the Information Manager, rather than giving options to be chosen as this will lead to non-standardised practice of PF2.

4.4.2 Data reliance

While Clause 2.2 of the CIC BIM Protocol puts priority on the BIM models over other documents or data extracted from the models, Clause 5.1 of the Protocol denies the integrity of the BIM models delivered in accordance with the Protocol. The clause states:

> Without prejudice to the Project Team Members' obligations under this Protocol and the Agreement (between the Employer and Project Team Member), the Project Team Member does not warrant, expressly or impliedly, the integrity of any electronic data delivered in accordance with this Protocol.

Udom (2013), Klien (2015) and Winfield (2015) strongly criticised the provision due to fact that such provision carries the meaning that the parties are not able to rely on BIM data. This is highly illogical as collaborative working environment and common data environment (CDE) depend on BIM models/data as the trusted and reliable source of information. This in fact contradicts the definition of CDE as stated in the PAS 1192-2:2013 (Note 3, A.30, Annex A) document:

> The fundamental requirement for producing information through a collaborative activity is to share information early, and to trust the information that is being shared as well as the originator of that information…The CDE is a means of allowing information to be shared efficiently and accurately between all members of the project team – whether that information is in 2D or 3D, or indeed textual or numeric.

Such disclaimer, if included in PF2 contracts, might cause difficulties in handling project data during the construction and operational stage. Any dispute arising from this disclaimer might jeopardise the intention to have collaborative and integrative environment as needed by PF2 projects. FM managers rely on BIM data during the operational stage as BIM can be combined with the intelligent building system to provide and maintain building performance information and life-cycle cost. Therefore, it is important for the data to be completed and to be accurate before handing over the project to the FM. What would be the incentive for the project team members to exercise the reasonable skill and care in producing the BIM model and data if such disclaimer is being put in the contracts?

Such disclaimer existing in the BIM Protocol might be to protect the project team members against any errors in the BIM models due to data degradation that might occur as the time passes. However, this situation shows that the reliability of the BIM models is at risk. Therefore, proper measures need to be undertaken to address this issue such as to have tangible hardcopy project data extracted from the completed, revised and validated models as the alternative backup for future reference. This might cause additional cost but may be worth the extra step in order to manage bigger risks of missing data and liabilities that might happen in the future.

Another issue of data reliance is on the risk that any parties might be referring to out of date data due to communication breakdown. BIM gives direct access to a model to a variety of parties. If the models have errors or is not updated, any of the parties might be exposed to the possibility of making the wrong decision or allocating resources based on the wrong information (Foster, 2008; Udom, 2012). More time spent in putting and reviewing BIM data will lead to new cost in the design and project administration process, therefore the issue then arises on who will bear the cost (Azhar, 2011). Thus, variation protocol with regards to BIM models might be relevant to be included in the contract to ensure systematic information management on data variation, so that all parties are aware of any latest changes and can respond to them in a timely manner. Furthermore, information sharing protocols might also be needed to ensure only validated and the latest version of the models are shared amongst the project team members.

Not every model serves all purposes, therefore the level of reliance should be spelled out in the parties' contract (Hurtado & O’ Connor, 2008). Although Clause 4.1.1 of the BIM Protocol requires the Project Team Members to produce models to the Level of Detail (LOD); however, there is no provision that mentions the actions to be taken if the design goes further than LOD and the other parties rely on the model’s accuracy more than the defined LOD. Additional clauses to make clear and to deal with such issues might need to be spelled out in the construction contract in the PF2 project to avoid the possibility of dispute to arise on this matter.

4.4.3 Status of BIM model

The US case regarding BIM as presented in section 4.4 gave a clear illustration on how BIM modelling in practice is frequently used along with hardcopy 2D drawings. Therefore, any inconsistencies between BIM model and the 2D drawings or other data extracted from the model can significantly lead to complications and conflicts. The BIM model evolves and changes over the design period and also over the operational period in order to cater to any new demands from the client and users. Therefore, any drawings or data extracted from the model carry a large risk to be outdated if there are changes to the BIM model.

This situation has raised the issue on whether the model is considered as the contract document or not and the extent to which the BIM model could stand as a contract document (Ashcraft, 2008; McAdam, 2010; Dougherty, 2015). Winfield (2015) considered that there is no real need for the BIM models to be part of the contract documents and it is enough for the models to be treated as contract deliverables. Therefore, the scope of the models can be formalised in the contract without the need to define and interpret which model and at which stage the models will form contract documents. While Winfield's opinion is considered relevant, the CIC BIM Protocol is silent about the status of the BIM models. However, Clause 2.2 in the BIM Protocol states that in the event of any conflict or inconsistency between the models and any document or information extracted from the model, the models shall prevail. Thus, it is obviously shown that the BIM models will be the focal point of reference for the project team members to rely on during the construction and operational stage, taking precedence over the 2D documents.

Notwithstanding the issue of whether the BIM models are contract documents or otherwise, proper clear mechanism and procedures for dealing with such inconsistencies need to be spelled out in the contracts; such as confirmation procedures with the designers or other project team members in order to ensure which version of the data is reliable. This issue is not unique for PF2 project, as other projects that implement BIM might also be facing the same problem. However, as PF2 contracts are lengthy and the BIM models need to be referred and maintained by the FM managers during the operational stage, it is considered wise to put a clear provision on the legal status of BIM models.

4.4.4 Intellectual property rights

In PF2 projects implementing BIM, the project stakeholders are all able to share and add details to the BIM federated model. Therefore, it is not easy to separate the contributions of the parties, which may lead to intellectual property rights (IPR) and ownership issues. In the United Kingdom, an intellectual property right is governed by the Copyright Designs and Patent Act 1988 (CDPA). The CDPA also protects rights in electronic databases (CDPA, Section 3A (1)), which are also likely to include BIM models (Currie, 2014).

Despite the problems arising regarding the intellectual property rights and ownership in BIM projects, at BIM Level 2, these problems are quite easily resolved. This is due to the fact that each project team member works on their individual models and subsequently the models are then submitted to the Information Manager to be combined to become the federated BIM model. Therefore, it may be relatively easy to trace the ownership of each data provided and to preserve the IPR of each contributor. As the Information Manager is responsible to integrate the data from the contributors to develop the common data environment, a question arises whether it is necessary for the Information Manager to have IPR on the BIM model as he may use sufficient skills in coordinating the various models (Currie, 2014).

Another issue in this area is on the lifecycle use of the BIM model and the need for the client to own the BIM model for the purpose of facilities management, maintenance and further development of the facilities (Foster, 2008; McAdam, 2010; Azhar, 2011; Chao-Duivis, 2011). In PF2 projects environment, after the construction stage, the BIM model or data in COBie format will be transferred to the FM managers who will then use the model and the data during the operational stage and afterwards hand over all of the project data to the Employer after the end of the PF2 contract period. There has been no definite answer as to who BIM’s copyright owner is in the Standardisation of PF2 Contracts or BIM Protocol. As in the Standardisation of PF2 Contracts document, the parties are being given three options to choose from (Clause 33.3.2, Standardisation of PF2 Contracts, p. 315):

a) The ownership of the IP in the Project Data can be transferred from the SPV to the Client and licensed back to the SPV for use in the Project. This option gives the Client the greatest level of security because regardless of what will happen to the SPV or the contractors under him, the Client will own and therefore be able to use the data and IP for any purpose;
b) The SPV retains the ownership of the IP in the Project Data but grants wide licence to the Client to use for the project and other projects, and to enjoy the Services. However, if the SPV becomes insolvent, the licence may become ineffective. The licence is royalty-free, perpetual, irrevocable, sub-licensable and transferable.
c) The SPV retains the ownership of the IPs in the Project Data and grants narrow licence to the Client to use for the project only. However, if the SPV becomes insolvent, the licence may become ineffective. The licence is royalty-free, perpetual, irrevocable, sub-licensable and transferable.

Therefore, it is up to the parties within the PF2 contract to determine the option to be chosen for the project they participate in. However, for the first option, the Employer is more secure as if anything happens to the SPV, the ownership of the project data remains with the Employer and the project can survive and the data remains secured. Other options put the Employer in a risky condition as should the SPV become insolvent, the licence may become ineffective and thus; will affect the PF2 project.

As for the CIC BIM Protocol, the Project Team Members shall grant either non-exclusive licence (Clause 6 of CIC BIM Protocol) or full ownership of the IPR to the SPV (Note 3.4 of CIC BIM Protocol Guidance). Both CIC BIM Protocol and Standardisation of PF2 Contracts are quite clear in setting out the IPR provisions. The concern now is the need for all parties in the PF2 project to be aware of the options available in both documents; and to decide from the beginning of the project which option that they want to choose and specify that in the contracts, depending on the suitability and nature of the project. There is also a clash between CIC BIM Protocol (Clause 6.4) and Standardisation of PF2 Contract (Clause 33.5.1). In case the parties choose to opt for the SPV to retain the ownership of the project data, the copyright licence granted by the SPV is revocable under the CIC BIM Protocol, but has to be irrevocable under the Standardisation of PF2 Contract. Thus, even though CIC BIM Protocol takes precedence over any contract attached to it, in the case of PF2, special consideration should be taken due to the nature of the PF2 contract which is far lengthier that other design and build contracts.

4.4.5 Liability

BIM federated model is the result of a combination of various contributions from the Project Team Members and client. Therefore, it is quite difficult to determine the liability for such contributions when everything has been put together to create a model. While concerns on this issue are spreading in the construction industry, it is actually a factual reality that no matter to what extent BIM is being integrated, it does not necessarily change the liability position or the contractual relationship (Sebastian, 2010; Liszka, 2011). The liabilities and risks shouldered by the Project Team Members remain as usual unless any of them have additional roles in managing the BIM data. In the situation where the role of the Information Manager is being put under the existing Project Team Members, he might be liable for any error in the BIM model or data due to poor management of the data, mistakes in providing information to the other parties, and incompetency in coordinating and integrating BIM models from contributors. PF2 contracts should be able to clarify the liabilities of the Information Manager with regards to the implementation of BIM; therefore, all parties would be well aware of such matter.

The use of BIM in PF2 projects requires all parties in the Project Team to work collaboratively even though there is no privity of contract between them. In situations where any error occurs in the design or in the physical building due to mistakes on the designers' part, the builder has no entitlement to sue the designers or request for compensation as there is no contractual relationship between them. Commenting this scenario, Foster (2008) and Dougherty (2015) highlighted the possibility of the builder or any other party who is affected by such negligence to use economic loss rule doctrine to cover their loss as this might be the way to compensate themselves in the absence of contracts with the designers. However, under the economic loss rule, only actual economic loss or damages suffered by the affected parties can be covered, which means that proper calculation on the actual loss due to such negligence needs to be done and approved or determined by the court. In relation to this issue, Winfield (2015) suggests for the parties to consider at the pre-contract stage if the designers or other consultants could provide warranty, indemnity or assurance as the integrity of the electronic data in the model or at least a standard of care for checking the integrity of the BIM model. While the latter is considered relevant to be practiced in PF2 contracts, the earlier suggestion seems to be in contradiction to the disclaimer stated in Clause 5.1 in the CIC BIM Protocol as discussed in sub-section 4.4.3.

Clause 5.1 of the CIC BIM Protocol is considered as an exclusion clause. According to Adriaanse (2016), there are two types of exclusion clause, which are: (1) a clause that totally excludes the liability of what would otherwise be the liability of the party in the event of breach, also known as exemption clause; and (2) a clause that limits the liability by means of limiting the sum of the replacement value of the defective item or service, also known as limiting clause. Based on the definition given by Adriaanse (2016), Clause 5.1 is considered as an exemption clause as it totally releases the project team member from the liability of the accuracy of the data provided in the BIM model. While contracting, it is important for the parties to the contract to be fully aware of and understand if there is any exclusion clause included. The importance of understanding the width of the exemption clause by the contracting parties is explained in the cases of *Photo Production v. Securicor Transport* (1980) and *Curtis v. Chemical Cleaning* (1951).

In the case of *Photo Production v. Securicor*[3] *Transport*, it showed how the exemption clause saved Securicor Transport from liability. It was stated in the contract, that Securicor Transport is exempted from any loss, "except in so far as such loss is solely attributable to the negligence of the company's employees acting within the course of their employment." Therefore, it was not a complete exclusion clause, and Securicor Transport would remain liable if it had not exercised due diligence. In the case of *Curtis v. Chemical Cleaning*, Lord Denning L.J[4] responded as in the following excerpt:

[3] *Photo Production Ltd v Securicor Transport Ltd* [1980] 1 All ER 556
[4] *Curtis v. Chemical Cleaning* [1951] 1 All ER 631, p. 634

> The present case is of importance because of the many instances nowadays when people sign printed forms without reading them, only to find afterwards that they contain stringent clauses exempting the other side from their common law liabilities. In every such case it must be remembered that, if a person wishes to exempt himself from a liability which the common law imposes on him, he can do it only by an express stipulation brought home to the party affected and assented to by him as part of the contract … any behaviour by words or conduct is sufficient to be a misrepresentation if it is such as to mislead the other party about the existence or extent of the exemption. If it conveys a false impression, that is enough. If the false impression is created knowingly, it is a fraudulent misrepresentation; if it is created unwittingly, it is an innocent misrepresentation. But either is sufficient to disentitle the creator of it to the benefit of the exemption … by failing to draw attention to the width of the exemption clause, the assistant created the false impression that the exemption related to the beads and sequins only, and that it did not extend to the material of which the dress was made. It was done perfectly innocently, but, nevertheless, a false impression was created.

Lord Denning L.J explained how the ignorance on the extent of exemption clause can lead to false impression and misrepresentation. As the remedy might be the possibility that the parties can rescind the contract, the right to rescind might also be lost if the misrepresentation is known long after the contracts concluded. Hence, it is really crucial for the contracting parties of PF2 projects including the Client, to review the relevancy of having the same kind of exemption clause as what we had in the CIC BIM Protocol.

4.5 Summary

This chapter provides understanding on contractual risks in PF2 projects and BIM as well as describing the potential of BIM in mitigating contractual risks in PF2 projects. Such potential increases the relevance of BIM to be used in PF2 projects. This chapter also highlighted five key contractual risks that need to be considered in PF2 projects implementing BIM (see 4.4.1 – 4.4.5). These will be the basis in conducting the data collection for the research. Figure 4.1 depicts the theoretical framework which is developed based on the literature reviews. The framework indicates that the implementation of BIM can improve the collaboration, risks mitigation, integration and coordination in PF2 projects. However, such implementation may expose PF2 projects to

BIM-related contractual risks. In addressing this issue, the strategies to manage the contractual risks have to comprehend the CSFs in order for PF2 projects implementing BIM to become successful.

The next chapter will provide an overview of the contrasting philosophical approaches to Social Science research vis-à-vis data collection and analysis, the narrative of which then justifies the research process employed to achieve the main aim and objectives vis-à-vis the develop a conceptual framework of the critical success factors and contractual risk for the strategic management of PF2 projects implementing BIM.

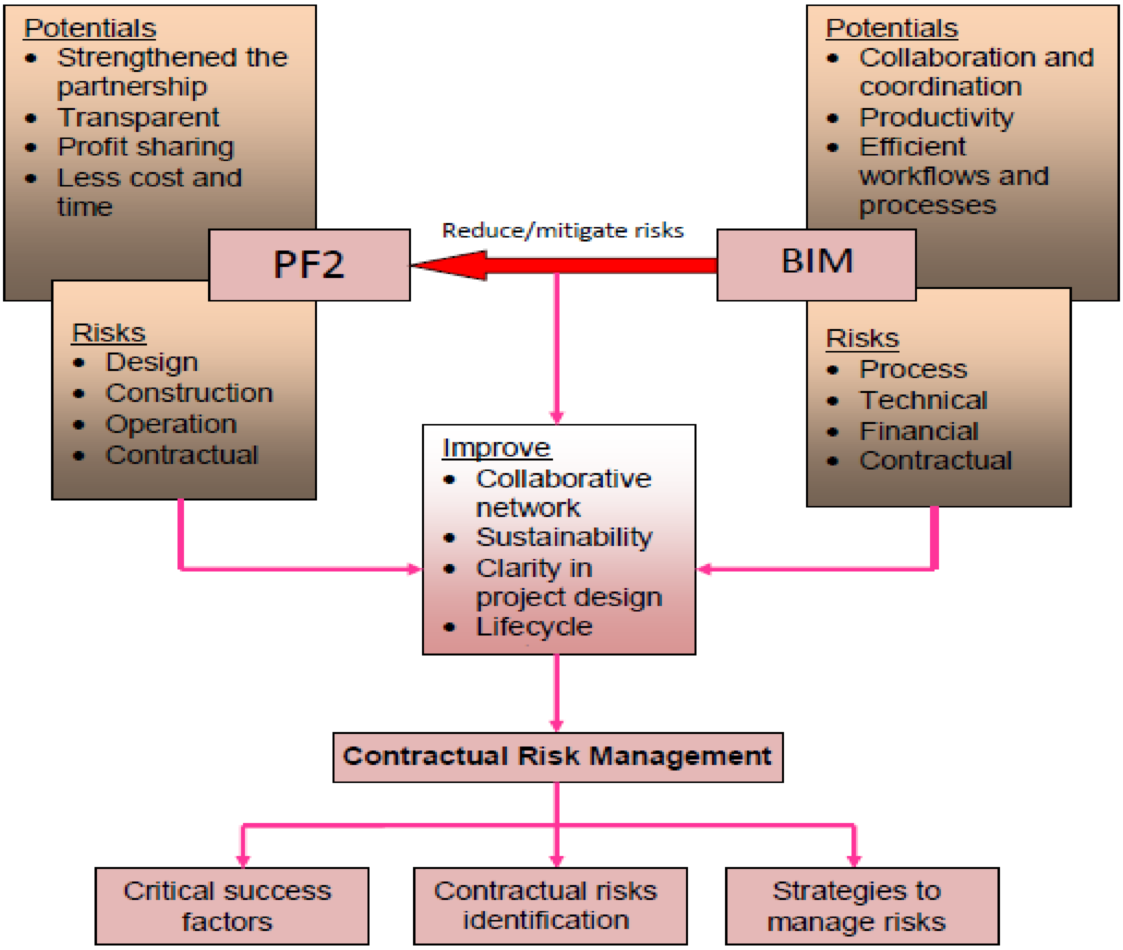


Figure 4.1: Theoretical framework of the study

CHAPTER 5

RESEARCH METHODOLOGY

5.1 Introduction

Research methodology is a systemic research approach that combines specific methods and techniques depending on the philosophical stance of the researcher. This philosophical stance includes the decisions and assumptions about the epistemology, ontology (Easterby-Smith, Thorpe & Jackson, 2012; Sarantakos, 2013) and axiology (Sexton, 2003), which create a clearly defined path on how the research is to be conducted. It is the approach that a researcher adopts in searching for the answer of the research questions and in achieving the research aim.

This chapter elaborates the research methodology employed for the present study. This includes the discussion on the research philosophy, its relation to the study and how it determines the research methodological choice, strategies and methods for the study. Furthermore, this chapter reports how the data collection and data analysis were conducted and how these relate to the aim and objectives of the study as presented in Chapter 1 of this thesis.

5.2 Research Design Approach

Research methodology is a procedural framework within which research is constructed (Remenyi et al., 2002). In pursuant to this, understanding the fundamental issues in designing the research methodology is critical as it influences every decision in the process of formulating an effective methodology. These fundamental issues include the awareness of the philosophical issues that root the logics behind the adoption of the research approach, decision of methodological choice and research instruments. Appreciating these issues and their influences towards the research can increase the quality of the research and enhance the creativity of the researcher in designing the methodology (Easterby-Smith, Thorpe & Jackson, 2012).

The relationships between research philosophy and research methodology have been illustrated by academics in so many ways. For example, Kagioglou, Cooper, Aouad, and Sexton (2000) introduced 'the nested model'; Saunders, Lewis, and Thornhill (2012) had developed a model so called 'the research onion'; and Easterby-Smith et al. (2012) used the metaphor of a tree trunk to illustrate the influence of philosophy in determining the way research methodology is designed. These models are slightly different from each other; however, they highlighted the fundamental components and stages in designing research methodology design, which are research philosophy, research approach or the theoretical drive, research strategy, and research technique and research process. A detailed reasoning and justification of the choices made for all of the components is provided in the following sections.

5.3 Research Philosophy

Research philosophy relates to the development and the nature of the knowledge. It is the assumption on the way one might view the world and from this view, it leads to how one decides on the plan for the research (Saunders et al., 2012). Other researchers might call research philosophy as 'worldview' (Creswell, 2009) or 'paradigm' (Liyanage, 2006; Lincoln, Lynham & Guba, 2011); nevertheless, Gliner, Morgan, and Leech (2000, p. 17) summarised this argument with a statement:

> …paradigm is a way of thinking about and conducting research. It is not strictly a methodology, but more of a philosophy that guides how the research is to be conducted. More important, paradigm determines the types of questions that are legitimate, how they will be answered, and in what context they will be interpreted.

Reviews on past research in social sciences lead to the discovery that there is an inevitable link between social science research and philosophy. Indeed, Gill and Johnson (2010) mentioned that the best approach to research is to compromise the options based on the philosophical understanding or the basic worldview. This understanding will be the foundation to argue that something new and valuable has been added to the body of knowledge through the particular research (Remenyi, 1998). Moreover, Easterby-Smith et al. (2012) emphasised the importance of philosophical issues in research by highlighting that the failure of the researchers to think through the philosophical sphere can seriously affect the quality of the research. There are three reasons why it is important to understand philosophy when conducting a research, which are (Gliner et al. 2000; Easterby-Smith et al. 2012):

a) it helps to clarify the research design;
b) it helps to define the suitability and applicability of research design within the research context;
c) it helps the researcher to invent a research design which is new to the researcher.

Therefore, the following sections will describe the researcher's view on what knowledge (ontology) is, how the knowledge is gained (epistemology) and the role of value (axiology) with respect to the present research.

5.3.1 Ontology

Ontology is the researcher's view of the nature of reality and existence, the connection between truth and facts (Easterby-Smith et al., 2012; Saunders et al., 2012). Sexton (2003) put ontology in a continuum between realism and idealism; however, Easterby-Smith et al. (2012) expanded the continuum further to nominalism. The positions along the continuum can be seen in Table 5.1.

Ontology	Realism	Internal Realism	Relativism / Idealism	Nominalism
Truth	Single truth	Truth exist, but is obscure	There are many 'truth'	There is no truth
Facts	Facts exist and can be revealed	Facts are concrete, but cannot be accessed directly	Facts depend on viewpoint of observer	Facts are all human creations

Source: Adapted from Easterby-Smith et al. (2012)

Table 5.1: The connection between truth and facts in ontological continuum

Drawing the understanding from Table 5.1, realism represents the position which is extremely objective in nature, where there will be only one reality in which there are pre-determined concrete evidences that can be revealed to confirm the reality. Internal realism is less rigid but yet still objective by having the view that single reality exists but the facts that support the reality cannot be accessed directly. Relativism or idealism is more subjective by having the view that there is no single reality and a reality is perceived on what the observers think is true. The last position in the continuum is nominalist who views that there is actually no truth and all facts are created by people just for the purpose to support the 'reality' that they created.

In relation to the present study, relativism or idealism can be identified as the most appropriate ontology. As set out in the objectives of the study, the researcher is to evaluate the views of the respondents on the CSFs, contractual risks, and the strategies for contractual risks management for PF2 projects implementing BIM. Therefore, the study takes the ontological assumption that the answer to the research problem is not single as there are going to be different views from different respondents based on what they think is right, and the outcome of the study is routed based on these views and experience of the respondents who are involved in PPP and BIM environment. The study is also not nominalism as the researcher believes that there are always true answers to the research problem or a situation, and the answers are barely created but are based on previous experiences and lesson learnt from others. In this research, as the outcomes are derived from the investigation of people's views, the true answers are not a 'one size fits all' type of solution. The strategies to manage the contractual risks are recommended in multiple choices as the researcher believes, the true answers also depend on the situation (case by case basis). Thus, relativism or idealism seems to be appropriate within the context of the present study.

5.3.2 Epistemology

Epistemology is about how we acquire and accept knowledge. Epistemology sets up a foundation for us to understand and identify what is considered as a warranted scientific knowledge (Johnson & Duberley, 2000; Sexton, 2003; Easterby-Smith et al., 2012; Saunders et al., 2012). There are two main contrasting philosophies identified by most scholars, which are labelled as positivism and social constructionism/interpretivism (Hughes & Sharrock, 1990; Johnson & Duberley, 2000; Collins & Hussey, 2003; Sexton, 2003; Easterby-Smith et al., 2012). Table 5.2 shows the epistemology continuum, their characteristics and the link between the epistemology and ontology.

Ontology	**Realism**	**Internal Realism**	**Relativism / Idealism**	**Nominalism**
Epistemology	**Strong Positivism**	**Positivism**	**Constructionism / Interpretivism**	**Strong Constructionism**
The observer	Must be independent	Must be independent	Is part what is being observed	Is part what is being observed
Human intervention	Should be totally irrelevant	Should be irrelevant, but takes minor consideration in inferring the nature of reality	Are the main drivers of science, while accepting minor inhuman objective facts	Are the only drivers of science
Explanations	Must demonstrate causality to confirm predetermined theory	Must demonstrate causality to test the predetermined theory or to generate new theory	Aim to increase general understanding of the situation	Aim to create the understanding of how and why the situation took place
Research progresses through	Hypotheses and deduction	Propositions and deduction	Gathering rich data from which ideas are induced to answer the research questions	Gathering rich data and creating meaning
Concepts	Need to be defined so that they can be measured	Need to be defined so that they can be tested	Should incorporate stakeholders' perspectives	Should incorporate stakeholders' perspectives and applicable to the researcher himself

Table 5.2: Epistemology continuum, their characteristics and the link between the epistemology and ontology

Ontology	Realism	Internal Realism	Relativism / Idealism	Nominalism
Epistemology	**Strong Positivism**	**Positivism**	**Constructionism / Interpretivism**	**Strong Constructionism**
Generalization	Statistical probability	Statistical probability with minor theoretical abstraction	Theoretical abstraction with minor statistical probability	Logical theoretical abstraction
Sampling requires	Large numbers selected randomly	Large numbers selected randomly	Small numbers of cases chosen for specific reasons	Small numbers of cases chosen for specific reasons

Source: Modified from Easterby-Smith et al. (2012)

Table 5.2: Epistemology continuum, their characteristics and the link between the epistemology and ontology (cont'd)

The key idea of the positivism position is the single truth or the reality is measured through objective methods, excluding social elements intervention (Easterby-Smith et al., 2012). Positivism is directly associated with objectivism in which the knowledge that develops through it is based merely on objective empirical measurement, experiment or observation rather than being influenced by one's experience, feeling or intuition. Data and evidences collected are used to search and proof regularities and causal relationship where it finally leads to the creation of general laws or theories that govern the world (Johnson & Duberley, 2000; Sexton, 2003; Creswell, 2009; Saunders et al., 2012). In contrast, social constructionism/interpretivism takes a position that the knowledge is socially constructed and the reality is subjectively determined by people based on their experiences, sensations, reflections and intuitions. Hence, the data collected through the interaction with people are influenced by historical and cultural norms. The interpretation of the output considers the background of the people and their surroundings rather than focusing on proof or to reject a hypothesis (Creswell, 2009; Easterby-Smith et al., 2012).

In the context of the present study, outcomes of the study are developed based on the reasoning, feelings and experiences of the people involved in PPP and BIM. Thus, the study values the ideas, opinions and perceptions of the people based on their experiences and considered human interactions as the main drivers of the study as in constructionist philosophy. Therefore, the 'reality' of the present study is socially constructed rather than objectively measured. However, the study also values minor inhuman objective measurement as part of the factors in concluding the outcome, thus it inclines towards the positivism view. Therefore, in determining the CSFs and the significant BIM risk factors, statistical analyses are being used which involving minor mathematical calculation are used. Furthermore, the study is increasing general understanding about the impact of BIM towards PF2 projects, explaining how the contractual risks can occur, and how to manage the risks. At the same time, the study also developed causality between BIM implementation - risks mitigation in PF2 projects - additional contractual risks to PF2 projects, in which it become the basis to investigate the strategic management of contractual risks in PF2 projects implementing BIM. The study also focuses on gathering views and ideas from the respondents in order to answer the research questions. Only a few areas are interpreted or have their meaning created by the researcher, such as how BIM assists in reducing PF2 risks; and the relationships between the critical success factors-BIM risks factors-management strategies of contractual risks. As the study is specifically on PF2 projects implementing BIM, it only gather specific samples that are particularly related to the areas under study and is not eager to obtain a large sample size. Thus, due to these reasons, the study is sitting in the middle between constructionism/interpretivism and positivism paradigm.

5.3.3 Axiology

Researchers such as Hughes & Sharrock (1990), Creswell (2009) and Easterby-Smith et al. (2012) have not specifically discussed much about axiology. The reason is believed to be associated with the opinion given by Weinberg (1970), that axiology has always been neglected by philosophers of science because it is a matter of style that involves a sensation and feeling to fit a theory to the world. However, Weinberg (1970) does not reject axiology with the belief that axiology is also critically important as well as other philosophies as it relates to the administration of science. Furthermore, axiology readily exists within science. Axiology has been defined by Bahm (1993) as the basic science of values. It is about how we inquire and judge goodness and badness. As value sciences cover many areas, for example, aesthetic, ethics, arts, religions, etc., axiology is the most basic value science that helps to determine, for example, beauty or ugliness, right or wrong, and wisdom or folly. Therefore, the understanding and success in inquiring axiology will be one of the foundations to achieve success in other sciences. It is the most basic value science on which other sciences depend on; it exists and is an important part of science which deserves warranted positions with other philosophies.

In relation to research environment, researchers who use axiological skill in their studies will be able to articulate clearly all their decisions in conducting their studies and their values will become the basis when they want to draw a conclusion out of their data and analysis. Therefore, these value judgements may lead to different conclusions drawn by different researchers based on the values they are within (Saunders et al., 2012). Due to this reason, the present study has decided to consider axiology. This is because deducing the outcome of the study, requires the researcher to clarify their decision by linking the data findings with the existing literature. In order to determine the axiological stance of the present study, the researcher refers to Sexton (2003) who put two extreme ends of axiology continuum which are value neutral, where research is value- free and objective; and value-biased, where research is value-laden and subjective. Table 5.3 shows the axiology continuum, their characteristics and the link between axiology, epistemology and ontology.

Ontology	**Realism**	**Internal Realism**	**Relativism / Idealism**	**Nominalism**
Epistemology	**Strong Positivism**	**Positivism**	**Constructionism / Interpretivism**	**Strong Constructionism**
Axiology	**Value-neutral**	**Value-trivial**	**Value-balance**	**Value-biased**
The researcher's view of the role of value in research	Research is taken in a value-free way; the research is independent of the data and maintains an objective stance	Values play a minor role in interpreting results; the researcher considers subjective points of view	Values play a large role in interpreting results, the researcher adopting both objective and subjective points of view	Research is value-laden; the researcher is biased by worldviews, cultural experiences and upringing that will give impact to the research.

Source: Modified from Sexton (2003) and Saunders et al. (2012)

Table 5.3: Axiology continuum, their characteristics and the link between axiology, epistemology and ontology

Based on Table 5.3, the present study is value-balance. Values play a large role in interpreting the results of the study especially in establishing the relationship between PF2 and BIM; and in developing strategies for contractual risks management in PF2 projects implementing BIM. These are where, the researcher need to evaluate all views, opinions and experiences shared by the respondents as well as to appreciate their meanings in order to arrive at the conclusion which is considered to represent the idea of the people involved in PPP and BIM. Furthermore, the study also considers objective points of view to be mixed with subjective 'things' in order to have an overall finding which is stronger and greater than a finding that is derived subjectively. This is by considering the findings obtained from statistical analysis of the survey and at the same time the findings obtained qualitatively through interviews.

5.3.4 The overall philosophical stance of the study

The philosophical stance of this study is shown with red writing as illustrated in Table 5.4. Overall, the study is within the pragmatism position. Hence, in general, the study takes the ontological assumption that reality is not pre-determined, but socially constructed. The study also takes the epistemological assumption that knowledge is gathered by examining the views of the people, with minor consideration of objective facts. The study also takes value-balance axiology where both objective and subjective points of view are considered to obtain the desired conclusion. There is minor consideration towards positivism view when the study values minor inhuman objective measurement in the process of concluding the outcome.

Ontology	**Realism**	**Internal Realism**	**Relativism / Idealism**	**Nominalism**
Epistemology	**Strong Positivism**	**Positivism**	**Constructionism / Interpretivism**	**Strong Constructionism**
Axiology	**Value-neutral**	**Value-trivial**	**Value-balance**	**Value-biased**
		Pragmatism	**Pragmatism**	

Table 5.4: The philosophical stance of the study

Pragmatism is an alternative paradigm which sits in between strong positivism and strong constructionism paradigms, therefore pragmatism takes the middle view of both assumptions. In that sense, pragmatism allows the researcher to be free from the mental and practical constraints due to the choice of strong positivism or strong constructionism views (Creswell & Plano Clark, 2011; Robson, 2014). Hence, both paradigms can be practiced by the pragmatist in searching for the answers of the research questions. A pragmatist assumes that all knowledge in this world is based on experiences and believes that all knowledge is social knowledge. It means that the knowledge is the product of social experiences based on individual experiences and it is socially shared because it comes from socially shared experiences (Morgan, 2013). In relation to the research environment, a pragmatist would use whatever philosophical or methodological approach which works best for the particular research problem or issue (Robson, 2014), therefore favours using mixed-methods approach. Table 5.5 shows the summary of research paradigms and comparison between pragmatism with other paradigms.

Research Philosophies	**Research Paradigms**		
	Positivism	**Interpretivism**	**Pragmatism**
Ontology: the position on the nature of reality	Objective and concrete; independent of social actors	Socially constructed, subjective, may change, multiple.	View chosen to best achieve an answer to the research question
Epistemology: the view on what constitutes acceptable knowledge	Focus on causality and law-like generalisations.	Focus upon the details of situation, the reality behind these details, subjective meanings and motivating actions.	Focus on practical applied research, integrating different perspectives to help interpret the data.
Axiology: the role of values in research and the researcher's stance	Research in undertaken in a value-free way, the researcher is independent of the data and maintains an objective stance	Values play a large role in interpreting the results, the researcher adopting mostly subjective points of view	Values play a large role in interpreting the results, the researcher adopting both objective and subjective points of view
Research methodology: the model behind the research process	Quantitative	Qualitative	Quantitative and qualitative (mixed method or multi method design)

Source: Modified from Wahyuni (2012)

Table 5.5: Fundamental beliefs of research paradigm

5.4 Research Theoretical Drive

There are three forms of reasoning in research theoretical drive, namely deductive reasoning, inductive reasoning and abductive reasoning. Deductive reasoning is inclined towards the positivism view while inductive reasoning is inclined towards strong constructionism view. The abductive reasoning is a balanced reasoning that sits in between of these two continuums (Saunders et al., 2012) and is normally used by the pragmatist (Morgan, 2014). Deductive reasoning is a theory-driven process, where a theory is developed from literature and tested to see whether it applies to specific instances. On the other hand, inductive reasoning is a data-driven process, which starts with data collection to explore a phenomenon of specific instances and consequently a general conclusion or theory is derived about the phenomenon (Hyde, 2000; Saunders et al., 2012). The study employed abductive reasoning, which is a combination of both deductive and inductive process, whereby a theory is derived from concluding the data collected and subsequently the said theory is tested by conducting additional data collection (Saunders et al., 2012, Morgan, 2014). Saunders et al. (2012) has summarised them as presented in Table 5.6.

Variables	Deduction	Induction	Abduction
Logic	When the premises are true, the conclusion must also be true.	Known premises are used to generate untested conclusions	Known premises are used to generate testable conclusions
Generalisability	Generalising from the general to specific	Generalising from the specific to general	Generalising from the interactions between the specific and the general
Use of data	Data collection is used to evaluate propositions or hypotheses related to an existing theory	Data collection is used to explore a phenomenon, identify themes and patterns and create a conceptual model	Data collection is used to explore a phenomenon, identify themes and patterns, locate these in a conceptual model and test this through subsequent data collection and so forth
Theory	Theory falsification or verification	Theory generation and building	Theory generation and modification; incorporating existing theory where appropriate, to build new theory or modify existing theory.

Source: Saunders et al. (2012).

Table 5.6: Deduction, induction and abduction reasoning

Within the context of the present study, abductive reasoning was used. From the review of literature, it was found that BIM can improve the communication among the stakeholders and project team members and may reduce the contractual risks of PF2. Additional contractual risks that may occur when BIM is used in PF2 projects were also deduced from the literature. Therefore, based on these theories, opinions from the experts involved in PPP and BIM were obtained to better understand the phenomenon and to develop the conceptual framework of the strategic contractual risks management for PF2 projects implementing BIM management. Moreover, in developing the CSFs for PF2 projects implementing BIM, the formulation of the theory was based on the theories from literature reviews and confirming such theories by the opinions, experiences and perceptions of people involved in PFI/PF2 and BIM. Hence, this shows that the study employed abductive reasoning.

5.5 Research Strategies

Quantitative approach and qualitative approach have always been seen as two opposing sides of the philosophical continuum. Quantitative methodology is guided by a realist view and characterised as an extreme of empiricism that uses empirical methods to reduce all phenomena to empirical indicators in the process of seeking the truth. The ontological position that underpins quantitative perceives that there is only one truth and the reality is independent of human consciousness that rests in order, and governed by unchangeable natural law according to which all people define the reality and, generate meaning and name in the same way (Sarantakos, 2013). Hence, quantitative research prohibits free will; human beings' behaviours are shaped to be standardised and structured so that the investigator would be able to study a phenomenon without influencing it or being influenced by it (Sale, Lohfeld, & Brazil, 2002). Quantitative research measures and analyses the relationships of variables numerically using a range of statistical techniques. The data are collected through a highly structured and standard protocol to ensure the phenomena are viewed and evaluated similarly by the respondents (Saunders et al., 2012). In terms of the management of the research, quantitative methodology allows large-scale data collection to be carried out in a short time frame and the statistical findings provide high credibility of reliance. However, the weaknesses of quantitative research fall mainly on the tendencies to take the immediate evaluation at a specific time of a situation without considering the possibility of changes that might happen over time (Amaratunga, 2001).

In contrast, qualitative research is based on the relativist ontology, and constructionism/ interpretism epistemology. Ontologically, the reality is based on people's perception, hence multiple realities exist as they are perceived and interpreted differently by different people. Hence, qualitative research is not jailed by natural law and human beings have the free will in creating meanings. The goal of qualitative research is to interpret and understand people's life and meaning (Sarantakos, 2013). The data collection for qualitative research is non-standardised; therefore the questions and procedures may alter and emerge during the research process (Saunders et al., 2012). The strength of qualitative research is that, it appreciates human behaviours, perceptions and beliefs through a broad and open-ended inquiry. On the other hand, the weaknesses are mainly on the facts that the process is time consuming, with no objectively verifiable result (Choy, 2014). Table 5.7 shows the characteristics of quantitative and qualitative research.

QUANTITATIVE RESEARCH	QUALITATIVE RESEARCH
Its purpose is to explain social life	Its purpose is to understand social life
Is nomothetic-interested in establishing law-like statements, causes, consequences etc.	Is idiographic-describes reality as it is
Aims at theory testing	Aims at theory building
Employs an objective approach	Employs a subjective approach
Is etiological-interested in why things happen	Is interpretive-interested in how things happen
Is a historical-interested in explanations over space and time	Is historical-interested in real cases
Is a close approach-is strictly planned	Is open and flexible in all spaces
Research process is pre-determined	Research process is influenced by the respondent
Researcher is distant from respondent	Researcher is close to the respondent
Uses a static and rigid approach	Uses a dynamic approach
Employs an inflexible process	Employs a flexible process
Is particularistic, studies elements, variables	Is holistic-studies whole units
Employs random sampling	Employs theoretical sampling
Places priority of studying differences	Places priority on studying similarities
Employs a reductive data analysis	Employs an explicative data analysis
Employs high levels of measurement	Employs low level of measurement
Employs a deductive approach	Employs and inductive approach

Source: Sarantakos (2013)

Table 5.7: Comparison between quantitative and qualitative approaches

The above discussion clearly demonstrates the differences between quantitative and qualitative research which rests on different philosophical assumptions and have different processes and procedures in conducting research. Despite the long debate in academia on both methodological choices, there are arguments that hold that quantitative research and qualitative research can be combined regardless of their differences. Sale et al. (2002) mentioned reasons why quantitative research and qualitative can be combined, which are basically based on the main intention of both paradigms. First, both methodologies can be combined because they share a similar goal, which is to understand the world. Secondly, both paradigms share the beliefs of theory-ladenness of facts, imperfection of knowledge, uncertain theory due to facts and value-ladened inquiry process. They also have similar commitments to improve human condition and disseminating knowledge. Thirdly, it is due to the fact that some types of research that investigate phenomenon that complex in nature requires the use of both qualitative and qualitative methods. Fourth, it is not worth to be preoccupied with quantitative-qualitative debate as the most important point in research is to forge ahead with what works to seek the truth. Moreover, as noted by Bryman (2006), the combination of the two can produce triangulate findings that may be mutually corroborated; to offset the weaknesses and to draw the strengths of both; to help explain findings generated by the other; and may produce more complete and unexpected findings resulting from the combination of data gained by both process.

Therefore, even though quantitative approach and qualitative approach have always been seen as two opposing sides of a continuum, they are also frequently used in combination which many academics identified it as mixed method approach (Sandelowski, 2000a; Bryman, 2006; Creswell, 2009; Borrego, Douglas & Amelink, 2009; Saunders et al., 2012; Mertens, 2014). The use of mixed-methods approach is normally adopted by researchers who have a pragmatism view (Creswell, 2009). This is due to the nature of pragmatists that are not imprisoned either by positivism or interpretivism views and their dualism of mind allows them to choose a mixture of both, based on the logics and relevancy to carry out the research. For the pragmatists, the important agenda is the appropriateness of the methodological choice that can help in finding the truth of reality (Feilzer, 2010; Saunders et al., 2012) and answering the research questions (Tashakkori and Teddlie, 1998). Even though Biesta (2010) argued that pragmatism is unable to provide the philosophical foundation for mixed/multi methods research as explanatory and interpretation research is based on the Deweyan pragmatism theory, this view is considered as minority since many researchers are suggesting otherwise. Johnson and Gray (2010, p. 87) in their study on the history of philosophical and theoretical issues in mixed methods (MM) research mentioned:

> During the emergence of MM (mixed methods) as a third methodological paradigm (along with QUAN and QUAL), MM has struggled somewhat with to develop a corresponding philosophical paradigm. Many or perhaps most leaders in the field are advocating some form of philosophical pragmatism.

In respect to the present study, the philosophical stance of the researcher falls within pragmatism paradigm, which provides reason why mixed methods research is being employed.

Creswell (2009) mentioned three variations of mixed methods, which are:

- Sequential mixed methods – the procedures involve the elaboration and expansion of the findings of one method with another method.
- Concurrent mixed methods – procedures involve merging quantitative and qualitative data in order to provide comprehensive analysis of the research problem.
- Transformative mixed methods – procedures involve the use of theoretical lens as an overarching perspective in a design that contains both quantitative and qualitative data obtained via sequential or concurrent approach.

This study employed mixed methods approach because both quantitative and qualitative approaches were used to achieve different objectives respectively, and then both results from both approaches are triangulated to develop the conceptual framework of the critical success factors and contractual risk for the strategic management of PF2 projects implementing BIM. The components of the quantitative approach and qualitative approach implemented in this study are as follows:

- Qualitative approach is used to establish the link and synthesis of PF2 and BIM by interpreting the existing data in the literature and seeking views from the construction experts. This approach is also used to develop the contractual risk strategic management framework of PF2 projects implementing BIM based on the opinions, experiences and suggestions of the people involved in PPP/PF2 and BIM.
- Quantitative approach is used to identify the CSFs for PF2 projects implementing BIM. This requires statistical analysis in order to filter which factors are more critical as compared to the other.

While the study combines qualitative and quantitative approach, qualitative approach dominates the overall research journey. The main theoretical drive is inductive; therefore, qualitative is the predominant thrust of the research. Quantitative research drive was used as the supplement to support the findings from the qualitative research method. It is concurrent embedded mixed method strategy as the quantitative method is embedded within the qualitative method (Morse, 2003; Creswell, 2009; Creswell & Plano Clark, 2011). Figure 5.1presents the general research framework that includes different phases of the research study with different research methods linked and triangulated in order to develop the contractual risk management framework for PF2 projects implementing BIM.

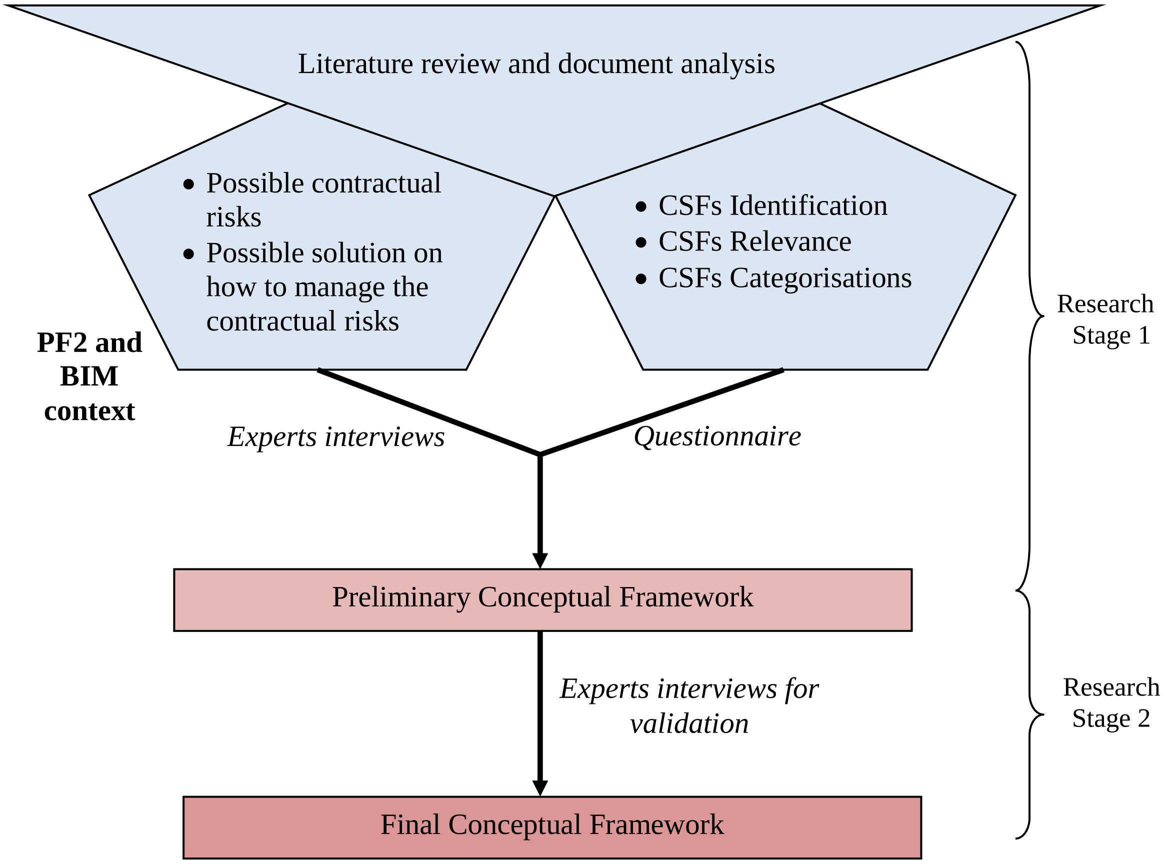
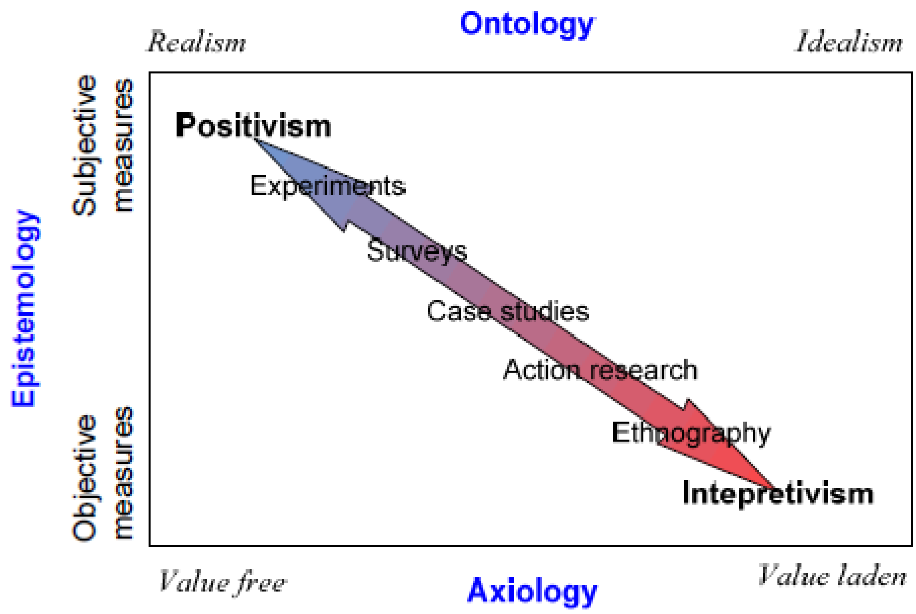


Figure 5.1: Concurrent embedded mixed methods research framework

The following sub-sections will explain in detail the process involved in this concurrent embedded mixed methods research study.

5.6 Research Techniques

There are many research techniques that can be used in conducting research such as experiments, surveys, case studies, action research, and ethnography. The selection of research techniques reflects the philosophical stance of the study. The positivist, with the view that there are always true answers and start the study with a hypothesis, will usually use research techniques that are objective in nature such as experiments or close-ended surveys. In contrast, the constructionist/interpretivist usually uses techniques which are subjective in nature, such as action research or ethnography in order to explore how reality is constructed in life (Remenyi, 1998; Easterby-Smith et al., 2012; Saunders et al., 2012). Adapting from Sexton (2003), Kulatunga (2008) plots the techniques against the ontology, epistemology and axiology continuum as in Figure 5.2.



Source: Kulatunga (2008) adapted from Sexton (2003)

Figure 5.2: Research techniques within the philosophical continuum

In reference to Figure 5.2, it is obvious that experiments lean more towards positivism view, whereas ethnography is more towards interpretivism view. Since this study is within the pragmatism view, the appropriate research techniques would be either surveys, case studies or action research. Action research is considered as inappropriate to be used because the present study does not intend to improve the situation of the participants or the environment by becoming the facilitator or a teacher (Saunders et al., 2012) nor does it not intend to change the participants' social system (Easterby-Smith et al., 2012). The study is more towards building a new theory and a framework based on the opinions, experiences and suggestions of the people involved in PFI/PF2 and BIM. Furthermore, case study is also not possible to be used due to the unavailability of on-going and completed PF2 projects implementing BIM. There was also limited access to people directly involved in PF2 due to the small number of people involved in PF2 projects as

PF2 is relatively new to the construction industry. Hence, in obtaining information the study also considered construction industry players who are involved in PFI project, as PFI is quite similar to PF2; and people who have knowledge about PF2 and BIM. Therefore, due to such constraints, the aim of the study can only be achieved through the survey technique. In addition, when deciding a research strategy to be used, concerns should be given to the ability of the strategy chosen to answer the research questions and objectives; and to link to the research philosophy, theoretical drive and methodological choice in order to have a reasonable level of coherence throughout the research (Saunders et al., 2012). Therefore, survey is considered as the most appropriate technique for the present study.

There are three types of research purpose, namely exploratory, explanatory and descriptive. An exploratory study is used to discover and clarify understanding of a problem when the research is unsure on the precise situation in the problem. Explanatory study is to study a phenomenon to explain the relationships of variables. Descriptive study is used to describe the accurate profile of events, persons or situations (Robson, 2014). The research questions for the present study (as listed in Chapter 1 of this thesis) comprise of “how” and “what” questions, hence the study is a mixture of exploratory research with minor part of explanatory research. Therefore, survey research is seen as the most appropriate technique to be employed as it can address the research questions by exploring and explaining the phenomenon investigated.

Survey research is a technique that involves collecting, organising and analysing structured or systematic data and the data are collected in a standardised manner (De Vaus, 2014; Saunders et al., 2012; Aldridge & Levine, 2001). The purpose of survey research is to provide information on the social conditions, relationships and behaviour (Moser & Kalton, 1971). It is also being used to fact-finding on attributes (for example: age, sex, marital status, education); and opinions, beliefs, preferences, attitudes of the respondents (Aldridge & Levine, 2001). Even though survey research is inclined towards formal and standardised methods, they are not mandatory as the use of less formal and less standardised methods can also be considered depending on the nature of the research (Moser & Kalton, 1971; Aldridge & Levine, 2001).

5.7 Concurrent Embedded Mixed Methods Research Process

The aim of the study is to develop a conceptual framework of the critical success factors and contractual risk for the strategic management of PF2 projects implementing BIM. Jabaraen (2009) has made a distinction between a 'conceptual framework' and a 'model'. According to him, a 'conceptual framework' is a "network of interlinked concepts that together provide a comprehensive understanding of a phenomenon or phenomena" (p.51). It is an organized idea on the collection of concepts that support each other within a framework which possesses the ontological, epistemological and methodological assumptions (Sheilds & Rangarajan, 2013). In differentiating the term with a 'model', Jabaraen (2009) indirectly defines 'model' as an extension of 'framework'; as it includes variables, factors and interrelationships among the factors and variables. This is also in line with the definition of 'conceptual model' as developed by Earp & Ennett (1991) and was being used by Konu & Rimpela (2002). Based on the above definition, the term 'conceptual framework' is used for this study. It is the intention of the study for the conceptual framework developed to show the interlink of three concepts: the critical success factors, contractual risks, and the strategies to manage the contractual risks.

As mentioned earlier in this thesis, in order to achieve the research aim, the study employed concurrent embedded mixed methods strategy with survey as the research technique. Buckingham and Saunders (2004), De Leeuw (2008), and Bryman and Bell (2011) further highlighted that survey can be conducted by using techniques such as questionnaire, interviews, focus group and mixed-modes techniques. De Leeuw (2008) mentioned that modes of data collection have different impacts towards the researcher's intervention. For example, in postal or internet survey, the researcher has minimum intervention as the researcher is absent in the question-answer process. The researcher or the interviewer has potentially more impact in face-to-face interview rather than in telephone interviews as the researcher has the opportunity to motivate respondents, to deliver, and when necessary clarify questions, to answer respondent's queries, to probe after inadequate answers and also to interpret respondents' nonverbal expressions like smiles and nods. Deciding which data collection mode to be used also depends on the researcher's consideration of quality of the data, time and costs. All of the data collection techniques have their own pros and cons; hence sometimes, mixed-modes survey is being chosen to counterbalance each other's weaknesses and limitations.

Although questionnaire and structured interviews are mostly used under this strategy, it is also appropriate to conduct a semi-structured or unstructured interviews (in-depth interviews) (Aldridge & Levine, 2001; De Vaus, 2002; Buckingham and Saunders; 2004), depending on the nature of the research and the suitability in answering the research questions. This study has used questionnaire, informal interviews and semi-structured interviews to obtain data for the research. Questionnaire is where a structured questionnaire is prepared and distributed to potential research participants who will then respond by selecting from predetermined answers (Harris & Brown, 2010). In this study, the questionnaire includes close-ended and open-ended questions. Informal or unstructured interview is a non-standardised, open-ended and in-depth interview that allows the interviewees to spontaneously give their opinions about a topic that is presented to them with additional subjects that they wish to talk about (Robson, 2011). The interview guide only includes points that need to be asked and the conversation depends on the interviewer's ability to generate questions in response to the context and feedback given by the interviewee to the direction of the researcher's interest (Easterby-Smith et al., 2012). Semi-structured interview is where the questions prepared are not asked in a specific order and it is a verbal interchange session where the interviewer is trying to elicit information from the interviewee based on the predetermined interview guide and the conversation provides chances for the issues to be whichever both parties felt important to be raised and discussed to be explored further (Longhurst, 2010). It takes place with respondents known to have been involved in a particular experience and it is focused on the respondents' experiences regarding the situations under study (Naoum, 2003). There are two stages in the research process, which will be explained in the following sections. Figure 5.3 shows the research process involved in this study.

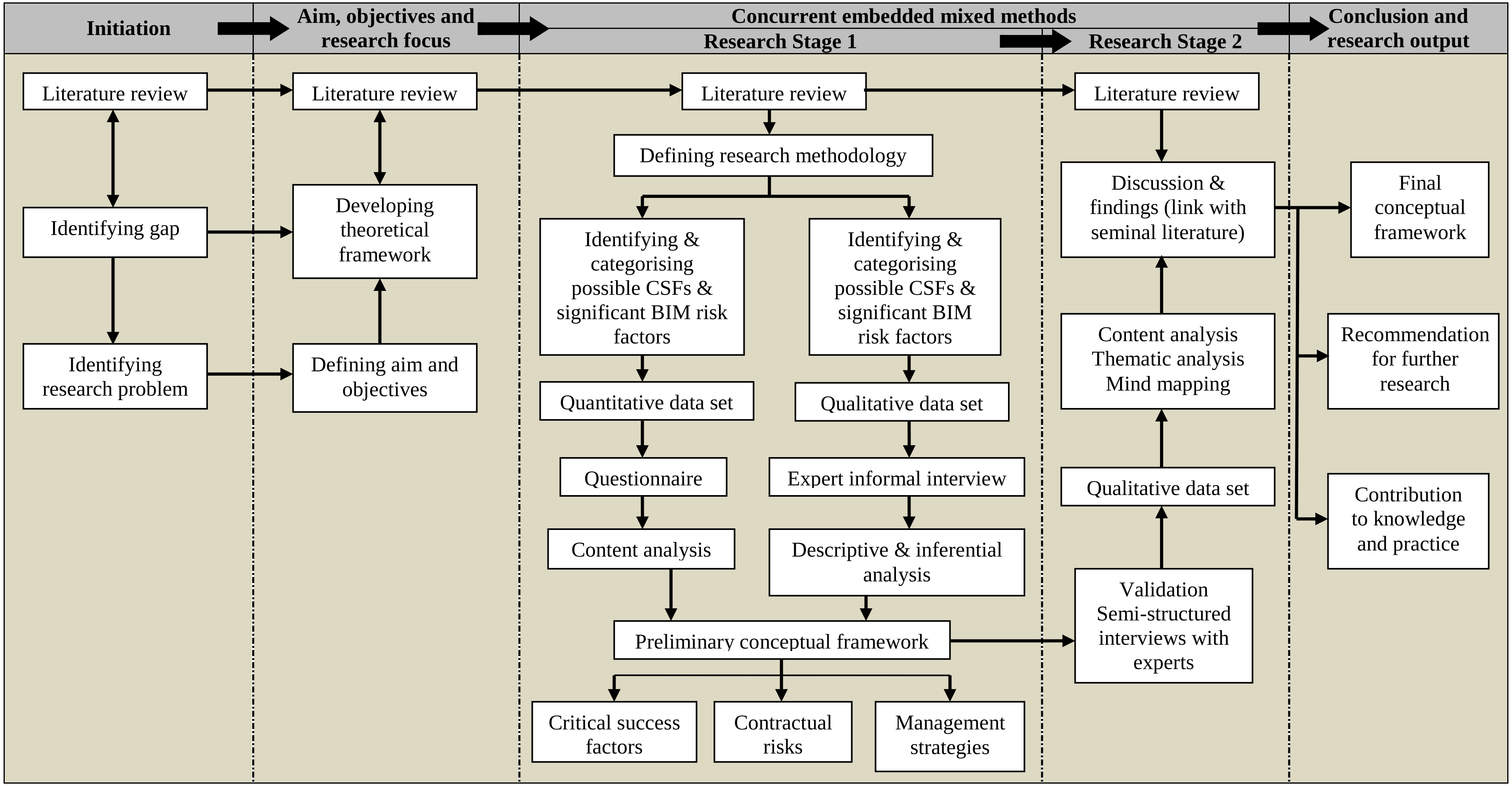


Figure 5.3: Process in the concurrent embedded mixed methods research

5.8 Research Stage One

5.8.1 Literature review and document analysis

The first move in the first stage of the research is conducting literature review. For a clearer understanding, Figure 5.4 provides the flow chart of the stages involved in conducting the literature review.

The literature review was conducted to be the basis to achieve Objectives 1-3 of the study, and to come up with a theoretical framework of the study (see section 1.5, Chapter 1 for the aim and objectives of the study). It requires the researcher to review relevant documents published by the government bodies; contractual documents related to BIM and PF2; as well as other research, books and journal articles related to these two subjects. Consequently, the desired information as required to achieve the objectives of the study were gained. The synthesis of the information gathered from Objectives 1 and 2 was done in order to establish the link between PF2 and BIM. Discussions were made in order to explain the relevancy of BIM towards PF2 (as BIM can help in reducing potential risks of PF2). A preliminary list of CSFs for PF2 projects implementing BIM; the potential contractual risks if BIM is implemented in PF2 projects; and their possible solutions were also established. These outcomes were used to conduct primary data collection through questionnaire survey and semi-structured interviews.

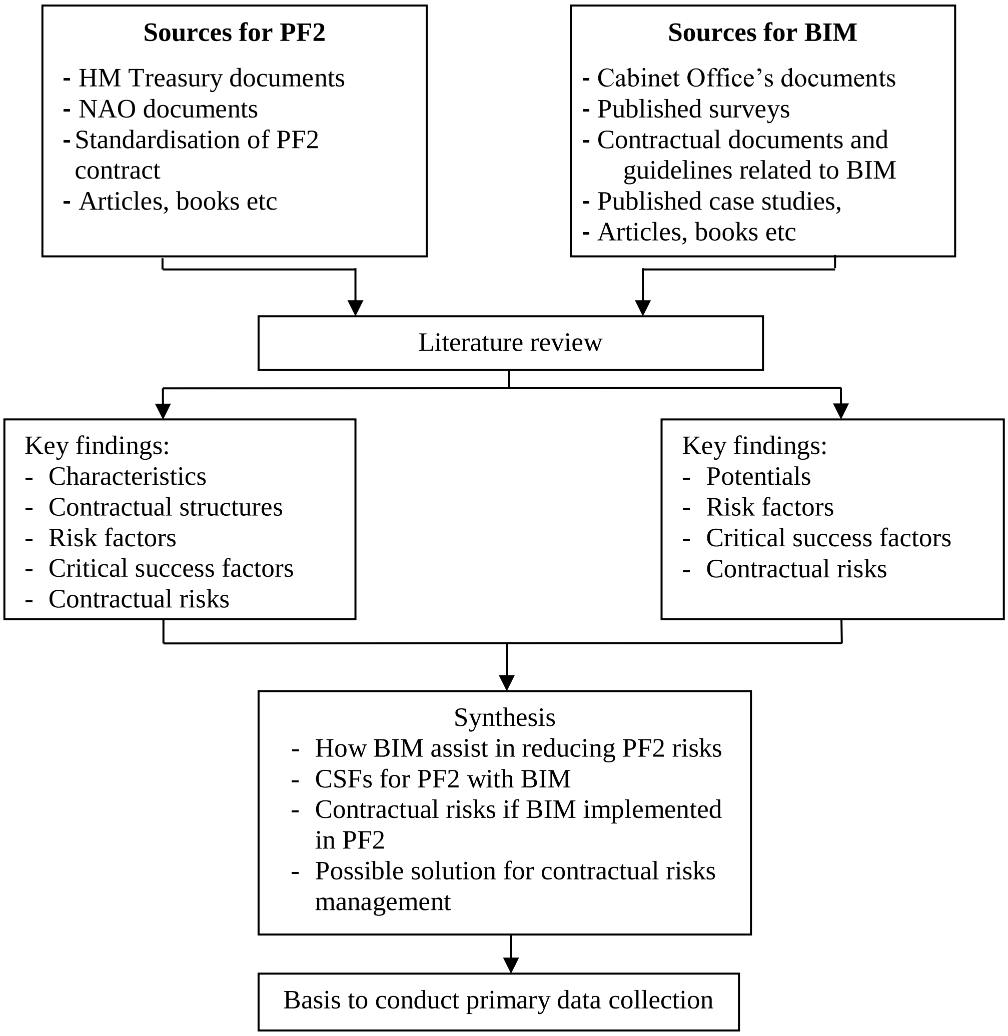


Figure 5.4: Stages involved in conducting literature review

5.8.2 Informal interviews with the experts

This research is exploratory in nature, therefore the information gathered from the literature reviews were extended to the people who were considered experts and knowledgeable in the areas of PF2 and BIM. The researcher carried out three informal experts' opinion interviews in order to identify the relevant contractual issues that need to be addressed in PF2 projects implementing BIM. The purpose of the interviews was also to help the researcher to refine issues that need to be explored in developing the conceptual framework. Due to the nature of the subject area which is very much towards legal and contractual aspects, the researcher had chosen three distinguished construction lawyers to elicit their perceptions on the subjects under research. All of the experts have very vast knowledge in BIM and PFI/PF2 based on their experience in drafting contracts for BIM projects and involvement as the legal advisor for PFI projects. The informal interviews were carried out between October 2015 and December 2015, in their respective offices. This method was used as the researcher needed the experts' opinion in scrutinising the important and relevant issues regarding BIM and PF2 that had been gathered from the literature and to explore the issues deeper. Based on their opinions, the researcher was able to capture broader views on issues regarding BIM implementation in PF2 projects and subsequently refine the preliminary conceptual framework of contractual risks management for PF2 projects implementing BIM, which was developed earlier through the literature reviews. This has made the researcher better equipped with knowledge to undergo the fieldwork in the later stage of this research journey.

5.8.3 Questionnaire survey

Simultaneous with the informal interviews with the experts, questionnaire survey was carried out with the purpose of identifying the CSFs for PF2 projects implementing BIM and BIM risks factors that can give significant impact to PF2. This questionnaire survey acted is supplemental to the contractual risks management strategies as the strategies need to be in line with the factors critically needed for the success of the PF2 projects implementing BIM. Figure 5.5 shows the stages involved in conducting the questionnaire survey.

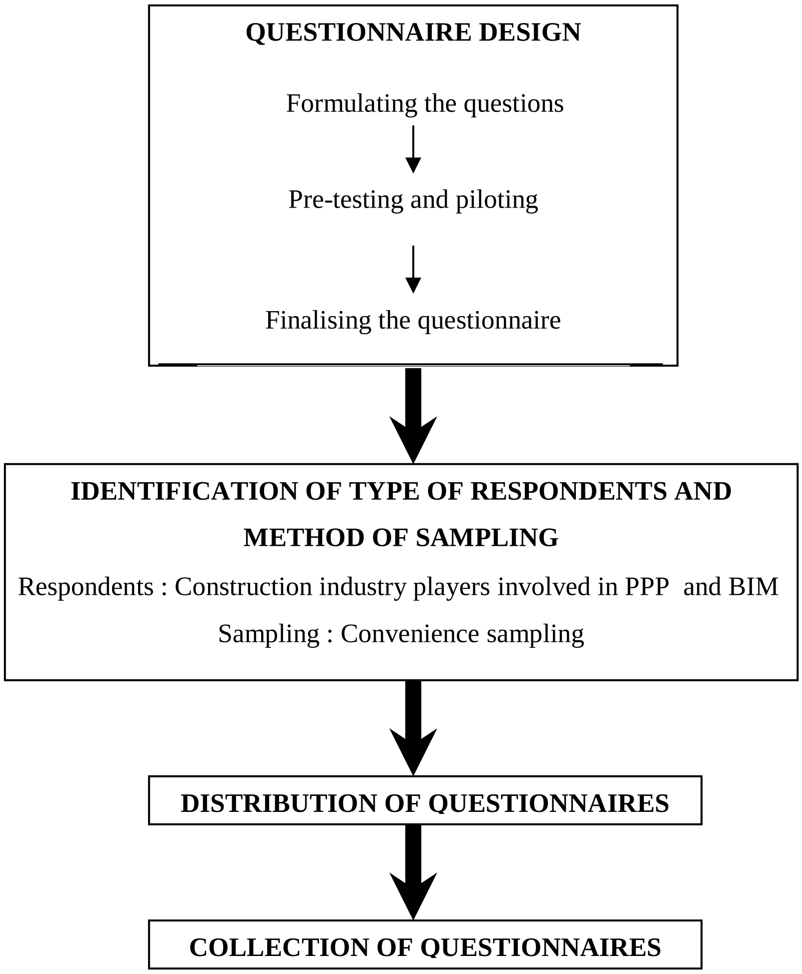


Figure 5.5: Stages involved in conducting questionnaire survey

5.8.3.1 The design of the questionnaire

The questionnaire was divided into three sections. Table 5.8 presents the title and the objectives of each section. The variables for the questionnaire were taken from the secondary data mostly via journal articles, thesis, and proceeding papers concerning CSFs for PPP/PFI projects and BIM. From the review of the literature and after conducting appropriate screening to eliminate redundant and repetitive items, 28 CSFs of PPP and BIM; while 24 risk factors of BIM were identified (see Appendix A). The questions designed were based on the literature review as presented in Chapter 2 and Chapter 3 of this thesis.

Section	Title	Objectives
A	Respondent's Background Information	To obtain the respondent's particulars
B	Critical Success Factors for BIM Implementation in PF2 Projects	To determine the Critical Success Factors for BIM implementation in PF2 projects as what contemplated by the experienced practitioners and academics.
C	BIM Risk Factors and Their Impact on PF2 Projects	To seek the respondent's view on what BIM risk factors that may give significant impact to PF2 project.

Table 5.8: Composition of the questionnaire

A Likert scale on five ordinal measures of opinion was used for both Section B and C. For Section A, the Likert scale represents five scale of '*importance'*, which are *'unimportant', 'less importance', 'moderately important', 'important*' and '*very important'*. For Section B, the Likert scale represents five scale of '*significance', which are 'not significant', 'less significance', 'moderately significant', 'significant'* and *'very significant'*. For both scales, *'no opinion'* choice was added to reduce the tendency of the respondents giving inaccurate answers due to lack of knowledge on a particular item being asked (Buckingham & Saunders, 2004). All of the questions used Likert scale, except in Section B where there were two optional questions that welcome any additional opinions regarding the CSFs and the reasons of the additional factors to be critical.

5.8.3.2 Pre-testing and piloting the questionnaire

The term "pilot study" and "pre-test" have always been used interchangeably (Stopher and Metcalf 1996; Trobia, 2008; Bryman, 2012); however, there are some academics who distinguish between "pilot study" and "pre-test". "Pre-test" is used to check the questions wording and the instrument layout (Stopher and Metcalf, 1996) in order to identify question defects such as ambiguity (Bolton, 1993), while "pilot study" is to completely run a trial of the data collection process with the pre-planned procedures, instruments, sampling and so forth (Stopher and Metcalf, 1996). According to Robson (2011), a pilot study is a small-scale version of feasibility study that is done in preparation to conduct the real fieldwork in a study. It is a trial for the questionnaire to ensure that the instrument functions well, so that any problems detected from the piloting can be addressed before it is used to collect the real data for the research. This is to reduce the risk of distributing questionnaires that are not relevant to the study, hence avoiding wastage of efforts, time and cost (Bryman, 2012).

Prior to the distribution of the questionnaire, it was pre-tested to ensure the questions are appropriate in terms of rhetoric and understanding of meanings, to ensure the relations between the variables are correctly interpreted, and to estimate the time taken to complete it. The questionnaire was pre-tested with the researcher's PhD supervisor and co-supervisor, and another two academicians from the researcher's personal contacts who are actively involved in research concerning BIM and PPP. Subsequently, a pilot study was undertaken for data reliability purpose. For the pilot study, the questionnaire was prepared electronically and emailed to the respondents who are personally known by the researcher and who are also involved in the construction industry. The pilot study for the questionnaire started sometime within the first week of July 2015 and ended in the first week of August 2015. The researcher managed to obtain 31 responses for the pilot study and after that, the preliminary analysis was carried out to assess the reliability and internal validity of the questionnaire. It was found that the questionnaire coefficient of Cronbach's alpha was 0.888 which is deemed as reliable for the data collection.

5.8.3.3 The data sampling

The study under consideration is basically more towards scrutinising the perceptions of construction industry practitioners and experts on the contractual risks associated with the implementation of BIM in PF2 projects, and the appropriate strategies to manage the contractual risks. The present study focuses on analysing the perceptions rather than facts. In determining the method of sampling for the research, several limitations are noted, which are:

1) There is no comprehensive, or any standard, database of organisations in the UK that are involved in PF2 or BIM projects.
2) PF2 is basically new to the construction industry, therefore the number of people who are involved in this kind of project is limited.

3) The number of organisations involved in PF2 and BIM is growing but not in a form that the overall number of these organisations involved can be determined.

Due to such limitations, the sampling technique used for data collection for this research is convenience sampling rather than random sampling. Random sampling requires involvement of large number of organisations or individuals and the population is known (Fellows and Liu, 2008). Convenience sampling is categorised under non-probability sampling. It is a selection of a population that is convenient and accessible to the researcher and makes no pretense of being representative of a population (Leedy, 1993; Houser 1998). Thus, convenience sampling was selected for this research. The difficulties in finding people involved in PF2 project also forced the researcher to extend the coverage of the sampling to people who are involved in PFI projects, but have adequate knowledge on PF2. This is because PFI and PF2 have many similar characteristics; therefore, it was appropriate to have PFI people as the research participants. As a result, three categories of targeted respondents were identified, which are:

1) Those who are involved in PFI/PF2 projects only but knowledgeable in BIM;
2) Those who are involved in BIM projects only but knowledgeable in PFI/PF2;
3) Those who are involved in PFI/PF2 and BIM projects.

5.8.3.4 The data collection

After the data reliability and internal validity have been ensured, the succeeding step was to distribute the questionnaire to the potential respondents by using convenient sampling as discussed in the previous section. Due to the absence of database of organisations or companies involved in PF2 and BIM, the researcher tried to retrieve the information from the internet and attended two conferences on BIM to be able to get some networking contacts. Consequently, the researcher was able to distribute 700 questionnaires to 128 organisations and their branches, including 60 individuals who were mostly academician involved in research concerning PFI/PF2 and BIM. The questionnaires were distributed starting from 30th October 2015 by post, through email, as well as by hand. Prior to the distribution, the Ethical Approval was obtained from the university. A cover letter explaining the aim of the study and the objectives of the survey were attached together with the questionnaire to provide understanding to the respondents on what the research is all about. The respondents were also requested to fill in the consent form provided as the proof of their voluntary participation in the research.

Three-week duration was given for the respondents to fill in and return the questionnaire. Efforts were made to the non-respondents via email and phone calls in order to encourage them to participate in the survey. Extension of time was given until 18th December 2015 for them to return the questionnaires. By the end of December 2015, a total of 92 completed questionnaires were returned and answered online. More than 60 questionnaires were returned unanswered with some of them apologising for the non-completion. From the 92 completed questionnaires received, 4 of them were excluded and considered as invalid. This is due to the fact that the respondents declared that they were never involved in either PFI/PF2 projects or BIM projects. Therefore, there were considered as not suitable to answer the questions as the sampling target of the survey are people who have experience either in PFI/PF2 projects, BIM projects or both. Table 5.9 shows the responses of the questionnaire survey.

Description	Quantity	Percentage (%)
Questionnaires distributed	700	100%
Answered questionnaires returned	92	13.14%
Unanswered questionnaires returned	65	9.29%
Valid	88	12.57%
Invalid	4	0.57%
Missing questionnaires	543	77.57%

Table 5.9: Responses of questionnaire survey

Based on the 88 responses received, the effective return rate is 12.6% (i.e. 88/700). This could be perceived as a low response rate, however, could be explained as follows:

1) PF2 and BIM are quite new areas in the construction industry, therefore the knowledge, experience and awareness among the construction industry players are quite lacking. Feedback received from the respondents mostly gave this excuse.
2) Some of the companies have a policy of prohibiting, participation in any surveys or questionnaires received from external sources. This was informed by them in their letters. Other than that, some of them were not be able to participate in the survey due to time constraints.

Despite the low response rate, the number was considered appropriate for the study due to the fact that the questionnaires were answered by very experienced and knowledgeable group of people who have had more than 10 years of experience in the construction industry. Furthermore, as PF2 is very new to the construction industry, the number of knowledgeable and experienced people on the subject is very limited, therefore the data gathered is considered sufficient and reliable.

There were three categories of respondents, which are: (i) people who are involved in PFI/PF2 projects only; (ii) involved in PFI/PF2 and BIM projects; and (iii) involved in BIM projects only. Table 5.10 presents the distribution of the respondents in these three categories. Respondents who have experience in PFI/PF2 and BIM projects were over 50% of the total respondents. Later in the statistical analysis, these categories and the overall totals are presented in order to show the disaggregated and aggregated outcomes. This is important to show the patterns of opinions given by these groups of respondents.

Categories of the Respondents	**Frequency**	**Percentage**
Involve in PFI/PF2 projects only	10	11.4
Involve in PFI/PF2 and BIM projects	44	51.1
Involve in BIM projects only	34	37.5
Total	88	100.0

Table 5.10: The categories of the respondents

Table 5.11 presents the position of the respondents in their current organisation. From 88 respondents who participated in the survey, a majority of them are Director and Quantity Surveyor, which respectively represents over 20% of the respondents. Design Manager is another major designation of the respondents, covering 15.9% of the respondents, followed by Engineer (9.1%) and BIM Manager (9.1%). Most of the respondents have spent a long time in the industry as indicated in Table 5.12.

Respondents' Designation	Frequency	Percentage
Director	18	20.5
Quantity Surveyor	18	20.5
Design Manager	14	15.9
Engineer	8	9.1
BIM Manager	8	9.1
Planning Manager	6	6.8
Academician	6	6.8
Project Manager	4	4.5
Architect	2	2.3
Supply Chain Manager	2	2.3
Contract Specialist	2	2.3
Total	88	100.0

Table 5.11: Respondents' designation within their organisation

In terms of the experiences of the respondents, Table 5.12 shows that over 70% of the respondents have spent more than 10 years in the construction industry; indicating that the questionnaires were mostly answered by very knowledgeable and experienced people in the industry. In addition, as presented in Table 5.13, about 78% percent of the respondents have had 1 to 5 years of experience involving in BIM projects, and more than 50% of the respondents have been involved in PFI projects. Even though only 9% of the respondents have been involved in PF2 projects, this percentage is considered sufficient due to the fact that PF2 is very new in the construction industry and none of the projects have been constructed so far, therefore the number of people involved in this kind of project is also very few. However, as the differences between PFI and PF2 are not really significant, respondents who are involved in PFI projects are considered adequate to participate in this survey, to respond to the questions based on their experience in PFI and their knowledge in PF2.

Respondents' Years of Experience	Frequency	Percentage
1-3 years	12	13.6
4-6 years	4	4.5
7-9 years	8	9.1
>10 years	64	72.7
Total	88	100.0

Table 5.12: Respondents' experience in the construction industry

Years of Experience	BIM Projects		PF2 Projects		PFI Projects	
	Number	%	Number	%	Number	%
Not involved	10	11.4	80	90.9	38	43.2
1-5 years	69	78.4	8	9.1	16	18.2
6-10 years	9	10.2	0	0	20	22.7
11-15 years	0	0	0	0	11	12.5
16-20 years	0	0	0	0	3	3.4
Total	88	100.0	88	100.0	88	100.0

Table 5.13: Respondents' experience in BIM, PF2 and PFI projects

The findings and results from the literature reviews, informal interviews with the experts and questionnaire survey were triangulated to facilitate the researcher in developing the preliminary conceptual framework for PF2 projects implementing BIM. The preliminary conceptual framework was then used to conduct the semi-structured interview with the experts.

5.9 Research Stage Two

5.9.1 Validation via the semi-structured interviews

After the preliminary conceptual framework has been developed, semi-structured interviews were conducted. The key objective of the semi-structured interviews was to refine and validate the preliminary conceptual framework. Figure 5.6 shows the process involved in conducting this final stage of the data collection.

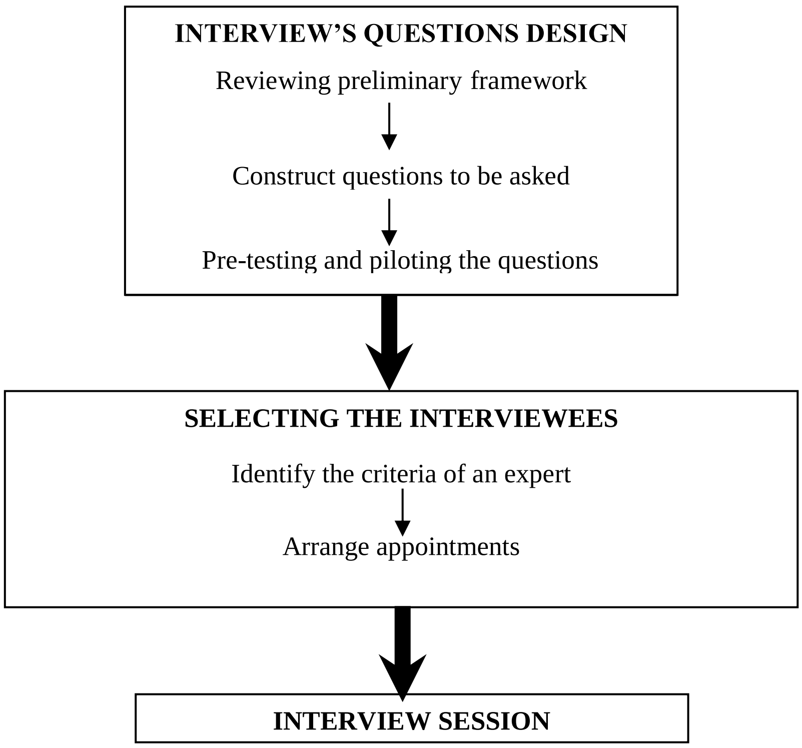


Figure 5.6: Stages involved in conducting the semi-structured interviews

5.9.1.1 The design of the semi-structured interviews questions

The questionnaire prepared for the semi-structured interview session was based on the preliminary conceptual framework developed earlier. Fourty questions were prepared and divided into three sections (see Appendix B). Section A of the interview guide asks about the background of the interviewee as well as their experiences and involvement in

PFI/PF2 projects implementing BIM. Section B asks about their general opinion on the sufficiency of the legal and contractual documents that are currently practised in the UK for PF2 projects and BIM. Finally, section C asks about their opinions on the contractual risks, and strategies to manage those risks; as well as getting their agreement on the CSFs identified from the questionnaire survey.

5.9.1.2 Pre-testing and piloting the questions

Before carrying out the interview sessions, the questions were pre-tested with the researcher's PhD Supervisor and Co-supervisor, and firstly piloted with two academicians in January 2016. This is to ensure that the meaning behind the questions will be properly conveyed for the understanding of the interviewees and to estimate the duration of time taken when conducting the real interviews. Based on the pilot study, several changes were made to the questions in order to ensure they were understood by the respondents. Some changes were also made to the questions as the interview lasted more than two hours. After the modification, the new version of the interview guide was piloted for the second time with another two academicians. This time, the pilot study showed that the interview questions were found to be clear and the duration of time taken in conducting the pilot study was approximately 1 hour and 30 minutes and therefore, considered to be satisfactory.

5.9.1.3 The data sampling

The targeted participants for these semi-structured interviews stage were individuals who were considered experts in PF2, BIM and legal issues concerning PF2 and BIM. Specifically, the experts to be included as the participants in the semi-structured interviews at this stage of the research were restricted to those people who meet two of the following criteria:

1) Involved in PF2 projects.
2) Have more than ten years of experience involving in PFI projects.
3) Have more than two years of experience involving in BIM projects.

4) Involved in PFI projects implementing BIM.
5) Published research on PFI, PF2 or/and BIM implementation.
6) Have experience as legal advisors in PFI, PF2 or /and BIM projects

Due to the predetermined criteria of the interviewees, the researcher opted homogeneous purposive sampling for this study. It is a non-probability sampling, hence the result gained from this sample will not be considered to be representative of the population (Robson, 2011; Bryman, 2012; Saunders et al., 2012). It is homogeneous sampling because the experts interviewed for the study were regarded as the same type in which all of them have outstanding knowledge in both PFI/PF2 and BIM. Other than that, the researcher also employed snowball sampling as some initial interviewees helped the researcher to establish contact with other experts who agreed to participate in the interview. Snowball sampling is a sampling technique where the researcher approached some people identified through other sampling and these sampled participants propose other participants to participate in the research (Bryman, 2012, Saunders et al., 2012). According to Bryman (2012), it is common for snowball sampling to be used together with purposive sampling.

This research was exploratory in nature in purpose to seek opinions of construction industry’s experts on the critical success factors and contractual risk management for PF2 projects implementing BIM. Therefore, the objective of the study is to obtain sample size that is specifically informative to the study areas that can give fruitful and in-depth knowledge which are able to answer the research questions. Initially, the researcher intended to interview 10 experts that meet the criteria of experts as mentioned hereinbefore. However, it was difficult to find 10 people who meet the above criteria within the context of this study. The response to the researcher’s request to have an appointment for the interview session was very disappointing. Most of the targeted respondents were not available and some of them refused to be interviewed as they confessed on not knowing very much about BIM or PF2. After about 100 invitations issued; only 20 was approached personally during conferences; coming to only 6 experts who finally agreed for the semi-structured interviews.

Due to this constraint, the time taken to carry out the semi-structured interviews was quite long (about 9 months). The slow response from the industry was actually anticipated as PF2 and BIM are quite new in the industry. Notwithstanding the small sample size, the interviewees who participated were very well known, experienced and knowledgeable people that have good reputation in the construction industry. During the interview sessions, other than validating the preliminary conceptual frameworkall of them gave in-depth insights about the subject matter under research and shared wise and beneficial thoughts with the researcher. Table 5.14 shows the background of the experts interviewed in the semi-structured interview. Due to their reputable background, the researcher was satisfied with the number of the interviewees, even though the number was below the researcher's expectation. Two of the interviewees have been actively involved in PFI projects implementing BIM and are much aware of the differences between PFI and PF2. Another two interviewees have been actively involved in promoting BIM in the UK and they are very much well-known in giving speeches and guiding the construction industry players about BIM. One of the interviewees was involved in the drafting of the CIC BIM Protocol. One of them was also given an award recently as the most distinguished and influenced scholar within the construction industry. Furthermore, three of the interviewees were also very active in publishing articles about BIM and the construction industry as a whole. Therefore, the data collected from the semi-structured interviews were considered robust due to the very strong background of the interviewees.

Experts	Type of organisation	Position	Work background	Work experience with the current organisation	Overall industrial experience	Experience in PF2/PFI projects	Experience in BIM projects
IV-1	Law firm	Partner	Construction Lawyer	2 year	21 years	12 years as legal advisor	5 years in research on BIM
IV-2	Contractor's Group Association; University	Chief executive; Professor	Construction Lawyer; Academician	26 years	26 years	25 years as legal advisor	6 years in research on BIM
IV-3	Law firm	Partner	Construction Lawyer	27 years	30 years	15 years as legal advisor	4 years as legal advisor
IV-4	University	Senior Lecturer	Construction Lawyer; Academician	9 years	11 years	2 years as legal advisor	5 years in research on BIM
IV-5	Developer company	SPV and Investment Manager	Quantity Surveyor, Project Manager	22 years	22 years	15 years	5 years use BIM in design and data
IV-6	Developer company	Builder	Quantity Surveyor, Developer	17 years	17 years	17 years	7 years

Table 5.14: The background of the experts in semi-structured interviews

5.9.1.4 Data collection

The interview sessions with the experts were performed between 11th January 2016 and 30th September 2016. Most of the sessions were held in the interviewees' offices in London, Glasgow, Shrewsbury and Manchester. The average time taken for an interview session was about one hour and thirty minutes and some of the sessions were much longer depending on how the discussion went.

Before carrying out each of the interview session, the researcher introduced herself to the interviewee. The brief outline of the research was informed to the interviewee by explaining the objective of the study and the objective of the interview. During the interview sessions with the experts, their views and opinions were audio recorded with their permission. Answers of the previous interviewees were kept confidential to the subsequent sessions in order to avoid bias and interruption in the following interviewees' answers.

Views and opinions of the experts were analysed in order to finalise the conceptual framework of the critical success factors and contractual risk for the strategic management of PF2 projects implementing BIM. The recorded audio tapes were all transcribed verbatim. The researcher spent considerable amount of time in transcribing the interviews by initially listening to the recorded audios to become familiar with the contents and to grasp the general important points. After that, the transcribing works began by using Microsoft Words and upon completion of the transcription of each interview, the transcript underwent one round of checking with the recorded audio to ensure the accuracy of the transcription. The researcher spent roughly about two months to complete the transcribing works.

5.10 Data Analysis Procedures

The next step in this research journey was the data analysis stage. In this stage, all data obtained from the literature review and document analysis, informal interviews with the experts, questionnaire surveys and semi-structured interviews were examined, tabulated, categorised and triangulated in the process to address the research questions (Creswell, 2009; Bryman, 2012). In this research, the analysis stage involved analysing both qualitative and quantitative data. Qualitative analysis deals with data presented in textual, verbal and multi-focus format, whereas quantitative analysis deals with data that have quantitative measurement and standardised data which require statistical techniques to process the data (Creswell, 2009; Sarantakos, 2013). These procedures involved content analysis, thematic analysis and statistical analyses. Content analysis and thematic analysis were used for analysing qualitative data obtained from the documents related to PF2 and BIM, informal interview with the experts, open-ended questions in the questionnaire and semi-structured interviews. Statistical analyses were used to analyse the data obtained from close-ended questions in the questionnaire. The following sub-sections discuss in detail the procedures carried out in analysing the data.

5.10.1 Analysis of the qualitative data

In this study, content analysis, thematic analysis and mind mapping were used to analyse qualitative data. Content analysis was used in analysing the literature review in the process of developing possible contractual risks, strategies to manage the risks, and CSFs for PF2 projects implementing BIM. Thematic analysis was used to analyse qualitative data obtained from semi-structured interviews. Meanwhile, mind mapping was used to create visual representation of the data was obtained from semi-structured interviews. The analyses were carried out by using Microsoft Words, Microsoft Excel and Cmap Tools. The analyses are described in the following sub-sections.

5.10.1.1 Content analysis

Content analysis is a method of analysing textual and communication messages (Cole, 1988; Elo & Kyngas, 2007; Bergman, 2010). According to Berg (1998), content analysis is where the interviews, field notes and any type of unobtrusive are analysed by way of applying coding scheme to the notes or data. Content analysis may also be applied for analysing published material such as published literatures, case studies and government documents. For example, Wang, Haertel and Walberg (1990) had analysed the content of 179 book chapters, published reports, government documents and journal articles in their educational research; Gold, Seuring, & Beske (2010) had applied content analysis on published case studies on sustainable supply chain management from the year 1994 to 2007; Seuring and Gold (2012) also conducted content analysis on 22 literatures of supply chain management in peer-reviewed journals between the year 2000 and 2009. The structured procedures of content analysis had been a powerful tool in generating valid and reliable findings from literature reviews (Seuring and Gold; 2012). Realising such facts, the present study employed content analysis in analysing the literature review in the process of developing possible contractual risks, strategies to manage the risks, and CSFs for PF2 projects implementing BIM. This is the first stage in this research before the findings were obtained from the content analysis being used as a basis to conduct semi-structured interviews and questionnaire survey. For the purpose of the study, the researcher followed the three-step process model derived from Elo and Kyngas (2007) as referred below:

1. Preparation Phase
    - Setting boundaries on the materials to be analysed and defining the unit of analysis. Unit of analysis can be a word or a theme.
    - Based on Figure 1.1 of this thesis (Chapter 1, p.8) there are three sub-unit of analysis to conduct the content analysis:
        - Contractual risks in PPP/PF2 and in BIM
        - Strategies to manage contractual risks
        - CSFs for PPP/PF2 and BIM

2. Organising Phase
    - This process includes open coding, creating categories and abstraction. Open coding is where the notes and heading are written in the text while reading. Following the open coding, the coded data are to be categorised based on the categories created in purpose to provide meaning of describing the phenomena, to increase understanding and to generate knowledge. After the categorisation, abstraction process takes place. Abstraction means formulating a general description of the categories. In this stage, the categories are arranged in a more

structured and analytic dimensions where they comprise of subcategories items that are grouped together as a category and being put under a main category.

- In this study, after the open coding takes place, the categorisation and abstraction were carried out one-by-one according to the unit of analysis. These have been shown in the earlier chapters in this thesis:
  - Contractual risks: see sub-section 4.3 and 4.4.
  - Strategies to manage the risks: see sub-section 4.4.
  - Critical success factors: see sub-section 2.4.1 and 3.5.

3. Resulting Phase
   - Reporting the analysing phase and the results of the content analysis. Sometimes it can be presented in the form of a model, conceptual system, conceptual map or categories.
   - In this study, most of the findings from the content analysis were presented in the form of tables in the literature review chapters. However, these findings were not finalised as these had become the basis to conduct the informal interviews with the experts and questionnaire survey.

5.10.1.2 Thematic analysis

Thematic analysis means the data is examined to extract the core themes through coding text or transcript. The theme is a category that has been identified by the researcher through the data, which relates to the research focus that can provide the researcher with the basis of theoretical understanding of the data (Bryman, 2012). It is a method that allows researchers to identify, analyse and report themes within the data (Braun and Clarke, 2006). Ryan and Bernard (2003) listed out guidelines that the researchers can look for to identify themes in their data which are as follows:

- *repetitions*: frequent recurrence of the subject
- *indigenous typologies or categories*: unfamiliar local expression
- *metaphors and analogies*: the ways participants represent their thoughts in terms of metaphors or analogies
- *transitions*: the ways in which topics shift in transcripts and other materials

- *similarities and differences*: how interviewees discuss a topic differently or have different opinions
- *linguistic connectors*: examining the use of words like ‘because’ and ‘since’ because such terms represent causal connections in the minds of the participants
- *missing data*: reflecting on what is not in the data or why the participants not answering the question
- *theory-related material*: using social-scientific concepts as themes

Moreover, Braun and Clarke (2006) identified six stages in performing thematic analysis, which are described as follows:

1. Familiarise with the data
   - Read and re-read the transcribed data.
2. Initial coding
   - Systematically coding interesting features of the data across the entire data sets and collating the data where possible.
3. Searching possible sub-themes
   - Collating codes into possible sub-themes and gathering all data relevant to each possible sub-theme.
4. Reviewing sub-themes
   - Checking if the sub-themes work in relation to the coded extracts and the entire data sets.
5. Defining and naming themes
   - Ongoing analysis to refine the specifics of each theme and generating clear definitions and names for each theme.
6. Completing the report
   - Final analysis of selected extracts, relating the analysis back to the research questions and literatures and producing a scholarly report of the analysis.

The above steps were followed by the researcher in the analysis of the semi-structured interviews with the experts. Firstly, all of the audio data recorded obtained from the semi-structured interviews were transcribed into text version using Microsoft Words. Each interview was given a specific code to represent the interviewee. The data was familiarised by re-reading the transcribed data while grasping the gist of the interviews' content. Once the researcher had become familiar with the transcribed data, initial coding was carried out. In this initial coding, key words and phrases mentioned by the participants were being observed, identified and extracted as codes. The researcher entirely let the data drive the coding; therefore, some of the words used by the participants were used to represent the codes. Figure 5.7 shows the example of how the coding process was carried out.

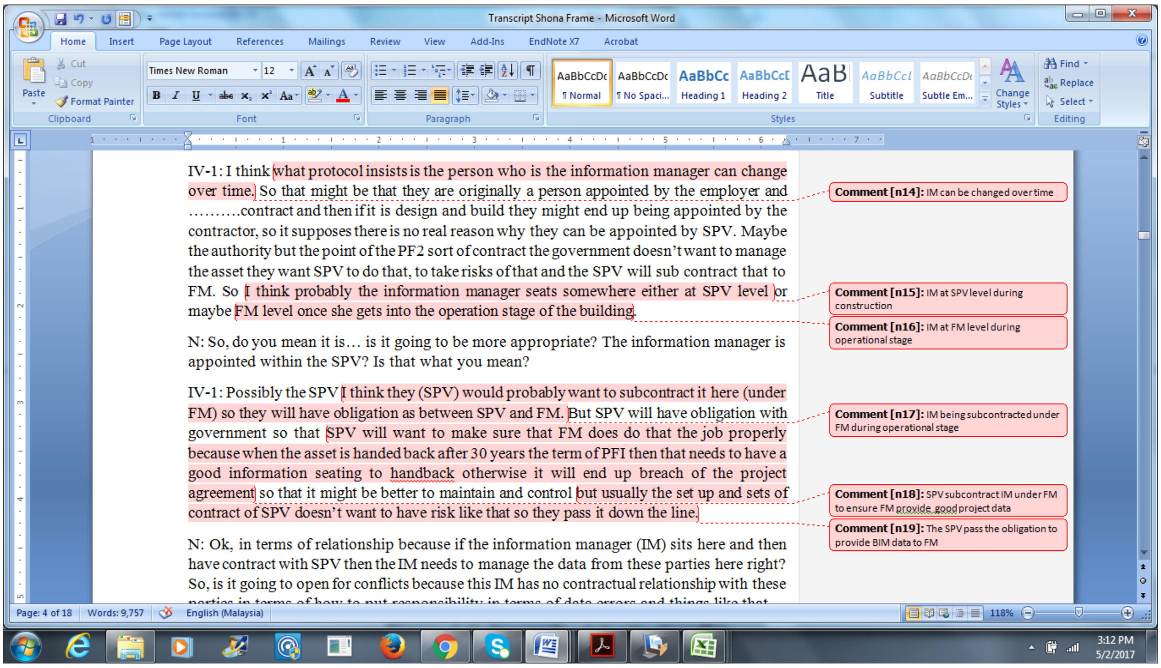
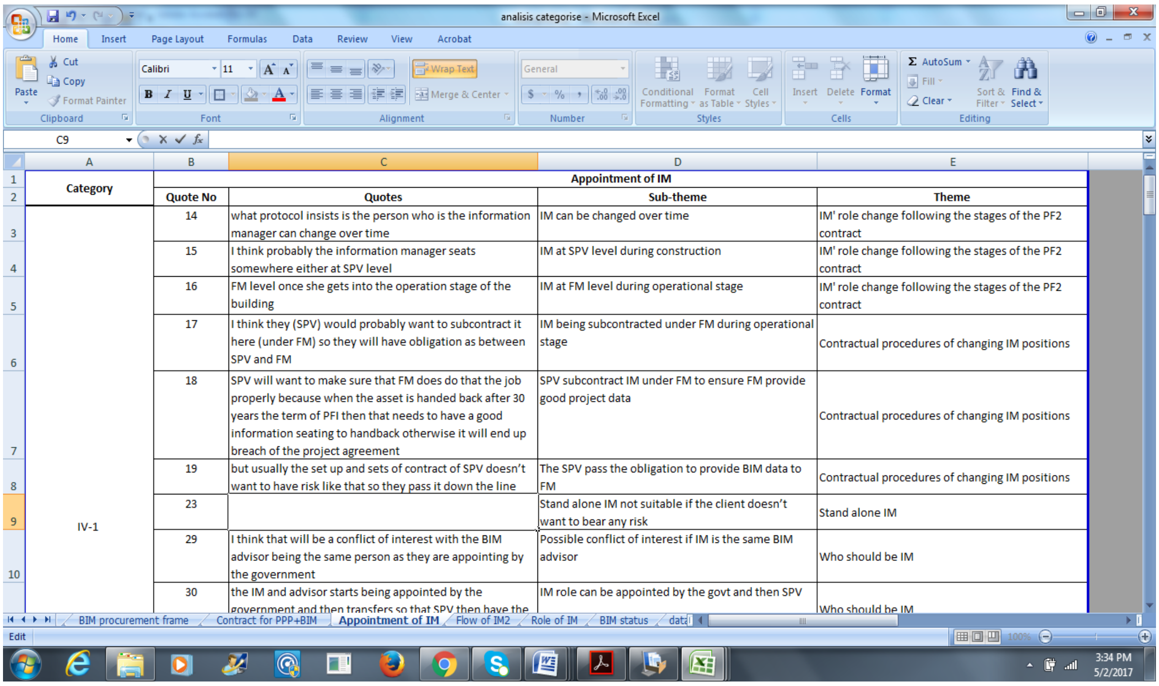


Figure 5.7: Example of the coding process by using Microsoft Word

After all of the data were coded, the researcher started to find the similarities, links and connections among the codes in the process of creating the sub-themes. Microsoft Excel was used to help the researcher in completing this task. This process continues in refining the sub-themes, creating the main themes and finalising the themes. In order to assist the researcher in reporting the analysis in the later stage, quotations from the transcripts were also included in the Microsoft Excel sheets. This also helped the researcher to stay intact with the original text throughout the analysis process. Figure 5.8 shows the example of the creation of sub-themes and themes process.



Category	Appointment of IM			
	Quote No	Quotes	Sub-theme	Theme
IV-1	14	what protocol insists is the person who is the information manager can change over time	IM can be changed over time	IM' role change following the stages of the PF2 contract
	15	I think probably the information manager seats somewhere either at SPV level	IM at SPV level during construction	IM' role change following the stages of the PF2 contract
	16	FM level once she gets into the operation stage of the building	IM at FM level during operational stage	IM' role change following the stages of the PF2 contract
	17	I think they (SPV) would probably want to subcontract it here (under FM) so they will have obligation as between SPV and FM	IM being subcontracted under FM during operational stage	Contractual procedures of changing IM positions
	18	SPV will want to make sure that FM does do that the job properly because when the asset is handed back after 30 years the term of PFI then that needs to have a good information seating to handback otherwise it will end up breach of the project agreement	SPV subcontract IM under FM to ensure FM provide good project data	Contractual procedures of changing IM positions
	19	but usually the set up and sets of contract of SPV doesn't want to have risk like that so they pass it down the line	The SPV pass the obligation to provide BIM data to FM	Contractual procedures of changing IM positions
	23		Stand alone IM not suitable if the client doesn't want to bear any risk	Stand alone IM
	29	I think that will be a conflict of interest with the BIM advisor being the same person as they are appointing by the government	Possible conflict of interest if IM is the same BIM advisor	Who should be IM
	30	the IM and advisor starts being appointed by the government and then transfers so that SPV then have the	IM role can be appointed by the govt and then SPV	Who should be IM

Figure 5.8: Example of creating sub-themes and themes by using Microsoft Excel

Subsequently, the researcher revisited the thematic analysis that had been done and made necessary adjustments to the name of the themes so as to make more sense of the theme and reflects the content of the interviews. Finally, the researcher brought the quotations, sub-themes and themes in reporting the analysis. While going through the process of the thematic analysis, the researcher dedicatedly let the data speak for themselves and always bear in mind that this is the essence of thematic analysis.

5.10.1.3 Mind mapping

Mind mapping is a process of transferring the data into maps which was primarily developed by Tony Buzan (Buzan, 2003). It started with the central subject being put at the centre of the map and the branches of other elements related to the central subject are extended and expanded in the form of organised structure of keywords or sometimes in the form of images. The original form of mind mapping introduced by Buzan is in the tree-like structure, by using the thickness of the branches to differentiate the main concept of the ideas with the sub-concepts. However, for the purpose of this study, the mind mapping technique introduced by Buzan has been modified to suit the information gathered from the data. The researcher follows some of the steps in drawing the mind mapping from Buzan (2003), which are:

1. Use emphasis such as images, colours, fonts, style variations to differentiate multiple ideas and precedence of point. In this study, the researcher used colours and fonts to differentiate the main concept with the sub-points.
2. Use association such as colour coding to differentiate types or category of information in the map.
3. Use key words clearly to represent the ideas or information.
4. Buzan encouraged the use of branches of various thicknesses to link the information key words. However, for the purpose of this study, the researcher only used arrows and lines to link the information.

With the use of mind mapping, the researcher can easily show the themes from the data and the concepts related to the themes; which created more understanding about the data. Cmap Tools software was used to help the researcher in completing drawing the mind maps.

5.10.2 Analysis of the quantitative data

The analyses of quantitative data from the questionnaire survey were undertaken by using statistical analysis. These include descriptive statistics by using mean ranking; and inferential statistics by using Kruskal-Wallis H test and Mann-Whitney U test. This research used the non-parametric test. This is because the data sampling was convenient sampling; the number of the respondents was small; and Likert scale was being used and it was an ordinal scale which allows the researcher to examine the consensus of opinions of the respondents (Frost, 2015). The analysis of the questionnaire survey consists of two parts:

a) Analysis on the importance of the success factors
b) Analysis of the significance of BIM risk factors to give impact on PF2 projects

Two Likert scales were used to gather data on these two attributes (see Appendix A). For both Likert scales, a five-points grading scale from 1 to 5 was used. There was also another option offered for *'no opinion'* answer. Table 5.15 shows the Likert scales and the values assigned to each option.

Parts	**Scales**					
Success factors	Unimportant	Less important	Moderately important	Important	Very important	No opinion
BIM risk factors	Not significant	Less significant	Moderately significant	Significant	Very significant	No opinion
Value	1	2	3	4	5	99

Table 5.15: Likert scales and the values assigned

The data gathered from the survey was entered into the SPSS software (version 23). The variables were defined according to the specified fields in the SPSS, such as name, type, label, value and measure. The analyses were described in the following sub-sections.

5.10.2.1 Reliability test

Reliability test was conducted before proceeding to data analysis with the purpose of examining whether the data obtained from the survey were reliable and valid to be used to generate the desired conclusion. Cronbach's Alpha test was conducted to measure the internal consistency of the variables, to examine how they are closely related and reliable to achieve the specific aim of the research. The general theory is that, the greater the Cronbach's alpha coefficient value to 1, the greater the internal consistency and reliability of the items in the scale (Gliem & Gliem, 2003; Tavakol & Dennick, 2011). Based on the studies done by Nunnally & Bernstein (1994), Bland & Altman (1997) and Zaiontz (2014), the present study considers 0.7 to 0.95 as the cut off acceptable value of alpha.

Based on the list of CSFs for PF2 projects and BIM presented in Chapter 2 (Table 2.5) and Chapter 3 (Table 3.3), both lists were synthesised and items which have similar meaning have been eliminated. From the synthesis, 47 possible CSFs for PF2 projects implementing BIM were derived. As for the BIM risk factors, 24 factors have been identified as presented in Table 3.4 (sub-section 3.6). The Cronbach's Alpha test was conducted on the result of the pilot study done on 31 pilot respondents. For the two attributes included in the questionnaire which are, the CSFs for PF2 projects implementing BIM and the significance of BIM risks factors on PF2 projects, the Cronbach's alpha reliability produced is as shown in Table 5.16.

Attributes	**Cronbach's Alpha**
Section B: Critical success factors	0.998
Section C: BIM risk factors	0.939

Table 5.16: First reliability test of the questionnaire

For Section C of the questionnaire, the measure of Cronbach's alpha coefficient has demonstrated the reliability and consistency of the questionnaire and confirmed the validity of different variables in the questionnaire. This shows that the data collected from the pilot survey are inter-related, and the scale (or measurement) is reliable. Therefore, the questionnaire for BIM risk factors was found to be reliable and can be used for the real data collection. However, for Section B, the Cronbach's Alpha is greater than 0.95. The high measure of alpha suggested that some item may be redundant as they might carry the same meaning. This might due to the reason that the researcher combined CSF for PPP and BIM to be the CSF for PF2 projects implementing BIM. By using the *alpha-if-item-deleted* statistics in the SPSS while considering the redundancy of the items, items which appeared to cause increase in the alpha were deleted. Based on this screening, 28 factors which are possibly critical for the success of PF2 projects implementing BIM, were short-listed. The Cronbach's Alpha tests were being run again, and the new measures of alpha are as presented in Table 5.17.

Attributes	Cronbach's Alpha
Section B: Critical success factors Section C: BIM risk factors	0.943 0.939

Table 5.17: Second reliability test of the questionnaire

Measures of Cronbach's alpha coefficient for both attributes show the high reliability and consistency of the items in the questionnaire, thus the questionnaires are considered as appropriate to be used for the real data collection stage.

5.10.2.2 Managing the missing data

In conducting the questionnaire survey, missing data from the responses received can happen. Missing data is a common situation where the respondents do not provide answers to the questions and this may have a significant impact on the conclusion to be drawn from the data. Missing data occurs due to many reasons, such as: refusal to answer the questions, language barriers, the respondent does not know the answer, the respondent suddenly stop answering the questions in the middle, and so on (Brick & Kalton, 1996; McKnight, McKnight, Sidani, & Figueredo, 2007). There are three types of missing data mechanisms which are missing completely at random (MCAR), missing at random (MAR), and not missing at random (NMAR). MCAR means that the probability of missing data is unrelated to the values of any variables in the dataset. MAR means that the probability of missing data is related to observed values on other variables. Whereas NMAR, which is the problematic non-ignorable missingness, means that the probability of missing data depends on the unobserved data (Scheffer, 2002; Allison, 2012). Before conducting the analysis of the data, missing values in the data need to be dealt first to determine the patterns of the missing values as this may affect the precision of the results.

In the present study, two types of missing data were found. Firstly, it was found that some of the items in the questionnaires were left unanswered. It was presumed that this happened either because the respondents accidently missed answering the questions or the respondents do not know the answers to the questions. Secondly, one of the respondents left Section C of the questionnaire totally unanswered. The respondent put a short note saying that he cannot complete the questionnaire due to lack of knowledge on PF2. According to Saunders (2012), missing data need to be coded according to the reasons why they are missing. As for the first type of missing data, the missing data was assigned with the value 99. This code is also used to code *'no opinion'* answer. However for the second type of missing data, the respondent was totally deleted from the Section C data. Therefore, the responses for the three parts of questionnaires are different, which are 88 respondents for Section A and B, and 87 respondents for Section C. As such, it was not necessary to distinguish these two types of missing data, hence only single code was used to represent the missing data.

After all the missing data were coded with the value 99, the next step is to determine the missing data mechanisms whether it is MCAR, MAR or MNAR. The null hypothesis is that, the missing data mechanism is MCAR. In order to check whether this hypothesis is rejected or not, Little's MCAR chi-square test was used. For Section B of the questionnaire, the p value for the Little's MCAR result was 0.671; whereas for Section C, the p value was 0.810. Therefore, the Little's MCAR results for both sections are not statistically significant hence, the missing values in the data set are considered as MCAR and the data is identified as missing without any specific patterns. Furthermore, the percentage of the missing data for all the affected variables is less than 3%, which is considered as low; therefore, subsequent EM (Expectation -Maximisation) imputation is considered valid to deal with the missing data (Scheffer, 2002; Garson, 2015).

5.10.2.3 Mean ranking

Mean ranking was used to assess the importance of the CSFs for BIM implementation in PF2 projects. Mean value is the average value of the data sets calculated. The separate mean values and ranking for the three group of respondents (only involved in PFI/PF2; involved in PFI/PF2 and BIM, only involved in BIM) were calculated, and then the overall mean values were computed. The final ranking is based on the overall mean values. From here, the levels of criticality of the success factors as presumed by the respondents were identified.

5.10.2.4 Kruskal-Wallis H test

Kruskal-Wallis H test is a non-parametric test, used to determine whether three or more independent groups are the same or different on some variables when measured using ordinal or interval measurement (Chan & Walmsley, 1997; McDonald, 2015). This test is used when the sample sizes are small and unequal and group variances are quite different (Zaiontz, 2014). For the purpose of the present study, the Kruskal-Wallis test was used to identify the difference in opinions between three independent categories which are 'only involved in PFI/PF2'; 'involved in PFI/PF2 and BIM', 'only involved in BIM'. These were coded 1,2 and 3 respectively. To determine whether there is a significant difference among the groups, the significant level named as Asymptotic Significance (Asymp. Sig) needs to be considered. When the significance is less than 0.05, the difference between the groups is considered statistically significant.

5.10.2.5 Mann-Whitney U test

Mann-Whitney U test is a non-parametric test used to identify the difference between two independent categories when the measured variables are of ordinal type (Kasuya, 2001; Nachar, 2008). In relation to the present study, the Mann-Whitney U test was used as the follow up test to do the pairwise comparison after the Kruskal-Wallis Test shows a significant difference between the groups (Zaiontz, 2014). Before running the Mann-Whitney U test, the p values were adjusted by using Bonferroni correction approach. This is to protect the alpha level from inflation (also called "false alarm" or "Type 1" error) due to performing multiple statistical tests (Abdi, 2010). The Bonferroni correction was performed by dividing the critical p value by the number of comparisons being made. In this case, as there are three comparisons from the three groups, the p value would be 0.05/3, which equals 0.015 (Napierala, 2012; Mangiafico, 2015). Accordingly, an Asymptotic Significance of less than 0.015 was taken as statistically significant for this study.

5.11 Triangulation

Triangulation was used to triangulate the results obtained from both methods for the purpose of strengthening and providing more details to the findings of the qualitative method. In the context of the present study, the finding on the CSFs of PF2 projects implementing BIM established from the quantitative approach serves the purpose of making the conceptual framework become more complete by linking the CSFs with the strategies to manage the risks. Therefore, it does not only strengthen the results obtained from qualitative approach, but also enhance the reliability and validity of the overall research findings.

5.12 Assessing the Quality of the Research

Reliability and validity are two important criteria that need to be used in assessing the quality of a research. Easterby-Smith (2012) contended that the reliability and validity are interpreted differently according to the philosophical stance. In assessing the reliability, the positivist looks on the extent the measures yield the same results on other occasions; whereas for interpretivist, reliability is about demonstrating transparency of the study by providing detailed information on the procedures undertaken in the research journey. In assessing the validity of the research, the positivist concerns whether the measures correspond closely to reality; whereas for the interpretivist, the focus is on the extent of the study gaining access to those on the research setting. Lincoln and Guba (1985) used the term ‘trustworthiness’ to represent ‘validity’ in qualitative setting. It concerns on how the researcher convinces his/her audiences, including his/herself, that the findings of the study are worth to be given attention and worth to be taken into account. Trustworthiness encompasses four criteria as identified by Guba (1981), which are ‘credibility’, ‘transferability’, ‘dependability’, and ‘conformability’. Yin (2014) divided validity into three more sub-criteria which are ‘construct validity’, ‘internal validity’, and ‘external validity’. The research adopts qualitative and quantitative approaches, therefore both criteria by Guba (1981) and Yin (2014) were considered in establishing the quality of the research, with more weight given to Guba as the study is more inclined towards qualitative research. This study followed the criteria as presented in Table 5.18 to appraise the quality of this study.

Criteria	Description
Reliability	Demonstrating transparency of the study by providing detailed information on the procedures undertaken in the research (Easterby-Smith, 2012).
Construct validity	Identifying suitable operational measures for the research to correctly addresses the concepts being studied (Yin, 2014).
Internal validity or Credibility	Establishing cause-effect relationship conclusion or testing the credibility of the findings by comparing them with various sources (audiences or groups) from which data were drawn (Guba, 1981).
External validity or Transferability	The extent to which the research findings is possible to be generalised to other populations and settings. But for qualitative research, generalisations are sometimes not possible because phenomena are intimately tied to the times and the contexts in which they are found (Guba, 1981).
Conformability	Implies that the data accurately represent the information that the participants provided and interpretations of those data are not invented by the inquirer. The findings must reflect the participants' voice and conditions of the inquiry, and not the researcher's biases, motivations, or perspectives (Guba, 1981).

Table 5.18: Criteria for assessing research quality

The following sub-sections explain how the research addressed the above criteria in order to produce quality research.

5.12.1 Reliability

Reliability means demonstrating transparency of the research. In this research, reliability is achieved by providing detailed information about the processes and the procedures undertaken in this research before arriving at the conclusion. These include the way the literature review, research design, data collection and data analyses were conducted; and also how the researcher interpreted the data in order to arrive to the final outcomes.

5.12.2 Construct validity

Construct validity is about the relevance of the instruments for data collection. The data collection methods and techniques used for this study were selected after considering the philosophical stance of the study and the areas under study. The methods and techniques used for this study were considered appropriate due to the constraints faced by the researcher as few people have the knowledge about both PF2 and BIM and only few PF2 projects are either ongoing or; still at the initial stage, therefore cannot be used as case studies. Before choosing these methods and techniques, the researcher reviewed previous studies, and the literature while and also consulting the supervisors. Mixed methods approach was chosen so that the study can triangulate the results from quantitative and qualitative approach to give more meanings to the findings, which consequently increases the construct validity of the research.

5.12.3 Internal validity or credibility

The cause-effect conclusion for the present study was derived from the findings of the study which shows the importance of robust and clear contractual provisions in facilitating PF2 projects implementing BIM to mitigate contractual risks. This study also portrays the pros and cons of the implementation of BIM to PPP-type projects. The findings were then linked with the research gap, research significance, aim, objectives, and research questions in order to achieve the internal validity of the study. The findings of the study were also based on the data obtained from various types of people. For example, in the questionnaire survey, there were three groups of respondents: those only involved in BIM projects; involved in PFI/PF2 projects implementing BIM; and only involved in PFI/PF2 projects. The respondents were very experienced and came from the top management level in their organisations. Moreover, the participants for the semi-structured interviews were also considered experts in the areas under study and coming from different backgrounds comprising academics, construction lawyers, and developers. Therefore, the researcher considers the internal validity and credibility of the research to have been addressed.

5.12.4 External validity or transferability

The research findings are considered relevant not only for PF2 projects implementing BIM, but also for other PPP-type projects using BIM. The findings suggest seamless and collaborative contractual instruments, which are important to projects with lengthy contract duration to ensure collaborative working and the smooth running of the projects can be sustained until the end of the contract period. Some of the suggestions made by this study are also relevant to be considered by other construction projects using BIM since the contractual framework for BIM implementation in construction is considered to be deficient. Therefore, external validity and transferability have been addressed.

5.12.5 Conformability

Conformability in this study has been addressed by giving priority to the voice of the data while conducting the analysis. In doing the analysis, the researcher always bear in mind that the findings must reflect the respondents' and interviews participants' voices, not the researcher's biases or perspectives. Therefore, direct quotations from transcribed text from data obtained by the open-ended questions in questionnaire survey and semi-structures interviews were frequently used to show the connections between the data and the results. The quotations have been done systematically to show the richness of the data gathered, while at the same time, they were controlled from becoming overused to avoid the analysis from being weak. This is how conformability was addressed.

5.13 Summary

This chapter provides details on the research methodology employed for the study starting from the establishment of the research problem to the writing up of the thesis. This chapter discussed the philosophical stance of the study, the theoretical drive, strategies, methods and techniques. This study employed concurrent embedded mixed method strategy that combines qualitative and quantitative approaches. The quality criteria of the study were also discussed. The following chapter presents the analyses, results and the discussion of the findings of the study.

CHAPTER 6

DATA ANALYSIS AND DISCUSSION

6.1 Introduction

This chapter presents the analysis of the data collected from the questionnaire, informal interviews and semi-structured interviews with the experts, presented in two parts:

Part One: In this part, the focus is on the analysis of the data collected from Research Stage One. This involved the data collected through the questionnaire and informal interviews with the experts. The key findings of the data were used to develop a conceptual framework of the critical success factors and contractual risk for the strategic management of PF2 projects implementing BIM.

Part Two: This part focuses on the analysis of the data obtained from Research Stage Two, which was from the validation via semi-structured interviews with the experts. In this stage, the findings on the and CSFs of PF2 projects implementing BIM together with the significant BIM risk factors obtained from the Research Stage One were validated by the experts. Besides that, based on the preliminary conceptual framework developed from Research Stage One, the contractual risks and the management strategies in PF2 projects implementing BIM were validated and refined. This is the final stage in the process of developing the conceptual framework.

Throughout this survey research, two series of interviews were carried out: firstly, informal interviews with the experts in Research Stage One; and secondly, semi-structured interviews in Research Stage Two. A questionnaire with the construction industry practitioners and academics was also carried out in Research Stage One. The stages involved in this research journey have been described in Chapter 5 of this thesis.

6.2 Part One: Analysis and Discussion of Research Stage One and the Development of the Preliminary Conceptual Framework

This part provides the data analysis and findings of Research Stage One based on the data collected using literature reviews, informal interviews with the experts and questionnaire survey. This part consists of three sub-sections: CSFs for PF2 projects implementing BIM; BIM risks factors that have significant impact on PF2 projects; and contractual risks in PF2 projects implementing BIM.

6.2.1 Analysis of the critical success factors for PF2 projects implementing BIM

From the review of the literature, the researcher managed to obtain 28 success factors for PPP and BIM, which are listed out in the questionnaire (refer Appendix A). The respondents were asked about their opinions on factors that are considered critical to the success of PF2 project implementing BIM. The first question is a close-ended question in which 28 success factors for PPP and BIM were listed out and the respondents were asked to rate the importance of the success factors in regard to PF2 projects implementing BIM. Table 6.1 shows the responses from the respondents regarding the CSFs for PF2 projects implementing BIM.

Success factors	Only involved in PFI/PF2		Involved in PFI/PF2 and BIM		Only involved in BIM		Total		Criticality	St dv	Asymp Sig.
	Mean	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**			
Good communication	3.40	6	4.50	2	4.47	1	4.36	1	Critical	0.886	0.014
Effective collaboration among project participants	3.20	9	4.59	1	4.35	4	4.34	2	Critical	0.981	0.113
BIM manager / Information manager	3.80	3	4.41	3	4.35	5	4.32	3	Critical	0.796	0.158
Detail project planning and evaluation	3.40	7	4.32	6	4.47	2	4.27	4	Critical	1.036	0.024
Favourable legal framework	4.60	1	4.16	8	4.24	8	4.25	5	Critical	1.139	0.023
Systematic workflows, coordination & integration	3.00	12	4.41	4	4.35	6	4.23	6	Critical	0.931	0.002
BIM training programme and education	4.20	2	4.05	12	4.47	3	4.23	7	Critical	0.827	0.014
Standardised work procedures for BIM	3.00	13	4.36	5	4.12	10	4.11	8	Critical	1.098	0.001
Information sharing protocol	3.00	14	4.27	7	4.06	14	4.05	9	Critical	1.049	0.016
Technical competence	3.80	4	4.14	9	3.94	17	4.02	10	Critical	0.844	0.687
Effective management control	2.80	20	4.14	10	4.12	11	3.98	11	Moderate	1.061	0.047
Strong and reliable project team	3.40	8	4.09	11	3.94	18	3.95	12	Moderate	1.005	0.780
Good governance	3.00	15	4.00	14	4.18	9	3.95	13	Moderate	0.993	0.176
Trust on completeness and accuracy	3.20	10	4.05	13	4.00	15	3.93	14	Moderate	0.814	0.078
Robust and clear contractual provisions	3.20	11	3.82	17	4.12	12	3.86	15	Moderate	1.279	0.300
Involvement of client and stakeholders in decision making process	2.80	21	4.00	15	3.88	20	3.82	16	Moderate	1.034	0.072
Thorough and realistic cost/benefits assessment	3.00	16	3.82	18	3.94	19	3.77	17	Moderate	1.025	0.399

Table 6.1: Mean ranking for critical success factors

Success factors	Only involved in PFI/PF2		Involved in PFI/PF2 and BIM		Only involved in BIM		Total		Criticality	St dv	Asymp Sig.
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank			
Appropriate risk allocation	2.80	22	3.68	20	4.12	13	3.75	18	Moderate	1.031	0.004
Data security	2.80	23	3.68	21	4.00	16	3.70	19	Moderate	1.041	0.022
Expert advice and review	2.80	24	3.86	16	3.65	26	3.66	20	Moderate	0.921	0.137
Good financial resources	3.80	5	3.55	23	3.71	22	3.64	21	Moderate	1.116	0.470
Competitive and transparent procurement process	2.40	28	3.41	24	4.24	7	3.61	22	Moderate	1.159	0.000
Selection of project delivery methods	2.60	27	3.77	19	3.71	23	3.61	23	Moderate	0.863	0.044
Government guarantee	3.00	17	3.59	22	3.65	27	3.55	24	Moderate	1.203	0.695
Clear shared authority between public and private	3.00	18	3.41	25	3.82	21	3.52	25	Moderate	1.164	0.184
Establish conflict resolution process	3.00	19	3.41	26	3.71	24	3.48	26	Moderate	0.844	0.117
Robust business case	2.80	25	3.36	27	3.71	25	3.43	27	Moderate	1.059	0.323
Community outreach	2.80	26	2.86	28	3.00	28	2.91	28	Minor	1.190	0.938

Table 6.1: Mean ranking for critical success factors (cont'd)

The results presented in Table 6.1 were ranked according to the overall mean value of the respondents. The mean values for the 28 factors listed have a wide range, which is from 2.91 for '*community outreach*' to the highest value of 4.36 for '*good communication*'. Factors with mean values over 4.00 are regarded as critical success factors. Moderate success factors are those factors with mean values over 3.00. Only one factor, which is '*community outreach*', was regarded as minor or unimportant factor to the success of BIM implementation in PF2 projects.

Based on the above findings and the mean ranking rated by the all respondents, there are generally ten CFS for PF2 projects implementing BIM which are listed as follows:

1) Good communication
2) Effective collaboration among the project participants
3) BIM Manager / Information Manager
4) Detailed project planning and evaluation
5) Systematic workflows, coordination and integration
6) Standardised work procedures for BIM
7) Favourable legal framework
8) Information sharing protocol
9) Technical competence
10) BIM training programme and education

Notwithstanding the CSFs listed above, there are actually differences in the opinions of the three groups of respondents regarding the criticality of the factors. Table 6.6 presents the ranking by these three groups of respondents.

Rank	CSF rated by respondents only involved in PFI/PF2 projects	CSF rated by respondents involved in PFI/PF2 and BIM projects	CSF rated by respondents only involved in BIM projects
1	Favourable legal framework	Effective collaboration among project participants	Good communication
2	BIM training programme and education	Good communication	Detail project planning and evaluation
3	BIM Manager / Information Manager	BIM Manager / Information Manager	BIM training programme and education
4	Technical competence	Systematic workflows, coordination and integration	Effective collaboration among project participants
5	Good financial resources	Standardised work procedures for BIM	BIM Manager / Information Manager
6	Good communication	Detail project planning and evaluation	Systematic workflows, coordination and integration
7	Detailed project planning and evaluation	Information sharing protocol	Competitive and transparent procurement process
8	Strong and reliable project team	Favourable legal framework	Favourable legal framework
9	Effective collaboration among project participants	Technical competence	Good governance
10	Trust on completeness and accuracy	Effective management control	Standardised work procedures for BIM

Table 6.2: The ranking of critical success factors by the three groups of respondents

All of the factors as listed in Table 6.1 were then subjected to the Kruskal-Wallis H Test. As presented in Table 6.3, from the list, twelve success factors showed significant values of less than 0.05, which included seven success factors which were categorised as critical success factors. Therefore, there are only three CSFs on which the respondents' views are not significantly different, which are *"effective collaboration among project participants"; "BIM Manager/Information Manager"*; and *"technical competence"*. The low significance values of the Asymptotic Significance indicate that the opinions of the three groups of respondents regarding their criticality vary significantly.

Success factors	Kruskal-Wallis H	Mann-Whitney U (at sig. 0.015)		
		Group		
	Sig.	1&2	1&3	2&3
Good communication	0.014	**0.007**	**0.008**	0.594
Detailed project planning and evaluation	0.024	0.17	**0.008**	0.631
Favourable legal framework	0.023	**0.007**	0.031	0.564
Systematic workflows, coordination & integration	0.002	**0.001**	**0.001**	0.946
BIM training programme and education	0.014	0.530	0.170	**0.004**
Standardised work procedures for BIM	0.001	**0.000**	**0.003**	0.350
Information sharing protocol	0.016	**0.007**	0.035	0.182
Effective management control	0.047	0.019	0.022	0.830
Appropriate risk allocation	0.004	0.038	**0.003**	0.037
Data security	0.022	0.161	0.019	**0.004**
Competitive and transparent procurement process	0.000	**0.012**	**0.000**	**0.000**
Selection of project delivery methods	0.044	0.015	0.029	0.786

Table 6.3: Difference of opinion of the respondents on the critical success factors for PF2 projects implementing BIM

Subsequently, these success factors underwent the Mann-Whitney U Test in order to evaluate pairwise differences among the three groups. The result can also be seen in Table 6.3. All of the statistically significant values are marked in bold. This indicates the significant difference of opinions between the groups of respondents when being compared for each factor. From the table, it can be seen that *"effective management control*" and "*selection of project delivery methods*" have no statistically significant values, as both factors are scored very near to 0.05 values in the Kruskal Wallis test. This indicates that the difference of opinions among the three groups for these two factors only have little difference in significance. As for the *"selection of project delivery methods",* this factor got all Asymptotic Significance of less than 0.015, which indicates that the opinions of the respondents from these three groups also varies significantly when being compared in pairs.

Questions 2 and 3 of the questionnaire were open-ended questions and inter-related. The questions were:

Question 2: **Other than the factors stated above, what do you think would be the critical success factors for the PF2 project implementing BIM?**
Question 3: **Based on your answer in (2), why do you think they are critical?**

Not all of the respondents answered these questions, as most of them left these questions blank. The researcher only received 25 answers from the respondents. These answers were analysed using thematic analysis as described in sub-section 5.10.1.2 in this thesis. Table 6.4 shows the outcome of the survey. In this table, new CSFs suggested by the respondents leading to the emergence of two major themes were highlighted in bold. Other CSFs of PF2 projects implementing BIM, which were stated by the respondents but appeared to be redundant with the success factors listed from the literature review, were themed by the label of success factors as listed in the questionnaire.

CSFs mentioned by the respondents	Reasons	Themes
Managing knowledge and intellectual capital	The rise of digital edge	**Management of knowledge and intellectual capital**
Clear understanding on the technology	Negative perception that BIM is complex needs to be erased to achieve success.	**Client and project team have good understanding on BIM**
Client awareness on BIM	Success of FM depends on availability of the information and BIM is the tool of information generation and manipulation during the whole life cycle of a facility	
Educating client on what BIM is	So that they know their information requirements	
Everyone involved needs to have understanding on BIM	Unless all disciplines understand and are trained in BIM, it becomes a piecemeal, uncoordinated process, and people will not be interested in using it and BIM uptake will be very slow	
Financial resources	Company needs to invest to upgrade for BIM to be utilised	Good financial resources
	Additional cost for BIM may affect profit in winning project bid	
	Implementing BIM is expensive	

Table 6.4: Critical success factors mentioned by the respondents

CSFsmentioned by the respondents	Reasons	Themes
Communication	Issues tend to arise in case of poor communication and collaboration	Good communication
Single source information	Conflicting sources of information lead to poor communications and reduced productivity.	
Clearly explain what is required from all involved	Tendency to pass incomplete or incorrect information onto the next process	
Clear information exchanges	These are important to agree on what information is shared, with who and when	Information sharing protocol
Collaboration	Not mentioned	Effective collaboration among project participants
Buy-in to BIM process by every person including the site team	Not mentioned	
Total buy-in by the project team from start to finish	If one party doesn't fully follow the BIM implementation, the whole process stalls	
Speed of data information	Data information transfer will need to be vastly improved to make BIM viable from PF2 perspective	Systematic workflows, coordination and integration
Allowing sufficient pre-contract time	The development of a coordinated robust model takes more time to propose than traditional 2D especially with a constant changing of brief.	
Training for the main consultants on the applications of BIM	Company needs to invest to upgrade for BIM to be utilised and consultants need to use BIM from the beginning of the project.	BIM training programme and education
Training and knowledge to be integrated with universities	If people have sufficient knowledge about BIM when they start their career life, they will be more ready to implement BIM	
Legal requirement to implement BIM	Implementing BIM is expensive and time-consuming. Unless it is a legal requirement, developers might be reticent to implement it	Favourable legal framework
Clear ownership of the model	Critical to the success of the project.	Robust and clear contractual provisions
Establishment of BIM related conditions of contract	Existing contracts do not fully support BIM implementation	
Clearly defined roles and responsibilities	Not mentioned	
Use of plain language in contracts	Plain language should be used to prevent any confusion in contracts	
Clear understanding on BIM requirements that need to be fulfilled	Ambiguous requirements lead to uncertainty amongst bidders and ultimately the client receives BIM proposals from bidders which cannot be compared or evaluated effectively.	

Table 6.4: Critical success factors mentioned by the respondents (cont'd)

6.2.2 Discussion of the findings on the critical success factors for PF2 projects implementing BIM

The results from the questionnaire survey suggest that the respondents agreed on the 10 factors considered critical to the success of PF2 projects implementing BIM. With 4 additional CSFs as mentioned by the respondents in the open-ended questions, which are: "*management of knowledge and intellectual capital"; "good understanding on BIM"; "good financial resources";* and *"robust and clear contractual provisions"*; 14 critical factors were short listed. These 14 CSFs are classified as follows:

CSF category	Critical Success Factors
Alliance	Good communication
	Effective collaboration among the project participants
Management	BIM Manager / Information Manager
	Detailed project planning and evaluation
	Systematic workflows, coordination and integration
	Standardised work procedures for BIM
	Management of knowledge and intellectual capital
	Good financial resources
Legal	Favourable legal framework
	Robust and clear contractual provisions
	Information sharing protocol
Competency	Technical competence
	BIM training programme and education
	Good understanding on BIM

Table 6.5: Critical success factors for PF2 projects implementing BIM

"Good financial resources" has been ranked low by the respondents in the questionnaire. However, this factor was mentioned three times in the open-ended question by the respondents. Hence, concerning the reasons given by the respondents in answering the question, the researcher decided to list *"good financial resources"* as one of the CSFs for PF2 projects implementing BIM. The same thing also goes to *"robust and clear contractual provisions"* success factor. Even though this factor has been ranked as a moderate success factor by the respondents, it was mentioned five times in the open-ended questions by the respondents as among the critical factors for PF2 projects implementing BIM to be successful. With the good reasons given by the respondents on justifying their answers, the researcher decided to accept this as a critical success factor.

BIM can enhance collaborative working, but at the same time BIM also demands effective collaboration for the success of its implementation in a construction project. The effective collaboration requires coordinated communication and communicated coordination (Charalambous, Thorpe, Yeomans, & Doughty, 2013). Both factors are interrelated and this explains why '*good communication'* scored the highest mean value, followed by '*effective collaboration among the project participants'* with a value of 4.34. In the open-ended questions, some of the respondents clarified further about the importance of good communication to PF2 project implementing BIM. The respondents commented that good communication is a critical success factor as *"issues tend to arise in case of poor communication and collaboration"* and *"to avoid the tendency to pass incomplete or incorrect information to the next process"*. Other respondents also commented that good communication in PF2 projects implementing BIM can be achieved by having a "*single source of information*" in order to avoid conflicts and confusion in getting the correct information for the project.

The UK Government Soft Landings Policy (Cabinet Office, 2013) aims to bridge the gap between design-construction and operation by using BIM as the medium of communication. Even though using BIM might be able to ease some aspects of communication in PF2 project, for example the use of image visualisation to provide equal understanding on the project's design among the project team members and client; but still, it is not the technology that that can ensure smooth communication among the clients and project team. Good communication still relies on the willingness and attitude of the people to share and communicate their ideas and opinions, to be part of the multidisciplinary decision-making process, to convey the contributions needed from other members in the team, and to be able to see which part in the process that needs contributions. BIM model may be lacking on material stability in being tangible and concrete point of reference; and has less interpretive flexibility to allow other members in the project team to freely interpret and change the original designs or plans (Neff, Fiore-Silfvast & Dossick, 2010); therefore, it requires the users' understanding to overcome these setbacks together. Consequently, the project's data and information can be communicated and coordinated, and the BIM model can be co-created across knowledge boundaries and distinct disciplinary environment.

The construction industry is by nature fragmented, hence, BIM and PF2 are seen as mediums for collaboration in which BIM and PF2 themselves require effective collaboration to succeed. They are elements that foster effective collaboration, which are: good communication, objectives alignment (Badi, & Pryke, 2015), trust, cohesion, commitment, and conflict resolution (Dietrich, Eskerod, Dalcher, & Sandhawalia, 2010). In PF2, having the government equity stake in the SPV is considered as a way to increase collaboration between the public and private sectors. In this new PF2 project arrangement, the project's and organisations' objectives can be properly aligned to achieve a win-win situation, consequently increasing trust among the project's participants. If BIM is used, parties participating in the PF2 project also need to trust in each other's capability and ability to develop or provide BIM models to the precision required, up to the standard that is credible to be used until the operational stage of the facility. This subsequently relates to the commitment of all parties in a PF2 project to wisely and competently use BIM. One of the respondents commented that it is important to have *"total buy-in by the project team from start to finish, as if one party does not fully follow the BIM implementation, the whole process stalls*". When the project participants have the required commitments to implement BIM, the possibility for major conflicts to arise will decrease. However, contract strategy is still an important variable for collaboration in a PF2 project implementing BIM to bind the parties in a relational contract environment that can cater to the changing roles of the parties in BIM environment. This may put the parties in a cohesive and collaborative setting (Sebastian, 2011; Lu, Zhang, & Rowlinson, 2013).

Apart from the factors above, other CSFs are associated with management, which are: '*BIM Manager/Information Manager'; 'systematic workflows'; 'coordination and integration';* and *'standardised work procedures for BIM'*. These factors are actually inter-related. The use of BIM, not only in PF2 projects but also in other construction projects, entails a new role of BIM Manager or Information Manager to be appointed in order to establish and manage the Common Data Environment (CDE). The presence of the BIM Manager is vital as it plays a major role in coordinating, integrating and distributing information among the project team members. In the context of PF2 project, it is important to determine how this role is to be allocated, whether in the existing appointments or appointing a stand-alone Information Manager that can monitor CDE throughout the project life cycle up until the operation stage, or other ways which are considered appropriate. The competency of BIM Manager in managing the BIM models and project information is very important in order to have systematic workflows that can coordinate and integrate the works of designers, builders and facilities managers in the co-creation of the BIM model as all disciplines need to be involved with each other from the very early stage of the project.

Furthermore, despite the various standardised work procedures for BIM as what has been developed under PAS 1192 and BS series, '*detail project planning and evaluation'* are also critical for the success of PF2 projects implementing BIM. The planning includes the preparation to execute the project consisting of project objectives, project schedule, procedures and budget (Wen-xiong et al., 2007; Porwal & Hawage, 2013). The evaluation involves the supervision mechanism and key performance indicator (Ismail, 2011; Mladenovic et al., 2013) to evaluate the performance of the SPV. These are important aspects to ensure that PF2 and BIM blend harmoniously to achieve the project's target and would not expose the project to any unforeseen additional risks associated with the BIM implementation. This factor is also related to *"good financial resources"* success factor. According to the respondents, financial resources are vital because implementing BIM is expensive. A company needs to invest high financial capital to upgrade their facilities and equipment; and also, to train their staff so that BIM can be utilised when executing PF2 projects (Hardin, 2009). While bidding for PF2 projects, high additional cost spent upfront for BIM may affect the profit margin.

Another critical success factor that is associated with management as suggested by a respondent is the *'management of knowledge and intellectual capital'.* However, there is no clear reason given on this except that the respondent stated that knowledge management and intellectual capital is needed in response to the '*rise of digital age'*. Based on the literature, knowledge management is about the process of utilising and managing knowledge to produce profits in an organisation (Egbu, 2004). This includes understanding and nurturing the knowledge resource, evaluating knowledge, promoting knowledge creation, disseminating it to those who need it when it is needed (Wiig, 1997; Johnston & Blumentritt, 1998; Zack, 1999; Seleim & Khalil, 2011), documentation and storage (Zack, 1999; Seleim & Khalil, 2011); developing and implementing strategies for new knowledge investments; and safeguarding intellectual property (Wiig, 1997). Intellectual capital is intellectual brainpower activity that is used to materialise higher value intellectual product (Wigg, 1997; Egbu, 2004; Seleim & Khalil, 2011).

Therefore, knowledge management and intellectual capital are interlinked in the sense that in the knowledge management process, intellectual capital needs to be utilised to facilitate the process, while at the same time the process also develops and maintains the intellectual capital (Marr, Gupta, Pike & Roos, 2003). In the context of PF2 projects implementing BIM, the lengthy contract duration requires the knowledge management process to be dynamically changed in response to the fast progressing BIM technology in order to develop and accumulate intellectual capital. On the other hand, this situation also entails intellectual capital to play an important role in the dynamic knowledge management process to maintain the competitive advantage of the SPV and support possible innovations. In this context, individual and project knowledge are both intellectual capitals (Egbu, 2004) of PF2 projects implementing BIM, therefore education and training need to be geared on the project team member and the client to improve their knowledge, skills, and awareness.

Thus, competency is another great issue under concern in relation to the implementation of BIM in PF2 projects. Two factors related to this matter were considered by the respondents as the critical success factors, which are: '*technical competence'*; and '*BIM training programme and education'*. There is also another critical success factor suggested by the respondent, which is for the client and project team to have *"good understanding on BIM"*. One respondent commented that, "*unless all disciplines understand and are trained in BIM, it becomes a piecemeal, uncoordinated process, and people will not be interested in using it and BIM uptake will be very slow"*. Another respondent also stated, the *"success of facilities management depends on the availability of information and BIM is the tool of information generation and manipulation during the whole-life-cycle of the facility"*. These comments given by the respondents show that *'technical competence'* and *'good understanding on BIM'* are the major aspects that determine the readiness of any organisation to implement BIM.

The concern on the readiness of BIM has been echoed for many years since the UK Government, in 2011, mandated BIM adoption on all centrally funded government projects by 2016 (Cabinet Office, 2011). Since then, many concerns were voiced out and surveys were carried out on the construction industry's readiness to implement BIM. The latest was the survey conducted by NBS (2016). The survey stated that only 18% of the respondents are very confident about their BIM skill and abilities, leaving a majority who are not very confident or not confident at all. Furthermore, in terms of awareness, big percentage of 42% of the respondents admitted they just recently became aware of BIM, and 4% were neither aware of nor using BIM. These findings show that BIM competencies and understanding at the moment of writing this thesis are still deficient. The incompetence of project team members in BIM will jeopardise the collaboration and integration mission in PF2 project which consequently will affect the whole process. If problems arise, BIM might be seen as a burden, not a saviour. Therefore, '*BIM training programme and education'* is vital for BIM implementation in PF2 projects (Khosrowshahi & Arayici, 2012). One of the respondents suggested for the BIM training and education to be integrated with courses in universities. The respondent stated, *"if people have sufficient knowledge about BIM when they start their career life, they will be more ready to implement BIM".* This suggestion was actually what the Built Environment education providers in the UK Higher Education Institutions are doing in offering BIM courses to meet the demands required for future professionals (Underwood et al., 2015).

Another three factors considered to be critical are associated with legal and contractual matters, which are: '*favourable legal framework'; "robust and clear project agreement";* and '*information sharing protocol'*. Acts, regulations, legal or contractual documents to govern the implementation of BIM in PF2 are considered by many respondents as very critical to the success of the project. Some of the comments given by the respondents in the open-ended questions include, among others, their concern on the need to establish "*BIM-related conditions of contract"* as they believe what have been stated in the Standardisation of PF2 Contract are "*not enough to support BIM implementation".* This comment is quite relevant as there is no provision in the document of Standardisation of PF2 Contract that mentions BIM or any technology-related matters that can be used specifically for the implementation of BIM. Even though, in the current practice, practitioners might be presumed to use any relevant BIM Protocol as supplementary contract to cater to the needs of BIM implementation, but the compatibility of such BIM protocol with PF2 project is still in open question.

Other than that, as information sharing and synchronisation is one of the basic important elements in BIM projects, a protocol related to it is considered critical to be in establishment. The current CIC BIM Protocol is said to have failed in addressing collaborative information sharing in common data environment (Winfield, 2015a; Klein, 2015). Singh, Gu & Wang (2011) underlined three important elements that need to be included in contracts using BIM in relation to information sharing, which are: intellectual property agreements and policies for data exchange; classification of public and private data; and correspondence protocols. In addition to that, one of the respondents commented that the *"speed of data information*" also needs to be considered as "*data exchanges need to be vastly improved to make BIM viable for PF2*". It is believed that if these matters are properly addressed and aligned, they can provide an impetus for the use of BIM in PF2 and as well as other PPP projects.

As the result, 14 CSFs have been identified for PF2 projects implementing BIM (see Table 6.5), subject to refinement with the experts in a later stage of this research. The following section will show how these CSFs interlink with the BIM risk factors.

6.2.3 Analysis of the BIM risk factors that have significant impact towards PF2 projects

Based on the literature review, 24 BIM risk factors were listed out in the questionnaire (refer Appendix A). In Section C of the questionnaire, the respondents were asked to give their opinions regarding BIM risk factors that can give impact to PF2 projects implementing BIM. The questions were close-ended questions in which 24 BIM risk factors were listed out and the respondents were asked to rate the significance of the risk factors in regards to PF2 projects implementing BIM.

Table 6.6 shows the mean ranking based on the opinions of the respondents on the BIM risk factors and their impact on PF2 projects. The mean values range from 3.25 to 4.20. Risk factors with mean values over 4.00 are regarded as very significant risk factors and in this case, there are two very significant risk factors, which are *"lack of available skilled personnel"* and *"resistance to change"*. On the other hand, risk factors which scored mean values of less than 3.50 are considered as moderate risk factors.

Risk factors	Only involved in PFI/PF2		Involved in PFI/PF2 and BIM		Only involved in BIM		Total		Significance	St dv	Sig.
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank			
Lack of available skilled personnel	4.20	2	4.20	1	4.18	2	4.20	1	Very Significant	0.986	0.360
Resistance to change	3.60	4	4.11	2	4.30	1	4.13	2	Very Significant	0.913	0.228
Little knowledge and experience	3.50	9	4.02	4	4.00	8	3.95	3	Significant	0.963	0.738
Lack of collaborative work processes	4.40	1	3.89	7	3.88	11	3.94	4	Significant	0.753	0.110
Integrity of BIM model	3.80	3	3.91	6	4.03	6	3.94	5	Significant	0.894	0.543
Defective integration between software tools	3.00	18	4.02	3	3.88	12	3.85	6	Significant	0.947	0.037
Inadequate top management commitment	3.40	11	4.02	5	3.76	18	3.85	7	Significant	1.029	0.303
Ownership of BIM model	3.00	19	3.70	10	4.06	4	3.76	8	Significant	1.034	0.056
High initial cost to implement	3.20	14	3.73	9	3.91	9	3.74	9	Significant	1.017	0.229
Lack of BIM standards and guidelines	3.60	6	3.52	17	4.00	7	3.71	10	Significant	0.926	0.050
Liability issues	2.60	24	3.57	12	4.18	3	3.69	11	Significant	0.944	0.000
Data security	3.40	10	3.57	14	3.88	10	3.67	12	Significant	0.936	0.269
Existing legal system not equipped to support BIM	3.60	5	3.55	15	3.79	16	3.64	13	Significant	0.964	0.533
Lack of guidelines for contractual agreements	3.40	12	3.55	16	3.85	14	3.64	14	Significant	0.915	0.241
Model management difficulties	3.00	17	3.73	8	3.67	19	3.62	15	Significant	0.967	0.172
Time consuming to be proficient	3.20	15	3.34	20	4.00	5	3.60	16	Significant	0.994	0.004

Table 6.6: Mean ranking on the BIM risk factors and their impact on PF2 projects

Risk factors	Only involved in PFI/PF2		Involved in PFI/PF2 and BIM		Only involved in BIM		Total		Significance	St dv	Sig.
	Mean	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**			
Status of BIM model	3.60	8	3.36	19	3.85	13	3.57	17	Significant	1.127	0.095
Unclear position, duty, responsibility and liability of Information Manager	2.80	23	3.59	11	3.67	21	3.53	18	Significant	1.087	0.283
Unclear allocation of risks	3.00	21	3.57	13	3.52	23	3.48	19	Moderate	1.021	0.498
Errors in the model	3.60	7	3.50	18	3.42	24	3.48	20	Moderate	1.109	0.652
Increase short term work load	3.20	13	3.20	21	3.82	15	3.44	21	Moderate	1.042	0.029
Change of BIM policies	3.00	16	3.18	22	3.79	17	3.39	22	Moderate	0.840	0.005
Privity of contract and third party reliance	2.80	22	3.16	23	3.55	22	3.26	23	Moderate	0.982	0.128
Intellectual property rights issue	3.00	20	3.00	24	3.67	20	3.25	24	Moderate	1.059	0.014

Table 6.6: Mean ranking on the BIM risk factors and their impact on PF2 projects (cont'd)

Therefore, based on Table 6.6, there are two very significant risk factors; and eighteen significant risk factors were identified, listed as follows:

1) Lack of available skilled personnel
2) Resistance to change
3) Little knowledge and experience
4) Lack of collaborative work processes
5) Integrity of BIM model
6) Defective integration between software tools
7) Inadequate top management commitment
8) Ownership of BIM model
9) High initial cost to implement
10) Lack of BIM standards and guidelines
11) Liability issues
12) Data security
13) Existing legal system not equipped to support BIM
14) Lack of guidelines for contractual agreements
15) Model management difficulties
16) Time consuming to become proficient
17) Status of BIM model
18) Unclear position, duty, responsibility and liability of the Information Manager

All of the risks factors listed in Table 6.6 were analysed via Kruskal-Wallis H Test to see the differences of opinions of the respondents on the BIM risk factors and their impact on PF2 projects.

Risks factors	Kruskal-Wallis H	Mann-Whitney U (at sig. 0.015)		
	Sig.	Group		
		1&2	1&3	2&3
Defective integration between software tools	0.037	**0.011**	0.037	0.511
Liability issues	0.000	0.053	**0.001**	**0.001**
Time consuming to be proficient	0.004	0.962	**0.002**	**0.001**
Increase short term work load	0.029	0.560	0.218	**0.008**
Change of BIM policies	0.005	0.849	0.046	**0.002**
Intellectual property rights issue	0.014	0.782	0.601	**0.002**

Table 6.7: Difference of opinion of the respondents on the significance of the BIM risk factors on PF2 projects

As seen in Table 6.7, after the data underwent the Kruskal-Wallis H Test, six risk factors showed significant values of less than 0.05, including three risk factors considered by the respondents as significant risk factors which are: "*defective integration between software tools"; "liability issues";* and *"time consuming to be proficient"*. The low significance values of the Asymptotic Significance indicate that the opinions of the three groups of respondents regarding their significance of impact towards PF2 projects vary significantly. Subsequently, Mann-Whitney U Test was carried out on these risks factors in order to test pairwise differences of opinions among the three groups. Results of the test are presented in Table 6.7. All of the values which are statistically significant are marked in bold; indicating that the Asymptotic Significance is less than 0.015, showing that the opinions between the groups of respondents when being compared for each risk factor vary significantly.

6.2.4 Discussion of the findings on the significant BIM risk factors to PF2 projects

Based on the responses received from the survey, eighteen BIM risk factors that might give significant impact to PF2 projects were identified which appeared to be inter-related with the CSFs of PF2 projects implementing BIM discussed earlier. Table 6.8 shows the matrix on how the significant BIM risk factors can be addressed by having the CSFs in PF2 projects.

BIM risk factors	Critical success factors													
	Good communication	Effective collaboration	BIM Manager / Information Manager	Detailed project planning and evaluation	Systematic workflows, coordination and integration	Standardised work procedures for BIM	Management of knowledge and intellectual capital	Good financial resources	Favourable legal framework	Robust and clear contractual provision	Information sharing protocol	Technical competence	BIM training programme and education	Good understanding on BIM
Lack of available skilled personnel							●					●	●	●
Resistance to change								●		●		●	●	●
Little knowledge & experience							●					●	●	●
Lack of collaborative work process	●	●			●	●								
Integrity of BIM model						●				●		●		
Defective integration between software tools				●	●							●		
Inadequate top management commitment	●	●												
Ownership of BIM model										●				
High initial cost to implement				●				●						
Lack of BIM standard and guidelines			●		●	●			●					
Liability issues										●				
Data security											●	●		
Existing legal system not equipped to support BIM									●	●	●			
Lack of guidelines for contractual agreements			●						●	●			●	
Model management difficulties	●	●		●	●	●					●	●		●
Time consuming to become proficient							●						●	
Status of BIM model										●				
Unclear position, duty, responsibility and liability of the Information Manager			●						●	●				
Total risk factors	**3**	**3**	**3**	**3**	**4**	**4**	**3**	**2**	**4**	**8**	**3**	**7**	**5**	**4**

Table 6.8: Matrix of BIM risk factors and critical success factors

The matrix shown in Table 6.8 revealed that out of the eighteen BIM risk factors identified by the respondents as significant, eight of the BIM risk factors can be addressed or alleviated by having *"robust and clear contractual provision".* This is followed by *"technical competence"* which is associated with seven BIM risk factors. Therefore, the findings show that *"robust and clear contract provision"* and *"technical competence"* are the most vital aspects that seriously need to be in place for a PF2 project implementing BIM to become successful.

Most of the highly ranked significant BIM risk factors are those that are related to legal and contractual issues, which included *"integrity of BIM model"; "ownership of BIM model"; "lack of BIM standards and guidelines"; "liability issues"; "existing legal system not equipped to support BIM"; "lack of guidelines for contractual agreements";* "*status of BIM model";* and "*unclear position, duty, responsibility and liability of the Information Manager".* These have been discussed in the literature review chapter; however, as many of the significant risks are associated with legal and contractual risks, this signifies that great care need to be taken to address or mitigate those contractual issues related to BIM implementation in PF2 contract. Contract is the fundamental mechanism for allocating risks that specifies the responsibilities, obligations, rights and liabilities of the parties involved in the project, therefore issues related to it need to be treated soonest possible for the smooth-running of the project and to lessen the risks of dispute in the future. As PF2 projects need to be sustained and kept running for a lengthy period of time, it is obviously putting contract as the critical document to be referenced throughout the project duration, therefore it has to be, as much as possible, free from ambiguous provisions and uncertain solutions to contractual issues.

With the rise of digital age, knowledge and skills related to BIM implementation have become increasingly important as without these, the maximum benefits of using the technology would not be achieved. BIM requires its users to be knowledgeable and skilled especially in managing and integrating data among different professionals and different phases of the project (Hardin, 2009). In PF2 projects, where integration and collaboration are very challenging given the myriad of parties involved and need to be sustained from initiation to the end of a lengthy contract duration, the lack of appropriate skills and knowledge may hinder the BIM models to be sustainably used extensively throughout the project duration. Consequently, the optimal advantages of BIM towards the PF2 projects would not be enjoyed. These are the reasons BIM risk factors which are related to competency issues, namely: "*lack of available skilled personnel"; "little knowledge and experience"; "integrity of BIM model"; defective integration between software tools"; "data security"* and *"model management difficulties"* were rated as significant risk factors that might impact PF2 project. These also contribute to *"resistance to change"* scenario in the construction industry as the many people in the industry do not understand BIM and are not fully equipped with BIM technical skills, thus causing anxiety to practise BIM.

Apart from that, *"resistance to change"* is also considered as a very significant risk towards PF2 project. Some reasons related to this risk factor were found in some of the answers given by the respondents in the open-ended questions in Section B. Based on their answers, the resistance to change is due to the mentality of the people in the industry that *"BIM is a complex tool"; "very difficult to use"; "costly investment"; "time-consuming";* and "*not having sufficient knowledge in BIM".* Their answers also indicate that there are strong relationships between *"resistance to change"* risk factor with other significant risks factors, which are *"inadequate top management commitment"; "high initial cost to implement";* and *"time consuming to be proficient".* These risks factors will give big impact to the BIM implementation in PF2 project as the project team members do not have the same level of trust in the capabilities of BIM to reduce PF2 risks, therefore making them reluctant to invest time and money for BIM.

Severe changes in the working environment, as BIM demands all professionals including Facilities Manager to be in active from the beginning of the project (Arayici, Egbu, & Coates, 2012; Lindblad & Vass, 2015), also contribute to the worries on the BIM implementation. These are also the reasons why *"good financial resources"; "technical competence"; "management of knowledge and intellectual capital";* and *"BIM training programme and education"* become the CSFs for PF2 projects implementing BIM. In a survey conducted by CONJECT Ltd., among the issues associated with BIM as the respondents pointed out is the need on training to educate the BIM users on the cultural change required in the way of working in order to make a BIM project successful (Mason, 2015). Khosrowshahi & Arayici (2012) also mentioned that BIM implementation not only requires learning new software applications, but also learning how to reinvent the workflow, how to train staff and assign responsibilities, and the way of modelling the construction. This will cause massive change in the traditional way of working, hence making the construction industry players refuse to embark on BIM.

The factor of "*lack of collaborative work process"* is considered as a significant risk factor that can give impact to the PF2 projects. Collaboration is the foundation of BIM and PF2 but it very difficult to be achieved as it relates to personalities of the project team members, experience, commitment and it needs clear understanding on roles and responsibilities that they are shouldering. PF2 projects implementing BIM is about bringing all parties together and to change the fragmented way of working into defragmentation. This is indeed taxing as all parties have their own interests towards the project that need to be protected but at the same time need to integrate their works, information and data to make the project successful. These are the reasons for the need of an Information Manager to be included as a new role in the project as it is expected that the Information Manager will take charge in managing the model and the data, which will indirectly contribute in helping the project members to collaborate. Therefore, it is also a significant risk if there is *"unclear the position, duty, responsibility and liability of Information Manager".*

There are also significant risks which are associated with the technical issues in BIM, which are: *"defective integration between software tools"; "model management difficulties"* and *"data security".* Software used by the project team members may be different depending on the skills and capabilities that they have. Therefore, during the exchange of files and transferring data or model in distinct software tools, data loss may occur after the conversion of files causing interoperability problem (Grilo, & Jardim-Goncalves, 2010; Steel, Drogemuller, & Toth, 2012). Furthermore, it is also challenging to manage the BIM model and the data in it. It requires the Information Manager to continuously update the model, which might cause confusion in the valid version to be referred to; accurate data entry is a necessity; and the software might be unable to accommodate large amounts of data. The data contain in the model are also exposed to data degradation and data hacking resulting from improper storage and handling, which leads to loss of data and information leak to third party (Boyes, 2015).

In the implementation of BIM in PF2 projects, these risks will definitely have very big impact to the PF2 project given the situation where the project normally last in 20 to 30 years of contracting.

Thus, from this survey, 18 significant BIM risk factors which are considered important and can give big impact to the PF2 projects were identified. The interlink between these significant BIM risk factors and CSFs as established previously in sub-section 6.2.2 of this thesis was also explained. From the discussion, two most significant CSFs were identified, which are *"robust and clear contractual provision"* and *"technical competence"*. The following sub-section discussed the development of preliminary conceptual framework of the critical success factors and contractual risk for the strategic management of PF2 projects implementing BIM and how the contractual risks and strategies to manage the risks are related to the CSFs as described hereinbefore.

6.2.5 Identifying the key contractual risks and management strategies in PF2 projects implementing BIM

While the researcher was conducting the questionnaire survey, three informal interviews with people considered experts in the area being researched were also conducted with the purpose of identifying the possible relevant contractual issues that need to be addressed in PF2 projects implementing BIM. The information gathered from the literature review on the contractual risks of projects using BIM and possible strategies to manage such risks were discussed with them and the experts helped the researcher in scrutinising the important and relevant issues regarding PF2 and BIM. In this section, the key findings extracted from the literature review are identified and the outcomes from the experts' opinion interviews are listed out. The findings were then synthesised with the CSFs of PF2 projects implementing BIM as identified earlier. Consequently, the preliminary conceptual framework of the critical success factors and contractual risk for the strategic management of PF2 projects implementing BIM was developed.

6.2.5.1 Key issues identified from the literature review

Based on the literature review, possible contractual risks if BIM is used in PF2 project are classified into five groups which are: “Information Management”; “Status of BIM model”; “Reliance of BIM data”; “Intellectual Property Rights”; and “Liability”. The issues are as follows:

<u>Contractual risk 1: Information Management</u>

A PF2 project implementing BIM relies heavily on excellent information management due to its nature which involves a myriad of parties, the need to integrate all these parties and coordinating the inputs of the parties virtually and in reality for the benefit of the projects. In this context, such project needs a competent Information Manager to shoulder the role of coordinating, integrating, and disseminating information throughout the project contract duration (see the discussion in sub-section 4.4.1). There were issues identified from the literature regarding Information Management in PF2 projects implementing BIM, listed as follows:

a) Unclear procedures on the appointment of Information Manager in the context of PF2 contractual structures which includes the position of Information Manager in the contractual structures, the procedures of appointment, when the appointment of the Information Manager should take place and the length of the duration for the role of the Information Manager to be sustained in the PF2 project.

b) The duties and the powers of the Information Manager in managing the flows of the information and to make other parties to comply with the directions and instructions given by the Information Manager on data-related matters in the situation where there is no contractual relationship between the Information manager and the other project team members.

c) Procedures for information contributed by the project team member to be included in the BIM model or BIM data. This includes how the information should be shared among the contracting parties in the PF2 projects.

<u>Contractual risk 2: Reliance of BIM data</u>

Collaborative working environment depends on the BIM model/data as the platform for contributions and as the trusted and reliable source of information. However, there are issues regarding the integrity of the BIM model and data contained in it and also the reliability as BIM model is exposed to data degradation and human errors. Specifically, the key issues regarding the reliance of BIM data are identified as follows (see the discussion in sub-section 4.4.2):

a) The reliability and integrity of the data in BIM model is in question due to Clause 5.1 in the CIC BIM Protocol which states that, *"... the Project Team Member does not warrant, expressly or impliedly the integrity of any electronic data delivered in accordance with this Protocol".*

b) Information overload issue. What appropriate actions that need to be taken if the model is produced further than the Level of Detail (LOD) and the other parties relied on it beyond the defined LOD.

c) The need to change protocol and information sharing protocol to facilitate any changes in BIM model during the construction stage or operational stage of PF2 project and to ensure the parties are adhering to standard procedures in sharing sensitive information.

d) Data security issues regarding the integrity, confidentiality and availability of the data.

e) The need to have standard of care for checking the integrity of the BIM model before the information is shared.

Contractual risk 3 : Status of BIM model

BIM model is not the only thing that comes out from the use of BIM as it is also normally being used as a source to extract drawings or other data for the purpose of further reference by the project participants. BIM model is not constant and can gradually be changed according to the needs of the project. Therefore, any drawings or data extracted from the BIM model are very prone to the risk of becoming out of date if they are not synchronised with the change or development of the BIM model (see the discussion in sub-section 4.4.3). Due to this situation, in the case there is any dispute or clash due to inconsistencies between the extracted information and the BIM model, conflicts may arise to see which one would prevail. The issues regarding this situation are extracted as follows:

a) The extent to which the BIM model could stand as part of the contract document.

b) If the model is treated as part of contract document, how to overcome the situation where the BIM model is very sensitive to changes over its use during the PF2 project lifespan and how this would affect the contract.

c) Clause 2.2 in BIM Protocol stated that any conflicts or inconsistency between the model and any document or information extracted from the model, the model(s) shall prevail. In a situation where drawings and other data have become part of the contract document, how can BIM model take precedence over the extracted documents?

d) If the BIM model is to be treated as a contract deliverable only, then how can the BIM model prevail over the extracted information as mentioned in the BIM Protocol?

Contractual risk 4: Intellectual Property Rights

Some of the issues regarding intellectual property rights and copyright license have been addressed by the CIC BIM Protocol, which seemed to be suitable to be used in PF2 projects. In the CIC BIM Protocol, the parties involved in the BIM project can licence or sub-licence the material that they are using from the third party. Within the context of PF2, this might be relevant to be used as in the PF2 project as the parties that do not have any contractual relationship can still use the materials produced by each other in the development of their own models provided they procure the licence. Another provision that is also relevant is the clause on the restrictions for others to modify the models or materials other that project-related purposes. This is to avoid other parties to modify the model that they got as a basis to create their own version on other projects. Moreover, at BIM Level 2, it is still easy to trace the ownership of the data provided by the contributors due to the fact that the parties are still working on their individual models before their models are being integrated to become the federated BIM model (see the discussion in sub-section 4.4.4). However, in the context of PF2 projects implementing BIM, there are still several issues that need to be addressed in the contract, which are as follows:

a) If the licensing and sub-licensing provisions as stated in the BIM Protocol are to be used, the individual contracts between the SPV and the other project team members (the third parties) need to have a provision that permit such scope of sub-licensing.

b) Whether there is a need to limit sub-licensing to one or two defined levels for the PF2 project implementing BIM, therefore the contributor can control the use of the information or material provided for the project throughout the PF2 contract duration.

c) Copyright licence is revocable under the CIC BIM Protocol (Clause 6.4), but irrevocable under the Standardisation of PF2 contract (Clause 33.5.1). Therefore, which provision would be more suitable with the PF2 project implementing BIM environment is still in question.

d) Whether it is needed for the Information Manager to have IP rights as he is using sufficient skills in coordinating various models provided by the designers and other contributors to produce the federated model.

e) The need to transfer the ownership of the IP to the Employer as stated in Standardisation of PF2 (Clause 33.1.2).

Contractual risk 5: Liability

Supposedly, BIM does not simply change the liability of the project team member unless any of them have additional roles that need to be carried out in managing the BIM data (see the discussion in sub-section 4.4.5). In Level 2 BIM, in the event there is an error or non-compliance of requirements by the parties, it is still easy to trace the party who caused such error or non-compliance as they are still working individually before merging their model or data in the federated model. Therefore, they are still individually liable for any error that they make. However, there might be little adjustments that need to be done to the contract after all of the data given to the Information Manager are managed and disseminated. As most of the data-related matters are managed by the Information Manager, clear liabilities of the Information Manager must be well-clarified in the PF2 projects as the Information Manager also needs to be very careful in controlling the flow of the information and the information database to ensure the smooth running of the project. The issues relevant to PF2 projects implementing BIM are as follows:

a) Liabilities of the Information Manager. Whether the Information Manager would be liable for data error due to poor management of the data, mistakes in providing information to the other parties and incompetency in coordinating and integrating BIM models from contributors seems to be an issue. The liabilities of the Information Manager need to be clearly spelled out in the contract.

b) The liability of the parties in the PF2 project when "…the Project Team Member does not warrant, expressly or impliedly the integrity of any electronic data delivered in accordance with this Protocol" (Clause 5.1).

Hence, these above are the key areas for investigation in the present study: information management; status of BIM model; BIM data reliance; intellectual property rights; and liability. Subsequently, three experts' interviews were carried out to further refine the issues on contractual risks for PF2 projects implementing BIM. In the next sub-section, the views of the experts are presented.

6.2.5.2 Experts opinions

The researcher carried out three expert interviews to identify the relevant contractual issues that need to be addressed in PF2 projects implementing BIM and possible solutions to manage those risks. The interviews were intended to help the researcher to refine issues that need to be considered in developing the conceptual framework of the critical success factors and contractual risk for the strategic management of PF2 projects implementing BIM (see sub-section 5.8.2).

Contractual risk 1: Information Management

All of the experts acknowledged the importance of information management in PF2 projects implementing BIM. All of them agreed with the contractual issues listed by the researcher regarding Information Management. In relation to information management, one of the interviewees was concerned about whether the current BIM legal documents were designed to take into consideration the information management up to the post-completion stage and operation stage of a project as what is needed by the PF2 projects. In commenting of what the UK construction industry has at the moment which is the CIC BIM Protocol, the first interviewee stated, *"there is no project team member under the protocol with any obligation to update and maintain the models throughout the life cycle of the building which again is the bulk off the time over PF2 contract arrangement."* It was also suggested by the second interviewee to refine the duties of the Information Manager in PF2 context. According to him, in the list of the duties of the Information Manager, it is important to check *"whether the Information Manager has that ongoing obligation through that operation phase or to have only the obligation at the design and build phase or maybe they became redundant at the operation phase."* On the other hand, the third interviewee suggested reviewing whether it is really needed to have an Information Manager in the PF2 projects implementing BIM as this role might be appropriate to be shouldered by the Project Manager. According to him, *"maybe there won't be a need for this data management anyway ... managing people and information need not be separated but they are trying to separate it from the project manager because it is not a 'project', but 'information'."* As for the confidentiality of the information, all the three interviewees acknowledge the need to protect the data from being overly exposed to unauthorised parties without the agreement of all providers. *"This is to avoid plagiarism of ideas and disclosure of commercially sensitive information that might be contained in the BIM model or the data"* as stated by the second expert.

<u>Contractual risk 2 : Reliance of BIM data</u>

The interviewees agreed that the BIM model and data must be reliable as the project team members and the client are referring to the BIM model throughout the PF2 project duration. Two of the interviewees expressed their concern for the PF2 projects not to employ, as what stated in Clause 5.1 in the CIC BIM Protocol, the clause that challenged the reliability and integrity of the BIM model. The fundamental concept in BIM is information sharing, therefore all parties should have solid trust to the information provided to them that is sourced from the BIM model. The first interviewee said, *"It is not appropriate for the Protocol to say that the integrity of the data is not warranted as in PAS 1192 the fundamental concept in BIM is to trust the information, then how to trust without integrity?"* The second interviewee commented by saying, *"to make the collaborative platform work, it is the sharing information concept that you need to rely on, or else you can't share something that you are not sure the integrity of it, because other people will be relying on false information*." On the other hand, the third interviewee viewed that the content of Clause 5.1 is only to be applied when reasonable skill and care have been taken care of. According to him, *"it is something to do with electronic data, sometimes something goes wrong due to nobody's fault so this clause is to give the protection. But if you use the clause and don't comply with the BIM requirements stated in the contract, for example store the data in a certain format or software, then you still have the liability."* Despite the different views, all of the experts agreed for the researcher to investigate the industry stance upon this matter. Furthermore, on the issue regarding LOD and protocol to share and change information in the BIM model, the interviewees as a whole agreed that these issues need to have a clear expressed clause in the contract that clarify the situations. As what the second interviewee said, *"well, I can say the clarity is not good enough. All of these requirements on the level of detail and what documents that need to arrive need to be clarified in the project contract. It is good to bring these matters to the knowledge of the people of the industry, to avoid people doing things in a very piecemeal basis*."

Contractual risk 3: Status of BIM model

All the three experts acknowledged the confusion in the industry in determining the status of the BIM model. They also admitted that the position of the BIM model in the CIC BIM Protocol is unclear and questioned the relevancy of the clause in the BIM Protocol, which stated that in the event of any conflict or inconsistency between the BIM model and any extracted information, the model shall prevail (Clause 2.2 of the CIC BIM Protocol). The first expert mentioned, *"if we said the model takes priority, it must be presumed that the model at stage it was before the contract was being entered into, the stage of the model before you contracting."* This is just the expert's guess, which shows that which version of the BIM model that shall prevail remains in question. As the second expert said, *"it's going to be a problem when you are trying to compare something that was built five years ago against a model that have moved on and been out dated over that time. So you need to be able to know which version of it."* Furthermore, the third expert questioned the necessity for the BIM model to be prevailed over other contract documents. He said, *"when the model prevails, what do you mean by what is prevail? The model has sort of information, dimensions, geometrical summation,* *properties of the individual elements, programming information and so on. How might these throw the league into obligation or language of obligation?"* Hence, with all of the questions thrown by the experts, it is obvious that something needs to be done to ensure the status of BIM model and its impact towards lengthy contract, as what PF2 projects are having.

<u>Contractual risk 4: Intellectual Property Rights</u>

The interviewees as a whole agreed on the issues brought by the researcher (see the issues listed in sub-section 6.2.5.1) on the intellectual property rights, as they commented that these are the issues that are always echoed by the people in the industry, therefore it is critical to propose solutions to the issues under the PF2 context. The first expert had a view that in the PF2 context, *"the licence has to be obviously available for a longer period, not only building the facility but until the facility in the maintenance and operation stage, and also can be sub-licensed down the line of construction and services delivery chains."* The interviewees prefer the contractual risk of the intellectual property rights to be addressed without comparing the issue in the PF2 context with design and build or traditional procurement contexts. This is because there are issues which are unique to PF2's lengthy contract, such as on the revocability of the licence. For example, according to the second expert, *"licence in PF2 cannot be revoked because it would make it impossible for the client to use the design possibly for future works or further amendments during completion. The same goes to the ownership of the model as the SPV in the PF2 project might be suitable to own the model and the IP, so that if anything is to happen, for example termination of FM provider, the SPV needs to give the model to the new FM provider so that the facility can continuously be managed during operation."* However, according to the third expert, *"these need to be clearly set up in the contract and it depends on the project team to give away their IP to the SPV. If it is just one piece of an intellectual property to this individual project and they are not going to use it again, then they might say it is fine for you to own it."*

<u>Contractual risk 5: Liability</u>

Liability issue in PF2 project implementing BIM is very much related to the risks allocated among the project team members and the Client. As in PF2 projects most of the risks are shouldered by the SPV, so there is not much that can be said in terms of liability in the contract between the SPV and the Client. It is clearly understood that Client is the procurer of the services provided by the SPV, therefore the quality of services is all that matters to the Client. Therefore, risks that are related to the use of BIM are normally shouldered by the SPV, unless it is stated otherwise in the contract, as what the third interviewee said, *"Liability of the SPV and the government depends on what they agreed on in the contract."* However, as in PF2 project, the Client is also involved in the decision-making process, so a question arises if the Client is also liable for any error in the decisions made throughout the contract duration. This is what has been highlighted by one of the experts apart from what have been listed by the researcher in sub-section 6.2.5.1 regarding the liability issue. According to the second interviewee, *"being an investor or a client, it doesn't mean that you interfere in the decisions that affect the delivery… if you do interfere, then you have to take the responsibility. You cannot cause interference without responsibility."* On the other hand, the first interviewee had given his opinion by saying, *"even if the government is involved in the decision making, the SPV still needs to be responsible with what they provided for the contract."* Given the different opinions given by the experts, the researcher decided to bring this issue to the next stage in the semi-structured interview.

Furthermore, all of the interviewees agreed with the issues listed out by the researcher (see sub-section 6.2.5.1) on liability. Regarding the liabilities of the Information Manager, one of the interviewees raised his concern on the need to *"set the demarcation line between the role of the Information Manager and other roles in the project. Therefore, his liability will be solely on data-related matters."* Since the integrity of the BIM data is also a major concern as discussed earlier, the interviewees agreed with the idea to have standard care for checking the integrity of the BIM model before the information is shared. *"Such approval before any information is being shared will* *discharge the project team members from providing false information to the other parties",* as stated by the third interviewees.

Hence, the experts' opinions were gathered and the contractual risks were refined. The next section of this thesis discusses the synthesis of the findings from this exploratory stage of the research which leads to the development of the preliminary conceptual framework.

6.2.6 Synthesis of the findings in the Research Stage One and the development of the preliminary conceptual framework

The results obtained from the questionnaire survey; and the findings from the literature review and informal interviews with the three experts facilitated the researcher to develop a preliminary conceptual framework of the critical success factors and contractual risk for the strategic management of PF2 projects implementing BIM. The layout of the preliminary conceptual framework is illustrated in Figure 6.1. The preliminary conceptual framework comprises three main components as follows:

- The critical success factors
- The contractual risks
- The possible strategies to manage the contractual risks

Based on the literature review and the experts' opinions, five main headings of the key contractual risks for PF2 projects implementing BIM were identified. These are information management; status of BIM model; data reliance; intellectual property rights; and liability. The need to manage those risks was acknowledged by the interviewees in order to minimise the inherent issues within BIM that can give impact to the PF2 projects implementing BIM and to ensure the success of BIM in making PF2 projects more systematically executed. The use of BIM in PF2 projects requires clear contractual obligations for all parties involved. Most of the contractual risks identified resulted from the unclear positions, duties, responsibilities and liabilities of the parties that are related to the information management and collaborative working environment.

Hence, robust and clear contractual framework is needed to address the issues. The interviewees admitted that the current BIM contractual document in the UK, which is the CIC BIM Protocol, is a good attempt in the industry to support the implementation of BIM, but still needs improvement to cater to the needs for lengthy contracts like PF2 or PFI arrangements. Even though it was claimed that the BIM Protocol can be used by all construction projects, unfortunately it was drafted without PF2 or PFI in mind. Therefore, proper strategies to manage contractual risks of BIM specifically under PF2 environment need to be developed and considered in the drafting of the contracts. From the discussion, it was found that the contractual risks that have been identified could be addressed by suggesting simple amendments that can be incorporated in the existing BIM and PF2 contractual documents to ensure the success of BIM implementation in PF2 projects. Some of the suggestions on the possible strategies to manage the contractual risks that were obtained from the interviews and reviewing literature were also listed in the preliminary conceptual framework.

Having identified the key contractual risks of PF2 projects implementing BIM and some possible strategies to manage the risks, it appeared that some of the CSFs identified in sub-section 6.2.2 were inter-related with the contractual risks. The CSFs that are related to the contractual risks were also positioned in the preliminary conceptual framework. From the fourteen CSFs of PF2 projects implementing BIM as identified earlier, only nine CSFs were found to be related to the contractual risks management, namely: "*good communication"; "effective collaboration among the project participants"; "BIM Manager / Information Manager"; "systematic work procedures for BIM";* "*robust and clear contractual provisions"; "information sharing protocol"; "technical competence";* and "*good understanding on BIM"*. Therefore, this shows that the framework denotes the contractual risks management within PF2 projects implementing BIM by targeting the critical success factors. By having most of the CSFs targeted in this contractual risk management framework, it shows that contractual risk management is vital in determining the success of BIM implementation in PF2 projects.

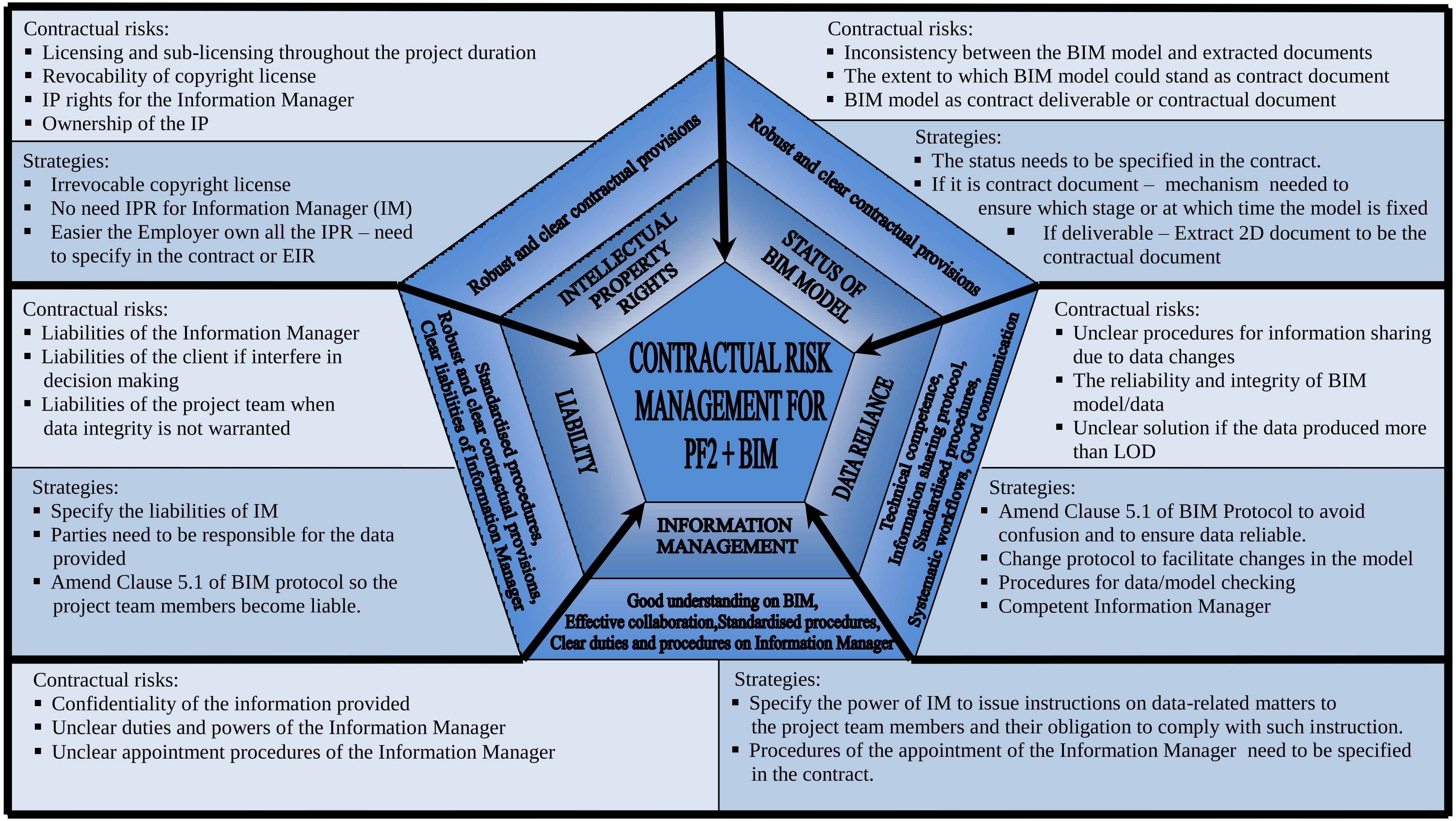


Figure 6.1: Preliminary conceptual framework of the critical success factors and contractual risk for the strategic management of PF2 projects implementing BIM

Hence, Figure 6.1 depicts the preliminary conceptual framework developed and refined through the literature review, questionnaire survey and experts' opinions. The framework highlights the contractual risks identified and some possible strategies to manage those risks. The framework illustrates the management of contractual risk in PF2 projects implementing BIM focusing in targeting the critical success factors. It shows the relationships of the components and denotes the main areas which will be empirically investigated during the semi-structured interviews.

These are the findings from Research Stage One, which becomes the basis to conduct the semi-structured interviews in the second stage of the research. The next sub-section presents the data analysis and discussion of Research Stage Two.

6.3 Part Two: Analysis and Discussion of Research Stage Two and Finalising the Conceptual Framework

In this part, data analysis and findings of Research Stage Two based on the data collected from semi-structured interviews with the experts are presented. This consists of the validation of the BIM risk factors and CSFs of PF2 projects implementing BIM, the contractual risks, and the strategies to manage the contractual risks. The findings from Research Stage One were used as a basis to conduct the semi-structured interviews. As mentioned in the previous chapter of this thesis, the researcher conducted six semi-structured interviews with the experts. Subsequently, the analysis was conducted using the thematic analysis as described in sub-section 5.10.1.2). All of the interviewees were labelled IV-1 to IV-6 in order to facilitate the researcher in analysing the data. The findings of Research Stage Two were used to refine and finalise the conceptual framework of the critical success factors and contractual risk for the strategic management of PF2 projects implementing BIM.

6.3.1 Validation of the critical success factors and significant BIM risks factors for PF2 projects implementing BIM

Section C of the Interview Guide (see Appendix B) asked the interviewees to validate the CSFs of PF2 projects implementing BIM and the BIM risks factors that can have significant impact towards PF2 project. Since these two subjects are interrelated (see the matrix in Figure 6.8), both lists of the CSFs and BIM risks factors identified in Research Stage One were presented to the interviewees. All of the interviewees agreed that the fourteen factors are critical to the success of PF2 projects implementing BIM while the eighteen BIM risks factors are found to be relevant. The experts gave their comments on the most dominant factor that needs to be accomplished in ensuring the success of a PF2 project implementing BIM and related that to the BIM risks factors.

The findings demonstrated slight differences about the most dominant critical success factors. As IV-3 said, "*I think the most critical success factor for BIM implementation in PF2 project is to have good and systematic information management. The use of the building changes over the 20-year period but the information doesn't change then there is a mismatch between the information that required for or the information does not keep up to date"* (393). Similarly, IV-1 has the same opinion that good information management is important and commented, *"Information management is important. Information may not be kept up-to-date, people just don't bother to do it properly they don't appreciate, so it is absolutely vital to making the BIM system work in PF2"* (191). Furthermore, IV-3 added, "*the understanding about how to work with BIM is also another factor which is important. The understanding and culture of the construction industry in what they mean and how it is to be used. The practical use of BIM is absolutely crucial to the success of it. If people understand what it is and how it works and what is expected of them, they want to make it work. But if they don't then and have slightly threatened thinking that it is going to change the way they work, take away their profits, then it is not going to work. If they don't understand, they won't collaborate either"* (398). Therefore, systematic workflows, coordination and integration, and good understanding on BIM are regarded as dominant factors by IV-3.

IV-5 also agreed that good understanding on BIM is very important in determining the success of PF2 projects implementing BIM. According to IV-5, the Clients are especially not in the know about BIM, which ends up causing them producing their requirements illogically. Based on his experience in PFI projects implementing BIM, he said, *"Clients don't really understand what BIM is and what it can deliver. If you look at the biggest document that we received in PFI contract, that is the Employer's Requirements or Authority Requirements. And that will tell us all the things that we need to provide in the proposals. And we probably only have got one page, if you are lucky, of BIM Requirements"* (592). He further put forward his concern on the lack of BIM understanding that will affect the performance evaluation of the SPV during the PF2 project execution. *"Clients don't know what they are specifying, and if they don't know what they are specifying, you would then ask yourself ... how would they be marking you in terms of the evaluation?"* he questioned (596). When the researcher asked IV-5 about the fact that the Clients can hire a BIM advisor to help them in specifying their requirements, IV-5 answered, *"Sometimes they do, but sometimes even their Advisors are not very knowledgeable. A lot of small government's departments, small councils, don't have that expertise. They don't have that knowledge, they don't have those skills. Knowledge is important. Even PAS 1192, we have briefing on how to interpret those documents, because different people interpret them differently"* (598).

On the other hand, IV-4 had a view that the most critical factors for the success of PF2 project implementing BIM are technical competence as well as; robust and clear contractual provisions. According to him, *"Technical competence is important, from what I've seen the contractors and consultants are not ready technically. That is dangerous because you are dealing with softwares and data, of course you need technical competence* (491). *Apart from that, somehow people are worrying about merging liability, somehow that is what people are worrying about BIM, they worry that BIM will blur the lines of people's contractual obligations. So we need to have robust and clear contracts"* (492). IV-6 highlighted the importance of collaborative working in PF2 projects implementing BIM, *"I think, all parties must have the willingness to collaborate. This bit is more complicated when there is more collaboration between the parties and the more blurred the design responsibilities and the decision making* *procedures become. And the more difficult fact is actually to decide who decides what. Yes, that is very much expected to be a problem with BIM"* (697).

Therefore, based on the answers given by the interviewees, from the 14 CSFs obtained from the questionnaire survey, factors which are considered dominant that need to be focused on to attain success in PF2 projects implementing BIM are: (1) *"systematic workflows, coordination and integration"*; (2) *"good understanding on BIM"*; (3) *"technical competence"*; (4) *"robust and clear contractual provisions"*; and (5) *"effective collaboration among the project participants"*. In reference to Table 6.5, each of the dominant CSFs identified is in each of the CSF category, except for two dominant CSFs which are *"good understanding on BIM"* and *"technical competence"* within the 'competency' category. This shows that competency is the most vital factor in determining the success of PF2 projects implementing BIM. With respect to the BIM risks factors, from eighteen risks factors identified from the questionnaire survey, six BIM risks factors were identified as the most significant risk factors, which are: (1) *"lack of available skilled personnel"*; (2) *"resistance to change"*; (3) *"little knowledge and experience"*; (4) *"model management difficulties"*; (5) *"lack of guidelines for contractual agreements"*; and (6) *"liability issues"*. Three of the BIM risks factors, which are *"lack of available skilled personnel"*; *"little knowledge and experience"*; and *"model management difficulties"* are also related to competency issues, therefore the result shows that lack of competency is the biggest risk for PF2 project implementing BIM. Two of the risks factors which are *"lack of guidelines for contractual agreements"* and *"liability issues"* are related to legal and contractual matters; showing that apart from competency issues, contractual risks also need to be addressed in order to eliminate the constraint that hinders having successful PF2 projects implementing BIM.

6.3.2 Experts' views on the current contractual framework for PF2 projects implementing BIM

In order to summarise and enhance understanding on the findings of this topic, Figure 6.2 presents the mind map of the experts' views on the current contractual framework for BIM implementation in PF2 projects.

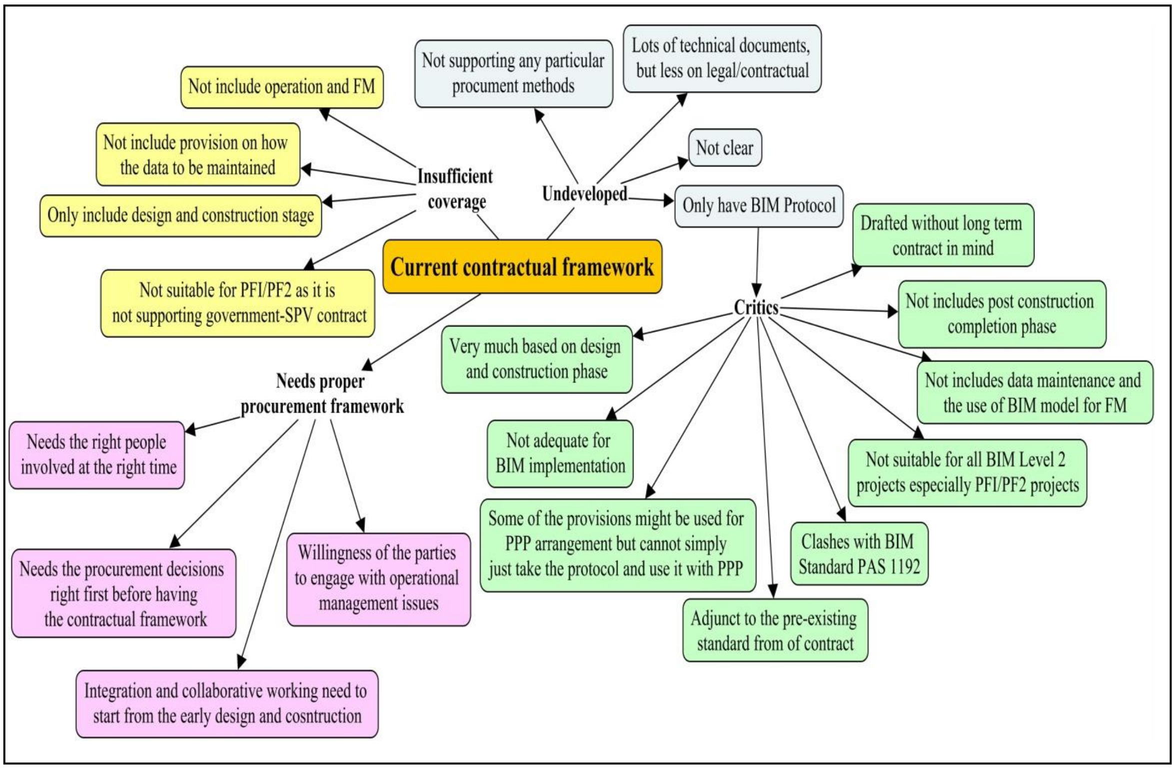


Figure 6.2: Mind map of the experts' views on the current contractual framework for BIM implementation in PF2 projects

The interviewees were asked about their opinion on the current contractual framework for PF2 projects implementing BIM, whether it is enough to support the implementation of BIM in PF2 projects. Based on the answers given, the current contractual framework in the UK construction industry is considered as lacking and insufficient to support BIM implementation in PF2 projects. In fact, IV-4 stated that the current BIM contractual framework that the UK construction industry is having does not actually support any particular procurement methods (406). All of the interviewees agreed that the lack of a contractual and legal framework to support the implementation of BIM extends beyond PF2 projects to other construction projects as well.

There are two main reasons given by the respondents for such situation. Firstly, the contractual framework is considered as less developed. According to IV-1, *"in terms of BIM implementation, it is verily undeveloped in terms of legal framework* (101)*. There are lots of technical documents available but less on the legal framework*" (102). This is proven by the lengthy list of BIM standards and technical documents as listed out in sub-section 3.4.1 of this thesis. However, in terms of contractual framework, the only BIM contractual document that is published within the country is the CIC BIM Protocol. IV-4 voiced out his frustration on this situation by saying, "*there aren't any standard form of contract that effectively incorporated BIM* (401)*... the problem is, the only one we have, the CIC BIM Protocol is the only protocol we have. I am not going to criticise the BIM Protocol too much, but it is so consultant-favourable*" (448). Although there are other standard forms of contract that recommended amendments; additional provisions; and guidance to accommodate the use of BIM, such as in JCT, CIoB, NEC3 and PPC2000 standard form of contract, these standard forms are considered insufficient as they are not specifically drafted to be used in the PF2 context.

The second reason given by the interviewees is insufficient coverage in the current BIM contractual documents as they only include design and construction stage without indicating any provisions on the use of BIM during the operational stage. The potentials of BIM can be optimised up to the operational stage (see sub-section 3.4). However, the absence of provisions related to its use during this stage might limit its application (Kassem, Kelly, Dawood, Serginson and Lockley, 2015). Such absence will make the people in the construction industry reluctant to use BIM further than in design and construction as there are many contractual uncertainties that might affect them if they are involved in any future dispute. For that reason, the current BIM contractual documents are not suitable to be used in PF2 projects as the projects would last 20 to 30 years' contract duration and involve facilities management during the operational stage. According to IV-1, the current contractual documents *"is only for the building stage, and not for PF2 which has the operation and FM works included* (103)*... it wouldn't be back to back with the government-SPV contract*" (104). Similarly, the IV-6 shared the same view as he said, "*we focus BIM on design, production, little bit on procurement but we missed operation and maintenance* (601)*. We missed the value of the data ... we keep it or leave it in the server and it will never get to be maintained"* (602). Hence, how to keep the data is also not properly addressed in the current BIM contractual document.

Furthermore, the prime contractual document which is the CIC BIM Protocol is claimed to be flexible and suitable to be used for all Level 2 BIM projects[5], however it is found

[5] As stated in CIC BIM Protocol, Item 2, page iv.

that the Protocol is also actually drafted to be used by design and build projects only without considering the post-completion stage of a project and lengthy type projects such as PF2. IV-1 criticised the BIM Protocol by saying, *"the CIC BIM Protocol, I don't think is drafted with a long-term contract in mind* (110) *… I don't think it really goes into the post construction completion phase … it doesn't talk very much about maintenance of the model and using it in the facilities management contract* (111). *I think when they talk about all types, they mean professional appointments, and building contracts, and supply chain diagonal line for building contracts, but I don't think PFI or PF2 affected"* (113). IV-4 also further criticised the BIM Protocol by saying, *"I think the CIC Protocol is not sufficiently adequate for BIM. It is a good attempt but it has drawbacks. It is okay but it is not a full package … it is very much based on the construction phase"* (402). Confirming the fact that the Protocol is actually not meant for all BIM Level 2 projects as what had been claimed, IV-3 who was involved in the drafting of the BIM Protocol explained that *"the protocol is an adjunct to the pre-existing standard form for example like JCT"* (306), thus it was designed to be attached to the existing standard form construction contract. According to IV-3, for mega projects such as PFI or PF2, it is expected that *"the contract documents to be drafted specifically and not to rely on the protocol"* (305), in which the parties need to use bespoke contract and negotiate their terms in relation to BIM implementation. Hence, this study has shown that the industry is lacking on guidance and contractual protocol to support BIM implementation. Although bespoke negotiated contract can be the option for PF2, guideline or framework specifically for BIM implementation needs to be materialised in order to assist the parties involved.

In the context of PF2, the lack of contractual framework to support BIM implementation during the post-construction stage would also hinder collaborative working that needs to be sustained among the project team members throughout the lengthy contract duration. Since the life cycle information management of the PF2 facility that needs to last for 20 to 30 years is highly dependent on the collaborative working, willingness, the ability to share information, provisions on BIM usage during the post-completion should be properly vested in PF2 contract. With this respect, Aguilar and Ashcraft (2013) identified the main issues that need to be addressed in contracts to ease the BIM implementation during the post-construction stage, which could be considered as the initial reference, which are:

- What is in the model and the contractual status
- Ownership of the model
- Intellectual property ownership
- Issues with interoperability and data exchange
- Whether the use of BIM will increase the liability of other parties

These contractual issues, however, are similar to the issues that haunt BIM implementation during the design and construction stage that might have been addressed in the contractual framework that we are having at the moment. Hence, for improvement, these issues should be extended to be addressed within the context of the operational stage.

There are also quite a number of other criticisms voiced out by the interviewees on the insufficiency of CIC BIM Protocol to be the only document that provides contractual guidelines for the industry. With a strong statement, IV-2 mentioned that he is *"not impressed at all"* (206) with the CIC BIM Protocol as *"it doesn't do what the BIM standard does"* (207). This is because there are certain aspects in the Protocol which are found to be in contrast with the BIM standards. He gave an example of such clash which is, *"BIM Standard 1192 said various levels are in need for common data environment. And when you look at the protocol, the protocol allows the parties to say, we don't want you to rely on our data"* (208).

Apart from this, the researcher also identified another clash when the Protocol allows for the Information Manager to be a stand-alone role, contrary to what is stated in the PAS 1192-2:2013 that the Information Manager is not a stand-alone role[6]. These are some clashes identified, and there might be more if critical examination is carried out on these two documents. The weaknesses of the BIM Protocol as stated in here are in line with what that have been highlighted by several literatures, such as in Al-Shammari (2014), Klien (2015), Golden (2015) and King's College Centre of Construction Law and

[6] See Item 7.5.1, Note 3, p.17 of PAS 1192-2:2013.

Dispute Resolution (2016), which have been mentioned in Chapter 4 (sub-section 4.4) of this thesis. Despite the drawbacks that the Protocol has, it is still has the potential to facilitate BIM implementation in the construction industry (Al-Shammari, 2014). IV-1 and IV-3 also commented that the Protocol could still be used to support PF2 projects, as IV-1 said, *"some of the provisions (in the Protocol) might be translated into PPP arrangement, but cannot just take this Protocol and use it in the PPP scheme*" (106). Therefore, the Protocol can still act as a guide but thorough examination on the suitability of the clauses in the BIM Protocol and the areas that need to be amended to suit the particular project need to be carried out and identified before its use.

In addition, with regards to the current BIM contractual framework as a whole, IV-5 stated that contractual documents involving BIM have always been found as "*not very clear"* (501). By referring to the documents such as EIR and Information Requirements that are supposed to be part of the contract, many Clients failed to provide clear output specification and their expectation from BIM in these documents due to their lack of understanding of BIM (502). Therefore, the problem of specifying clear and robust contractual documents actually results from the lack of knowledge on BIM. Some of the Clients actually are unsure of what to expect from BIM, even though they asked for BIM to be used in their projects (502). The lack of knowledge and skills in BIM has been highlighted in numerous literature and has been identified as one of the barriers that need to be addressed for BIM to be continuously implemented, for example in Lei, Perera, Udeaja and Paul (2012) and Khosrowshahi and Arayici (2012). This study has demonstrated that the lack of knowledge and skills not only affects the BIM work process but also could become a factor for a serious contractual issue. Even though in the NBS Survey 2016 (NBS, 2016) such problem seemed to be gradually improving; promotion, briefing and training about BIM need to be continuously provided to ensure that the people in the industry are all familiar with the current trend in BIM technology as it progresses.

Despite putting great concern on the robustness of contractual framework, having proper procurement framework shall become the first priority before shaping the contractual arrangement. This is another concern highlighted by the experts that needs to be considered for the contractual framework to be correctly positioned within PF2 project implementing BIM. Proper procurement framework takes precedence over the contractual framework and it needs to be understood and designed earlier before embarking into PF2 projects implementing BIM. IV-2 commented that the main issue in BIM implementation is not about lacking a legal and contractual framework but the critical problem is on the lack of a proper procurement framework to implement BIM. According to him, "*you need to get the procurement decision right then only the legal framework falls. You can't put the legal framework without having decided how the framework is gonna be. You have the framework, so generally, the supply chain engaged and then you decide how you are going to support that with the contracts and so on. So, to me it's a second event"* (205). IV-2 was referring to the need of having the right people getting involved in the project at the right time, therefore it is important for the integration and collaborative working of all parties to start at the very beginning of the project.

As known, the construction sector is traditionally fragmented resulting from the sequential work process which separates design, construction and operation. The use of BIM requires integration and collaboration, and as such a seamless procurement framework that integrates the project team members from the beginning of the project until the end needs to be established. The main problem in having this kind of procurement framework is the attitude and understanding of the parties involved on the need to have their tasks and themselves to be linked and involved with other people in the project team. Sometimes, the parties are unwilling to share information because they are still influenced by the traditional way of working and do not really understand the nature of working with BIM. IV-3 pointed out that, *"there is not so much evidence showing people are integrating their FM teams in the early design and construction. Even we are talking about operational management, but people are not sufficiently willing to engage with operational management issues. And there are also issues with pre-construction. We feel the BIM relies on early contractual involvement to be successful"* (404).

These are some of the challenges which are also identified by Khosrowshahi and Arayici (2012) in BIM implementation that need to be addressed. Having proper procurement framework is related to the concept of supply chain management on which the establishment on what level of integration should be applied, what stages or processes should be linked and the key members involved in every stage of the project (Lambert & Cooper, 2000) need to be identified prior to the execution of the project. The study reveals another critical factor for PF2 projects implementing BIM to be successful, which is a seamless procurement framework that is able to make the project well-organised for a lengthy period of time with the use of BIM. This is another area in PF2 projects implementing BIM that might be worth investigating, which also might have a special link with the improvement of the BIM contractual framework that is said to be lacking. The findings of the study also revealed the need for research in the area of contractual risk management for PF2 projects implementing BIM.

6.3.3 Validation of the contractual risks and management strategies in PF2 projects implementing BIM.

In the exploratory stage, five main heading of the contractual risks for PF2 projects implementing BIM were identified. They are information management, data reliance, status of BIM model, intellectual property rights, and liability. In this section, the analysis of the strategies to manage contractual risks is presented according to the said headings.

6.3.3.1 Information management

All of the interviewees acknowledge that the success of PF2 projects implementing BIM heavily relies on information management. Information Management is one of the contractual risks that has been identified during the exploratory stage of this research. Based on the findings from the semi-structured interviews, there are two main concerns within the topic of information management highlighted by the experts which are the issues related to the Information Manager and information integration. In order to have a clearer view on the findings of this research, Figure 6.3 presents the mapping of the experts' view on the strategies to manage the contractual risks in information management.

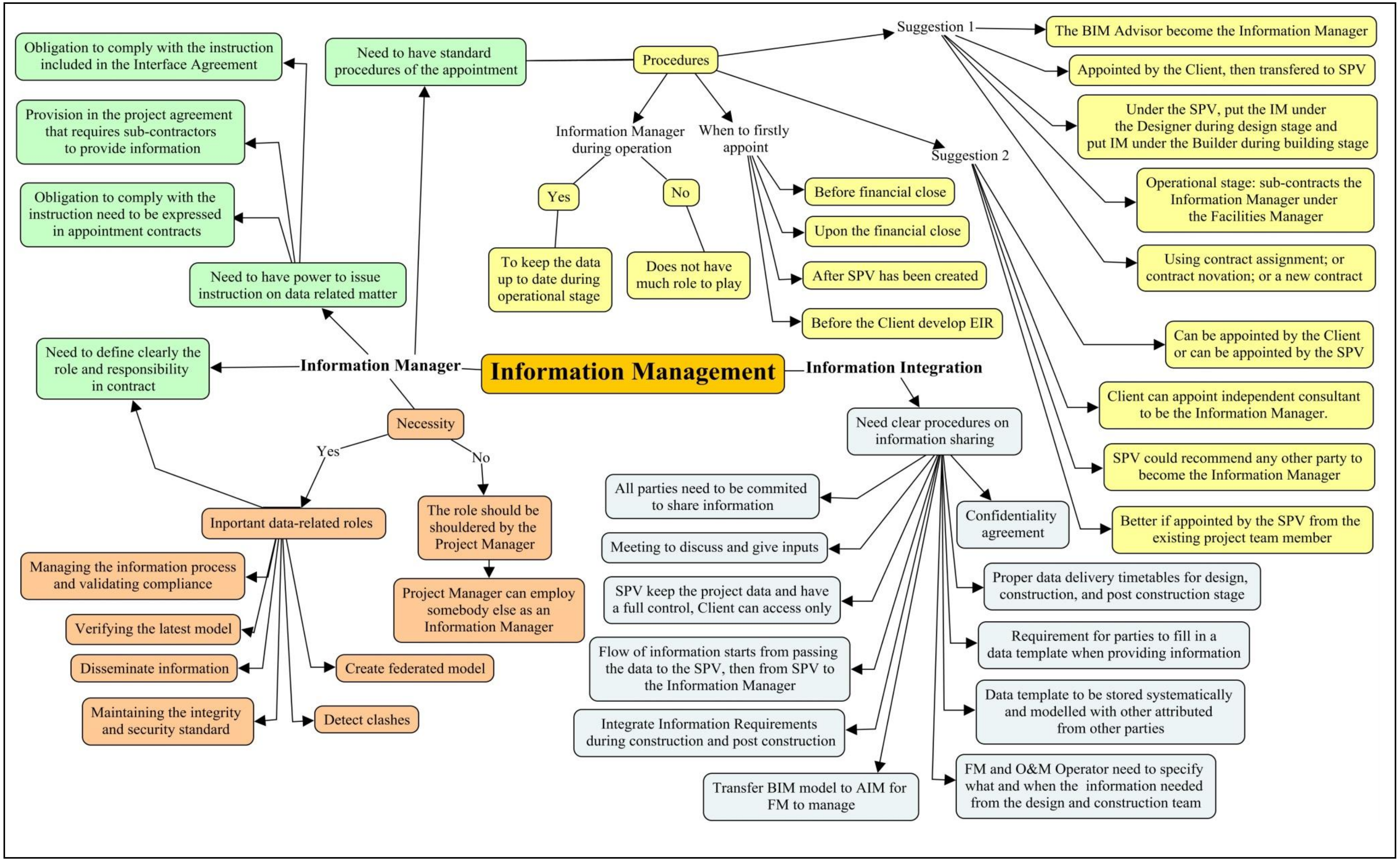


Figure 6.3: Mind map of the experts' view on the strategies to manage contractual risks related to information management

The interviewees were asked about the roles of Information Manager in information management. PAS 1192-2:2013 (2013, p.17) defined Information Manager as a role responsible for facilitating the management of the federated BIM model and production of project outputs as well as managing the operation, standards and culture of the common data environment. One of the interviewees argued on the need of having an Information Manager within the PF2 projects. According to IV-2, *"my view is the role should come from one person, comes from the Project Manager. He can employ somebody else as an Information Manager but it should be passed from the Project Manager's roles"* (211). This view does not actually represent the idea that the Information Manager is not important, but it conveys the suggestion that the Project Manager should be the one bearing the role of the Information Manager. In the context of PF2, this is actually sensible as there are two parties to the PF2 project agreement which are the Client and the SPV (see the contractual structure in sub-section 2.7.1); and within the SPV, as the entity who is responsible for developing the PF2 project facility, there is a Project Manager who manages all issues surrounding the project. Therefore, the duties of the Information Manager are actually vested in the Project Manager, unless the Project Manager employs somebody else to carry out the duties or delegates such duties to any other parties within the project. Otherwise, the Project Manager is responsible to perform the duties of the Information Manager himself. This view is actually concurred with the study conducted by Fazli, Fathi, Enferadi, Fazli and Fathi (2014) in appraising the effectiveness of BIM in project management in the context of the Iranian construction industry, where 24% of the respondents considered the Project Manager should be the one to be in charge in all BIM-related matters.

IV-3, however, highlighted the different roles of the Project Manager and Information Manager, "*they are slightly different. The main focus of project manager is to get the job built ... his job is to get things done properly while the information manager's job is to make sure that everybody has the information they need in order to build; and also ensure that when the job is handed over to the supplier, FM manager; that information is complete and appropriate and the FM Manager can use it to run the facility. It is slightly different from the project manager but equally they are very much doing the management role"* (317). Thus, in deciding whether the Project Manager should shoulder the duties of the Information Manager or otherwise, these features need to be put under consideration.

Notwithstanding the facts that the duties of the Information Manager is actually vested in the Project Manager, having a different person or entity to carry out these duties might be a wise choice in order to have a better organised project management. This is due to the fact that despite both roles carrying management role and almost having similar management skills, there are also unique roles and skills that the BIM Managers possess that are not possessed by the Project Manager, thus this adds value to the project by having a BIM Manager or Information Manager take charge of BIM-related matters. This view broadly conforms to the study done by Rahmana, Alsafouria, Tanga, and Ayera (2016), which compared the BIM skills possessed by Project Managers and BIM Managers. Although the study is only based on the analysis of information obtained from social media, generally, the Project Managers and BIM Managers share a great number of skills. However, the BIM Managers have eleven unique skills which the Project Managers do not possess, therefore this shows the value that a BIM Manager or Information Manager could bring if employed within a PF2 project. Figure 6.4 shows the shared and unique skills between the Project Managers and BIM Managers.

Project manager	Project manager and BIM manager		BIM manager	
Metal fabrication	3D	Drawing	3D modeling	MEP
Modeling	Architectural design	LEED	3D studio max	MicroStation
New business development	Architectural drawings	Mixed-use	Construction safety	Piping
Steel	AutoCAD	Navisworks	Facilities management	Sketchup
Steel structures	BIM	Revit	High rise	Urban design
	CAD	Space planning	Interior design	
	Comprehensive planning	Steel detailing		
	Construction drawings	Submittals		
	Design research	Sustainable design		

Source: Rahmana, Alsafouria, Tanga, and Ayera (2016)

Figure 6.4: Shared and unique skills between the Project Managers and BIM Managers.

Therefore, the experts acknowledged the importance of having an Information Manager (or sometimes also referred as BIM Manager) within a PF2 project who is responsible for managing the coordination, integration and dissemination of information among the project team members and the client. Among the key roles mentioned by the experts are: *"managing the information process and validation compliance"* (170); *"maintaining the model to meet the integrity and security standard"* (171); *"obtain data from the federated model and disseminate the information"* (324); *"managing and updating the* *federated model"* (517); *"create federated model"* (517); *"detecting clashes"* (518); *"make sure everybody is working from the same version of the BIM model"* (522); and *"continually verifying the model"* (520).

All of these roles have actually been listed out in the CIC Outline Scope of Services for the Role of Information Management document and can also be applied for the Information Manager during the post-construction stage. This is an example of the list of duties and obligations of the Information Manager that need to be described in the PF2 contract or in the appointment contract of the Information Manager. IV-4 highlighted the importance of having provisions in the contract that clearly describe the duties of the Information Manager. According to him, *"if we don't define this role and its responsibility really, then when something goes wrong who do we sue? This is the danger of piecemeal mind…this is why you got to define whose responsibility and put it very clearly. This is the role and this is who is doing it and this is what happened if they are doing their job badly"* (463). Therefore, the researcher believes that the CIC Outline Scope of Services is quite comprehensive to be used as reference when drafting the provisions in PF2 contract regarding the duties of the Information Manager.

The Information Manager needs to ensure the smooth running of the information exchange and dissemination, therefore the question is whether it is appropriate to state the Information Manager's power to issue instructions on data-related matters or for other parties to comply with the data-related instructions given by the Information Manager. In response to this question, all of the interviewees (except for IV-2 because he suggested not to have Information Manager) acknowledged the need of having provisions in the contract that give powers to the Information Manager to issue instructions in order to collect and manage the information (120, 121, 122, 314, 458, 527, 612). IV-3 had the opinion that such provision in contracts are needed to *"say to these suppliers and these subcontractors, that they must provide information to the Information Manager when they are asked to*" (313). If the parties failed to comply with such clauses, it can cause a breach of contract with the SPV, because they are the sub-contractors of the SPV (314). IV-3 explained that, *"even though there is no contract between the Information Manager and the Supplier for example, if the supplier failed to* *provide air conditioning plant data according to the Information Manager's instruction, the supplier breaches the supply contract"* (314).

By responding to the same question, IV-5 and IV-6 explained the normal practice in PFI projects implementing BIM in which they were involved. According to IV-5, based on his five years of experience in PFI projects implementing BIM, he has never seen any clause in the contract for the parties to comply with the Information Manager's instructions (528). As a lesson learnt, IV-5 suggested for the obligation of the parties to comply with the Information Manager's instructions to be expressed in their appointment documents (527). Furthermore, IV-6 suggested for the provisions to comply with the Information Manager's instructions to be spelled out in the Interface Agreement[7] (612). Although this is not a normal practice in the industry, as the industry progresses and intact with the trend of using BIM in project management, special consideration might be best to be given to this issue. The results from the semi-structured interviews depicted the concern of the experts on the importance of having such provision in PF2 contracts that employ using BIM. The researcher believes it is appropriate to state the Information Manager's power to issue instructions on data-related matters and this also corresponds to the suggestion given by Udom (2012) in his article. According to Udom (2012), such provision is to give exclusive power to the Information Manager on data-related matters in order, to avoid any data-related conflicts in the future.

Due to the fact that an Information Manager's role is very important and can have exclusive powers under the contract, a question was raised on the needs of having clear procedures on the appointment of the Information Manager in the contract. IV-4 commented, *"I think it would be good if we have standard procedures for the appointment. That is why BIM Protocol is said as not detailed enough. BIM does need to be reflected and the process and the requirements are needed to be part of the contract form including the appointment"* (415). Similarly, IV-6 also agreed that the appointment procedures *"should be in the contract"* (608). On the other hand, as IV-2 suggested for

[7] Interface agreement is normally used in Private Finance Initiative (PFI) projects, defining the interface of two parties, normally between the building contractor and facilities management provider. This is to create a direct contractual relationship between these two parties on the basis for both parties to have more effective remedies and liabilities under the contract against each other.

the role of the Information Manager to be shouldered by the Project Manager, and as such appointment procedures are not needed. Agreeing with this view, IV-5 however added, *"if you are looking for an external provider to be the Information Manager, then yes you probably need that* (referring to the procedures of the appointment of the Information Manager)*"* (515). The views given by the interviewees indicate the importance of having clear procedures on the appointment of the Information Manager in the contract, unless such role is to be executed by the Project Manager. The researcher viewed this issue as more or less similar to the provisions of sub-consulting appointment in the NEC3 contract or the sub-contractor appointment under the JCT contract.

Generally, the interviewees suggested for the appointment of the Information Manager to be either through contract assignment (309); contract novation (131, 309, 310); or it could be just a new contract (611). Lord Justice Staughton in *Linden Gardens Trust Ltd v Lenesta Sludge Disposals Ltd and others; St Martins Property Corporations Ltd and another v Sir Robert McAlpine & Sons Ltd* (1992)[8] clarified the terms assignments and novation in the following excerpt:

> (a*) Novation:* This is the process by which a contract between A and B is transformed into a contract between A and C. It can only be achieved by agreement between all three of them, A, B and C. Unless there is such an agreement, and therefore a novation, neither A nor B can rid himself of any obligation which he owes to the other under the contract.
> *(b) Assignment:* This consists in the transfer from B to C of the benefit of one or more obligations that A owes to B. These may be obligations to pay money, or to perform other contractual promises, or to pay damages for a breach of contract, subject of course to the common law prohibition on the assignment of a bare cause of action.

Based on this definition, novation is about the transfer of the contract to the other person with the consent and agreement by all parties involved in such arrangement. Assignment is about the handover of the rights and benefits to the other party.

There are many suggestions on the procedures of the appointment of Information Manager. Firstly, IV-1 suggested for the Information Manager to be the same BIM

[8] *Linden Gardens Trust Ltd v Lenesta Sludge Disposals Ltd and others; St Martins Property Corporation Ltd and another v Sir Robert McAlpine & Sons Ltd* [1992] 30 ConLR 1

advisor appointed by the Client (in case the Client appointed a BIM advisor to help in determining the EIR). IV-1 suggested for the advisor to be appointed by the Government and then transferred to the SPV (130), saying that, *"So, you could either have new contract with them or just novate the contract so that the SPV then have the appointment. The advisor roles stop once the EIR in place and it is just the Information Manager role going forward"* (131). She mentioned that the knowledge that the BIM advisor had gained from knowing what the Client wants is useful in complying with the EIR during the execution of the PF2 project. The Information Manager's role then, can be sub-contracted under the Facilities Manager or Operator once the project gets into the operation stage of the building (117). *"The SPV will want to make sure that FM does the job properly because when the asset is handed back after 30 years of the term of PF2, then it needs to have good information setting to hand back. Otherwise, it will end up as a breach of project agreement"* (118). This suggestion is more towards using the contract novation mechanism as what has been explained by the Lord Justice Staughton.

IV-3 gave a lengthy explanation supporting this view. According to IV-3, *"the Information Manager is first appointed by the employer, the government, because they make the initial decision about what information they require in the employer requirement. I would say they will pass it to the special purpose vehicle and initially in SPV. I expect it to be in the design lead who is in there somewhere probably in design and construction. So, first of all I would expect the information manager to be a design lead, when the project is being designed. And then when the project is actually going on to site to be built, I would expect the information manager's role to be passed to the contractor. So that he can manage it on well, the job is actually being dealt on site. Then, once a job is finished on sit, the information manager role will come to an end. Probably, it could conceivably be passed on to the operator"* (308). Furthermore, IV-1 and IV-3 also explained the logics behind this suggestion due to the scenario where Information Manager's role that can be passed from one party to another (114, 307). This is mentioned in the PAS 1192-2:2013 document that the Information Manager's role can be shifted among the parties in the project according to the stage of the projects and the necessity.

Moreover, IV-4 suggested another option for the parties to choose in the procedures of appointment of the Information Manager. The Information Manager, according to him, could either be appointed by the client (419); or could also be appointed by the SPV (417). "*Sometimes the SPV might have someone in-house that would be willing to take on that role or to take part of their services"* (420), therefore the role of the Information Manager rests under the Project Manager's role. Sometimes, the client might want to appoint an independent Information Manager as, *"some consultancies refer to themselves as BIM Information Managers as independent consultants*" (420). *"Sometimes, the SPV could also recommend another party for that role. It really depends on the procurement method"* (419). Even though having a stand-alone Information Manager is one of the options given in CIC BIM Protocol, IV-5 argues that, *"the Information Manager should come from the existing project team member. Having someone external creates interfaces. And from experience I would say that, the fewer number of interfaces you have, the better that would be*" (516) as introducing another layer in contracting will make the contractual structure becoming more complicated (572). The researcher believes that this is also the reason why PAS 1192-2:2013 encourages the Information Manager's role to be shouldered by any of the existing project team member and this is also actually the option that the interviewees mostly prefer. In contrast, commenting about this issue, IV-4 said, *"It can be and it should be a stand-alone role. But it depends on the scale of the project. It depends on the skills of the parties. If the Architect has sufficient capacity and has the skills required to perform that role, then it can be done by the Architect or anybody else. So, I am open about it being internal or external"* (413).

On the other hand, IV-6 suggested for the Information Manager to be appointed as a separate contract by the design and build team and facilities management team. "*I think he should be appointed by the construction people upon the financial close* (609). *In my view* (by looking at the diagram of the contractual structure of PF2), *we need to have someone here* (refer to design and build) *and then at the handover, we need someone new here* (refer to facilities manager)" (610). In answering the question on when the Information Manager should be firstly appointed, IV-1 and IV-3 suggested for the Information Manager to be appointed before the Client develops the EIR document. As IV-3 said, "*"the Information Manager is first appointed by the employer, the government, because they make the initial decision about what information they require* *in the employer requirement"* (308). This is because IV-1 and IV-3 recommended for the BIM Advisor and Information Manager to be the same person. IV-4 suggested for the Information Manager to be appointed after the SPV has been created (417). This is because the earlier stages would be more on the discussion about the project, so there is no data to be managed just yet by the Information Manager. As he said*, "the Information Manager's role is when there is information to be managed I would say. So, the point the team have early discussion about the design and operation, that is when the IM needs to be involved to facilitate the exchange of data. But, before the data, they need the project, at this stage it is more on concept. I am not sure if the IM needs to be in at that point because the IM's role is to facilitate the exchange of data once we start making the design"* (418). IV-6 seemed to agree with IV-4's view. IV-6 commented, *"Normally* (referring to PFI projects implementing BIM that he has been involved with) *it might be appointed after the financial close. However, I think it should be either before then. I think it should be earlier than the design phase because at the design phase it is too late. He is appointed by the construction people upon the financial close, but it should be earlier"* (609).

Furthermore, IV-4 disagreed with the idea of retaining the role of the Information Manager until the operation stage. The reasons given by IV-4 are that, "*the role of the Information Manager is to manage the information exchange in design, construction, building during the pre-construction and construction phase. Once the construction phase ends, we hope we end up with a model, a BIM model that can be given to the FM team. They can take it, use it, integrate it ... and there is no need for the IM anymore because the information is fixed* (422). IV-4 contended that the Information Manager does not have much role beyond the handover. He said, *"... if the Information Manager is still around to help to facilitate the handover and help them to integrate the BIM models, maybe the Information Manager is needed. But the facility is going to be there for 30 – 40 years and Information Manager cannot be as background only. Personally, I think the IM doesn't have much role beyond the handover"* (423). In contrast, IV-3 was more on the opinion that Information Manager need to be retained during the operational stage, albeit depending on the skills that the Operator has. He said the Information Manager must be active *"for the length of the construction. He must be involved until the information is handed over to the operating entity. The question whether the Information*

Manager has a role of the handover, I think depends on what the Operator wants and the surface of the information requirements. As I say there are some process plants, hospitals for example that have huge amount of IT and operating systems. Now, if this is done under PF2 arrangements, it may well have the continuing role to keep the information up-to-date as the operating theatre is replaced you know, the information manager could have the role in that" (318).

The results from the semi-structured interviews highlighted that the procedures of the appointment of the Information Manager really depend on the needs of the project. Such procedures also depend on how the Client prefers the procurement framework to be. Thus, it appears that having an appropriate procurement framework as discussed in sub-section 6.3.1 hereinbefore is actually vital before shaping the contract terms. Such procurement framework would also determine the best time to appoint the Information Manager or whether it is needed to retain the Information Manager until the operational stage of the PF2 project. If the Client would like the BIM Advisor to become the Information Manager, then the appointment should take place before the Client develops his EIR. Otherwise, the Information Manager might best be appointed upon the financial close, after the SPV has been created and confirmed in the contract. Furthermore, if the Project Manager in the SPV found that there is not much role that the Information Manager can play after the construction of the asset, then the Project Manager might take over such role since it is actually vested within the Project Manager's role. This also again, depends on the BIM skill that is possessed by the Project Manager. Moreover, the study reveals that the shift of the Information Manager's role from one party to another throughout the PF2 contract duration is best being done by using contract novation mechanism. Another option such as assignment is not suitable as the shift is not about transferring the rights or benefits, but it is shifting the role to another party in which it involves the transition of obligations and responsibilities. Embarking to a new contract is also not an option because the process of termination and appointment of the Information Manager at every stage when needed might affect the smooth flow of the information management and progress of work.

The second issue highlighted by the experts within the topic of information management is the information integration, concerning information sharing for PF2 projects implementing BIM. BIM is known as a way to provide an information-sharing platform among the parties in a project in order to address the risk of information fragmentation and work process disintegration that is typical to the construction industry (Utiome, Drogemuller, & Docherty, 2014; Redmond, Hore, Alshawi, & Westwood, 2012). Based on the literature there are two main concerns under information integration which are interoperability issue (Hurtado, & O' Connor, 2008; Grilo & Jardim-Goncalves, 2010; Klein, 2015) and information sharing procedures (Wang & Love, 2012; Udeaja & Aziz, 2015; Lee, Chi, Wang, Wang, & Park, 2016). However, interoperability issue is not within the subject area of the present study as it is more about technical issue, whereas this study concerns more on the information-sharing procedures among the parties in a PF2 project.

With respect to information sharing procedures, IV-5 mentioned that the first thing that the SPV needs to do is to have all parties to meet to discuss and give inputs about the projects (508). Afterwards, all parties need to give commitment in sharing the information that they have, so that the integration and coordination of the information can be exercised. He gave example by saying, *"... for example, the Design and Build Contractor will buy material and install it but they won't specify it. The FM will specify that and they will say to the Contractor, for example, this is the best carpet to buy as it is easier to clean, can be easily replaced and it is 5 miles from the shop etc. Or another example, if the FM wants a certain type of light fitting because it has cheaper electricity ... so, everything that goes in to the building is specified by the FM company. We meet together and do all that. So, from the design and build perspective, the Design and Build Contractor has the responsibility but relies on others. When it comes to BIM, the Information Manager under the Design and Build company manages the information"* (507, 508).

The view given by the interviewee corresponded with the concern raised in the literature about the need to change the norm of working in response to BIM (see Chapter 3, sub-sections 3.2). In contrary to the traditional practice, all parties in a project from design, construction and facilities management team must be kept intact from the beginning of the project to discuss and integrate their inputs. Such situation requires commitments from all parties to ensure the success of integration and coordination of work. Therefore, this not only depends on BIM, but also on the attitude of the people and their willingness to share. After reviewing two BIM case studies from Macau and Hong Kong; Rowlinson, Collins, Tuulic, & Jiac (2010) concluded that the change of working culture is necessary and the implementation of BIM in projects delivery must be accompanied by a relationship management approach since its aim is to create a centralised shared knowledge platform that contains all design and project operational information. Resistance to change in working culture was also highlighted by Singh, Gu and Wang (2011) and Khosrowshahi and Arayici (2012) as one of the factors that hinder BIM projects to become successful and is noted as the most challenging aspect in BIM implementation by Chunduri, Kreider and Messner (2013). However, in the context of PF2, such culture change is not that massive as from the very beginning all parties are within the umbrella of the SPV, including the Client. Indeed, it is understood from the beginning that the aim of the PF2 project is to provide services desired by the Client, therefore due to the nature of PF2, automatically the Client and the Facilities Management provider are supposed to be involved from the initial stage. It is just the matter of bringing all parties to the table, virtually or in reality, and making all parties aware of their commitment to share and work collaboratively.

Furthermore, another suggestion on the flow of the procedures was given by IV-6. According to IV-6, "…*O&M Operator needs to identify, to look into what the design and construction team to provide and see the information required. And then that information would be used and then transferred to the right time when required"* (614). He also suggested for the O&M Operator to provide the information in a data template (615), so that the information can be stored systematically and can be modelled with other attributes (616). He gave an example, *"…this is just saying you give someone a sheet and this information will get tied to whatever the asset cost or the model cost and then you can look it better than modelling aggregate these items*" (617). The suggestion given by IV-6 is about linking the design, construction and operational stage. This is to create a seamless information management by starting with obtaining the Facilities Management provider's information requirements, which are then supposed to be linked with the Client's expectation of the end product and also the EIR. The suggestion given by IV-6 was in line with the comments given by IV-4. IV-4 mentioned that it is important for PF2 projects implementing BIM to integrate the Information Requirements during construction and post construction. "*They need to integrate it. This is the problem with the FM team, they need to be brought on board early. In construction project with BIM, there are two parallel construction going on, the first one is the construction building that and also the verge of the construction of the data. And the FM team is most interested in the data in the form that they can understand with all the details in it"* (425).

Thus, the study reveals one way to integrate these two by having the 'template' as the conveyor to bring the Facilities Management requirements to the earlier stage of the project delivery. This 'template' activity can accompany the virtual model as normally practiced in BIM project (see the discussion in sub-section 3.4); therefore, making the flow of information smoother. Notwithstanding such situation, IV-4 voiced out his concern that such integration might be difficult to be exercised due to the massive amount of information to be managed, which might cause confusion (426). It was even claimed by Wang et al. (2013), that BIM could effectively merge these data and provide convenient storage for retrieval, however, data delivery timetable is needed to facilitate such activity. Unfortunately, IV-4 commented, *"I am personally interested in design and construction phase and I would say that even at that point none of these contract forms have yet to properly address the issue of how we have a proper data delivery during construction. Even the CIC Protocol has the opportunity for you to add your own data release schedule; they are not setting proper data delivery timetables. But even they are or anybody is thinking ... I don't think they are thinking about data delivery post construction"* (424). Thus, not only data delivery timetable during construction is important, it is also necessary to have data delivery timetable during post-construction.

Based on IV-5's experience involved in PFI projects implementing BIM, when it comes to the operation stage of the building, IV-5 further mentioned that the BIM model is transferred to Asset Information Model (AIM) where the FM company will manage the AIM and for the building progresses during the 25-30 years of contract duration (509, 510, 511). This has been practiced in PFI projects implementing BIM, which might be suitable to be applied in PF2 projects as well. This is also stated in PAS 1192-3:2014 on the management of information during the operational stage of a facility, containing the process of: (1) creating AIM; (2) exchange asset information with the Project

Information Model (PIM)[9]; (3) the use of AIM in supporting organisational requirements; (4) the need to update the AIM as the asset changes; (5) maintain the AIM; and (6) record keeping of the disposal, decommissioning or demolition of the asset. However, as criticised by Owens and Quinn (2014), the framework of information management during the post-construction stage as contained in the PAS 1192-3:2013 document has a lot of weaknesses. Among others, it is said to be confusing and lacking details on how the data should be maintained and modified. This is another area that needs to be looked after and to be addressed in the PF2 contract to avoid contractual dispute in the future. This is also the area that has been highlighted by IV-6 as lacking and needs to be improved (see the discussion in sub-section 6.3.2). In addition, there are also suggestions given by the interviewees to ensure the smooth running of the information flow among the Project Team Members. IV-1 suggested for the data to be passed by the Project Team Members to the SPV first, and then the SPV will pass the data to the Information Manager (127). The reason behind the suggestion is because *"they all have obligations to the SPV, and the SPV is really in the interest in getting information and then put it once as enforceable obligations by its contracting parties to provide that information"* (127).

6.3.3.2 Data reliance

The interviewees were asked about four issues under the contractual risk of data reliance, which are: (1) reliability and integrity; (2) information overload; (3) data security; and (4) change protocol for data changes. Figure 6.5 presents the mind map of the experts' views on the strategies to manage contractual risks of data reliance.

[9] Project Information Model is the name given to BIM model produced during the design and construction stage.

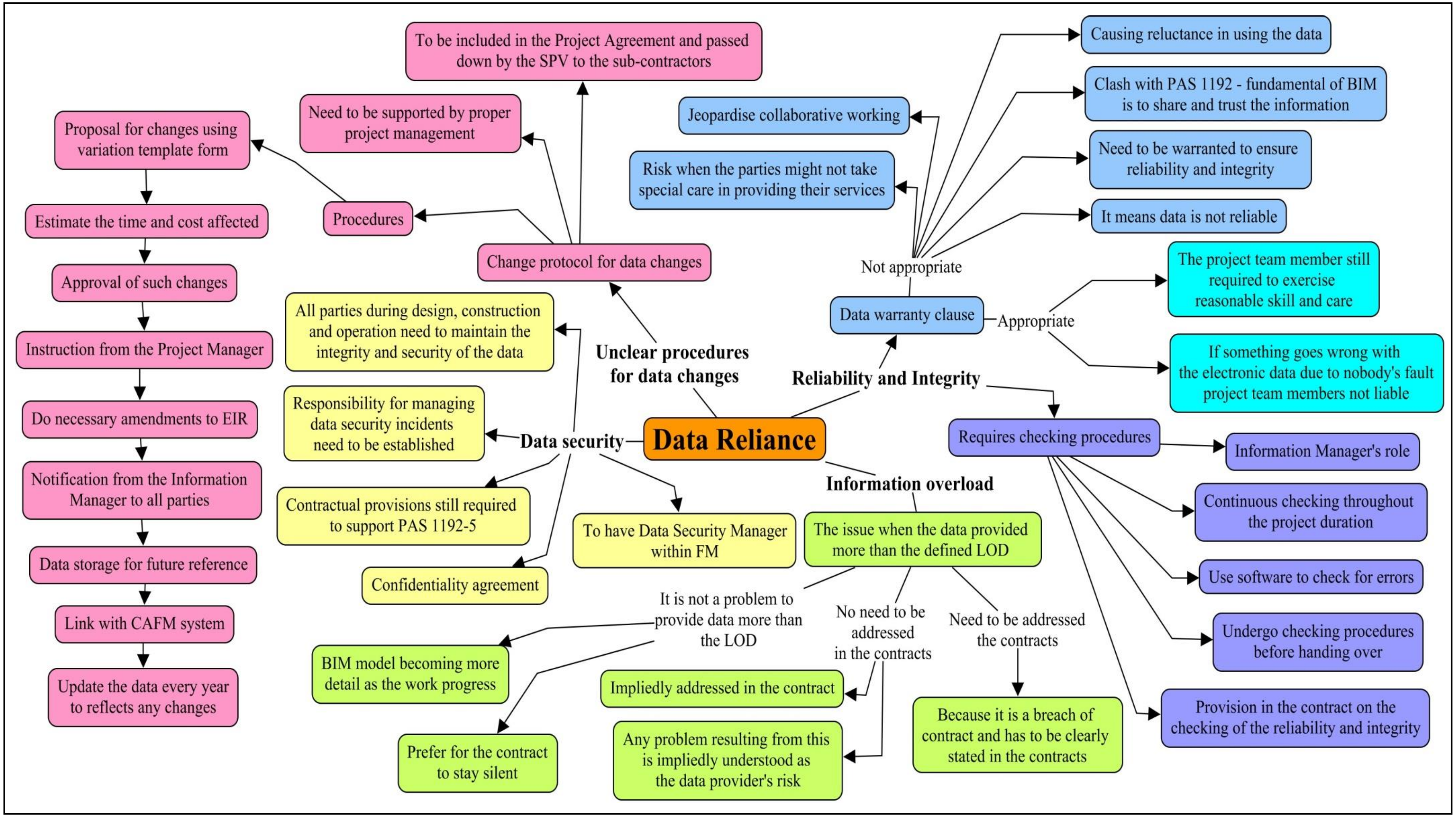


Figure 6.5: Mind map of the experts' views on the strategies to manage contractual risk related to data reliance

In terms of reliability and integrity, the interviewees were asked to share their opinion on Clause 5.1 of the CIC BIM Protocol that has always caused confusion on data reliance and data integrity issues, whether such clause is suitable to be included in PF2 contract. IV-1 and IV-3 explained that the clause actually refers to errors resulting from complicated computer system and not due to negligence of the people. In clarifying this issue, IV-1 stated, *"I think it is something to do with electronic data, sometimes goes wrong due to nobody's fault and if it is a different clause that gave project team member responsibility, then it increases the risk as well as increase the cost of the project"* (147). Similarly, IV-3 also clarified that, *"because the computer system is so complicated, what goes on in the computer, in terms of machine language and so on, that from time to time they get errors. Not because of anybody's fault but because the system is so complicated"* (328). In addition, IV-1 and IV-3 clarified that this clause only applies when reasonable skill and care has been exercised. In other words, the electronic data are still reliable because it is presumed that the parties have taken reasonable effort to avoid problems from happening. According to them, the disclaimer would not work if the parties deliver their services not in accordance with the contract (153, 155, 329, 341). IV-3 further commented, *"the reason for that Clause is to say that, problems happen and all the design team or particularly project team have got to do is to exercise reasonable skill and care to stop problems from happening. But if it happens, something goes wrong and nothing I can do about it… it's not by fault, and what it does, what this is a very contentious clause to be put in and I know many people don't like it and so on, because the implication of this, it is the employer's risk. If something goes wrong and it is not by fault then if loses, it goes back to the Employer"* (329). Sharing the same view IV-5 asserted that such clause is relevant to be used for PF2 (546, 547).

In contrast with the above statement, IV-2 argued that it is inappropriate to have the disclaimer clause such as Clause 5.1 in projects that implement BIM. He commented, "*No, it is inappropriate. As you can see in PAS 1192, it says fundamental concept in BIM is to share the information early and to trust the information. So it is not appropriate because the Protocol says the integrity of the data is not warranted* (230)*… it means the data is not reliable"* (231). He further added, *"…another person, other project participant can access and use it to develop their own bit. If they can't rely on it, how can then this database operate? It is a common data environment, its collaborative … so* *to make this common data environment work, to make the collaborative platform work, it is sharing information that you need to rely on it. Or else you can't share"* (258, 259). If the data integrity is not warranted, then it would present a risk for the parties to not take special care in providing their services, and according to IV-2 that is wrong (257). Besides that, IV-4 and IV-6 shared their view and suggested the clause to be amended if the parties want to use it, not only in PF2 projects but for other projects as well. For them, BIM model or data need to be warranted to ensure reliability and integrity (436, 621). IV-4 argued, *"I don't think the responsibility for the BIM data should be any different from the responsibility we currently have for the data we produced in 2D … If you hand over design, you do warrant them"* (435, 436).

The findings show that there are two interpretations of Clause 5.1 of the BIM Protocol given by the interviewees, which contradicted each other. The first interpretation is that, the data is not reliable because the integrity of the data in the BIM model is not warranted by the data providers. Secondly, the data is reliable because the integrity of the data is still preserved as it is assumed that all of the parties who contributed the data to the BIM model have exercise reasonable skill and care as required by their appointment contract. This is because, the parties are only eligible for protection under Clause 5.1 if they have exercised reasonable skill and care as according to their profession and expertise claimed under their contract of appointment.

Based on the reviews given by the interviewees and the literature, it is obviously shown that the content of this Clause is ambiguous as it is subjected to more than one interpretation which is in disparity with each other. Such ambiguous clause is obviously dangerous to PF2 projects in which collaborative working and trust need to be sustained for 20 to 30 years' duration of contract, therefore it requires amendments. If the Client expects legitimately that the project team members shall warrant the integrity of the data provided for the federated model, the Clause needs to emphasise on the obligation of the parties to exercise reasonable skill and care according to their respective roles for the project and make them responsible for the reliability and integrity of the data they provided. Such example of the clause can be seen in Clause 11.4 of the CIOB Contract for use with Complex Project Contract 2013 which provides that the Contractor shall:

> …select and remain solely responsible for the suitability and integrity of the selected software and any information, drawings, specifications and other information extracted from the model.

Another example can be seen from Clause 22.1 of PPC2000 Contract which stated:

> …each of the Partnering Team members shall use reasonable skill and care appropriate to their respective roles, expertise and responsibilities as stated in the Partnering Documents, and shall owe each other such duty of care in respect of all their agreed obligations under the Partnering Contract…

Therefore, by having these types of clauses, the integrity and reliability of the data is warranted and may reduce uncertainty among the parties on the validity of the data that they received and they can comfortably rely on each other data as the basis to produce their own data and to develop the federated BIM model.

In order to ensure the reliability and integrity of the data in the BIM model, IV-5 advised for the data provided to undergo checking procedures before being disseminated or handed over to the Client. Based on his experience in PFI projects implementing BIM, a software named as Solibri has always been used to make sure the data is reliable (546). According to IV-5, *"this is a software that can check to see if something in the model just doesn't look right*" (519). The other experts also agreed for the need to have a provision in the contract on the checking of the reliability and integrity of the BIM data (162, 184, 251, 361, 641). As put forward by IV-1, *"the checking probably may also to be done as part of the Information Manager's role as he goes along ... it should be an ongoing process to make sure it is being done properly. Not necessarily just at the very end of the project, it will be probably just too late"* (184).

The advice given by the experts is actually more or less similar to PAS 1192-2:2013 document in which it is stated that the information needs to be checked and approved by the lead designer before the information can be shared with other parties. However, in PAS 1192-2:2013, it only mentioned that the checking is to be done before sharing the information. PAS 1192-2:2013 and PAS 1192-3:2014 did not mention who is going to undertake the checking task after all the data have been gathered and transformed into the federated BIM model and after the data has been transferred to AIM. This is the area that has been emphasised by both documents that need to be provided by the contract (see Item 9.2.2.4 of PAS 1192-2:2013 and Item 4.6.4 of PAS 1192-3:2014). Even as IV-1 said that this task should be delivered by the Information Manager as what has been discussed in sub-section 6.3.3.1, it is worth to note that the Information Manager is not responsible for the accuracy of the data. As mentioned by IV-4 in the context of the differences between the Designer and the Information Manager, *"absolutely the IM is not responsible for the accuracy of the design or the data. He is only responsible for the transmission of the data between the parties. That is my understanding on the IM roles. He shouldn't be liable for the correctness of the design as it has always been the case that the liability lies with the designer. It is about making sure that the terms of everyone's contracts represent what exactly what it is. If you employ somebody just to be the Manager of the Information, that is their role and there must be liability for the success of information management. If you employ an architect to design your building all their liability should be on that design"* (457). Thus, it might be possible for the party the Information Manager is in is being shifted under to undertake the responsibility of data checking. This can possibly be the Designer during the design stage, the Builder during the construction stage and the Facilities Manager during the operational stage; or else it also can be the Project Manager of the PF2 project. This is a matter that needs to be decided and clarified in the contract.

Another issue brought to the experts under the topic of data reliance was on the unclear procedures for information sharing for data changes. Information sharing has been discussed in sub-section 6.3.3.1 of this thesis. However, there are aspects which are slightly different when dealing with data variation. Research indicates that BIM is very useful in managing and tracking changes in a project (Aslani, Griffis, & Chiarelli, 2009; Chen & Luo, 2014). However, the researcher believes that a procedure to administer change within BIM also needs to be systematically established (see the discussion in sub-section 4.4.2). As the parties are relying on the data in the BIM model, all of the interviewees agreed that having Change Protocol to communicate any changes in the BIM model during design, construction or post construction to all parties involved need to be included in the contract. IV-1 proposed for the Change Protocol to be included in the project agreement between the Client and the SPV. According to her, *"I think that sort of provision needs to go into the FM contract. So, I think it will be going to the project agreement and then it will be passed down to the FM contract with that party* *having an obligation to keep the model up-to-date"* (161). With such arrangement, IV-1 explained that the provision will act "*as an incentive on SPV to make sure the Operator does his job properly* (164). This is because the SPV would not want to provide faulty information or data to the Client as this is going to be a breach of contract by the SPV towards the Client. This is also to ensure that any change to the data also needs to involve the Client as this is included in the PF2 project agreement, thus to avoid the information to only revolve within the SPV without the Client. Moreover, IV-2 commented that the Change Protocol needs to be *"supported by proper project management. There is also about project management, it is not just contract*" (237). He further added that change protocol needs to highlight the role of Project Manager in giving instruction regarding any changes that happened. He said, *"... the Project Manager should have the ability to give instruction and say as there is model is emergence ... the project management function is probably a centre to manage this process"* (238). The management of change within BIM model or BIM data is found as missing in any of the BIM standards including PAS 1192-2:2013 and PAS 1192-3:2014. In these documents, the emphasis is only on the requirement to store the records of any changes[10] including change orders[11] and to communicate the change to all involved[12], but there is no known emphasis on the need of having change protocol.

Therefore, this study reveals the need of having Change Protocol of data changes within BIM model/data in PF2 projects implementing BIM. Such procedures might also be useful to be applied in other BIM projects. In specifying how the Change Protocol might look like, all of the experts agreed on the list prepared by the researcher. IV-3 commented that the Change Protocol is like the procedures that we had in contracts for variation in building construction (347, 348). IV-4 also stated, *"I think all you put in there are relevant. Basically, to sum up, we don't want to complicate things in here. I think what we need to do is simply to apply the same change protocol to BIM model, same as applied to 2D model, which is what exactly what you have identified here. Of course, 3D model has extra data but all the things you created are the same process as design, estimation, quantify, just it is at the higher level. That is why BIM is not to*

[10] See Item 4.6.3 in PAS 1192-3:2014
[11] See Item B.1.4, B.2.3.1 in PAS 1192-3:2014, and Item 9.2.2.7 in PAS 1192-2:2013
[12] See Item See Item 8.1 of PAS 1192-2:2013

change the nature of roles we have, all it does is it requires everything to be done in a more sophisticated and more detailed way" (445).

Talking about the procedures in the Change Protocol, IV-5 gave lengthy suggestions to be considered. He suggested for EIR to be changed as well in parallel with the change on the asset. He said, "*We have the Employer's Requirements that had been set up from Day 1. During the construction stage if there are any changes made by the Client, the requirements need to be updated"* (541). He further commented that, "*... we can easily go to the BIM model and we can add the 20 classrooms, for example. And we can update that model. We can then calculate all the calculations that deals with it, in terms of daylight heating, energy consumption, we can do all those things in the BIM model but we also need to go back and we need to update the Authority's Requirements as well. So, the Authority's Requirements change as well"* (542). Thus, not only EIR has to be updated, any change in Client's Requirements throughout the PF2 project duration also needs to be updated, and applied on the BIM model and the real asset and vice versa (543). IV-5 further proposed a mechanism where the BIM model is to be updated every year to ensure all data reflect the current state of the real asset (545). *"At the end of each year we would like the BIM model or the AIM to be updated. So, if you carried out any lifecycle, if you make any changes to the building, carry out any paint work… anything, we want that to be recorded in the BIM model every year"* (544).

Additionally, based on the IV-5's experience involved in PFI projects implementing BIM, if the Client wants to make changes to the requirements, IV-5 proposed to design a standard form or template for the Client to communicate his intentions (553). This template can also be applied for other parties or the SPV to propose changes to Client (554). If the change order comes from the Client, "*… the Client will inform the SPV, the SPV will then go to the D&B Contractor saying that the Client would like to change this meeting room into a kitchen, can you tell us how this can be achieved? So, the D&B contractor will respond and say this is how we make that change and get it back to the Client. The Client will then to go ahead with the change ... people are assigned on different stages, and that it contains the cost of the change if there is a cost, not just the cost just now but the cost for 25 years and then what would need to be done from the design perspective, from the legal perspective in order to capture that change"* (556). If the change is recommended by the Design & Build (D&B) contractor, *"the D&B will tell the SPV and the SPV will tell the Client. But it would be almost the exact same form. And then it would say whether the Client would agree? Whether it would cost more money? … the Client does not need to accept the change, he can refuse the change but again it would set out what changes that need to be made to the BIM model, what change that needs to be made to the contractual documents, etc."* (557). This can also be applied if the FM company wants to propose changes (558). IV-6 also expressed his agreement to have notification of changes to all parties involved when there is any change to the BIM or asset (623). However, in addition he proposed for the Computer Aided Facilities Management (CAFM) to be linked to such notification mechanisms (624, 625).

Therefore, based on the findings from this study, procedures for Change Protocol for data changes in BIM can be concluded as follows:

1) Change Protocol to be included in the PF2 Project Agreement and passed down by the SPV to the sub-contractors
2) The procedures need to be supported by proper project management, thus the procedures involved:
   (a) Proposal for changes using Variation Template Form
   (b) Estimation of the time and cost affected
   (c) Approval of such changes by the relevant parties and Project Manager
   (d) Instruction from the Project Manager to execute the changes
   (e) Necessary amendments to EIR
   (f) Notification from the Information Manager to all parties
   (g) Data storage for future reference
   (h) Link with CAFM system
   (i) Update the data every year to reflects any changes

The next question asked to the interviewees is about the issue of information overload when the data provided by the parties is more than the defined Level of Detail (LOD), whether the contract needs to specify the consequences of such act. IV-1 and IV-2 had the similar opinion that the consequence of such act is actually impliedly addressed in the contract. IV-1 said, "*It is probably implied. There would be some breach in there* (if it is more than the defined LOD)" (157). For IV-2, his opinion is expressed as, *"My answer is, that obviously if you submit beyond the LOD, that is your risk"* (232). Therefore, they had the opinion that it is not necessary to express in detail on the impact of providing information beyond the defined LOD in the contract as it is impliedly understood. Conversely, IV-3, IV-4 and IV-6 had the opinion that this issue needs to be addressed in the contract (346, 442, 622). As according to IV-4, *"if you over produce the information, and therefore the information is not useful by the client because the client got too much information, then that would be potential of breach of contract terms if the contract says the level of detail must be at this level and you produce more. This could be an interesting case because I have this level but I would like to add extra value… but if the extra value make is impossible to derive this level of data, then it could be breach of contract"* (443). However, IV-5 had a totally different opinion as he contended that it is not a problem if the data provided exceeding the defined LOD due to the nature of the BIM model which becomes more detailed as the works progresses. He said, *"BIM model at the initial stage is very generic, but when we start going through the construction, we then start to bring all the subcontractors' details on board and put that into the model. Architects for example will design the building, but they won't design the detail of how that goes together, you know like curtain walling system … you need to go to the supplier for that level of detail. So the model at this stage would always be a lower level than how the BIM model will finish"* (550, 551). Due to such nature, IV-5 preferred for the contract to stay silent about this matter.

The issue of information overload resulting from over-providing the data has been discussed in several literatures. As mentioned by Tang (2008), information overload can make the decision-making process difficult and result in loss of high-value information. Even the problem of information overload in the day-to-day activities in the construction industry can be addressed by the use of BIM (Büchmann-Slorup and Andersson, 2010), Reed (2016) highlighted that the lack of understanding on how much information to be provided at different stages of BIM process can compromise the benefits of BIM. The reason is that, too much information provided more than the defined LOD could cause the progress of work being hampered by waste. BIM is collaborative working, therefore all parties need to work at the same level of detail and complexity, so that the works they produced can be combined and matched perfectly. More time might need to be spent in order to screen which information is really useful at a certain point of time which might delay the progress of project delivery as a whole. In the context of PF2, the delay in delivering the facility for services to the public users might ruin the objective of having PF2, which is to improve the procurement of the public facilities and services.

Due to this reason, the IV-5's opinion for contract to be silent about this matter might need to be reviewed. The reason given by IV-5 is reasonable in the sense that in reality, the design, construction and modelling work can never be perfectly at the same level as the BIM model is becoming more detailed as the work progresses. This view is also consistent with the opinion by Dougherty (2015) when he discussed LOD from contractual perspective. It is worth mentioning that the information overload might not extremely affect the collaborative working in PF2 if the information is not significantly overload. However, the situation might be in contrary if the overloading of the information is massive and continuously happen, thereby causing confusion and difficulties for the Information Manager or Project Manager to manage the data. This might expose the data to errors, which consequently will affect the PF2 project as a whole. Therefore, in deciding whether the consequences of providing the data more than the defined LOD need to be specified in the contract or otherwise, these factors need to be considered. This is not going against the reality where the data produced by the project team members, indeed, can never be perfectly at the same level; or to over-specify in the contract as it is impliedly understood that the data provider is bearing the risk while providing data beyond the LOD; but this is to make clarity in the contract so that all parties are aware on the liabilities they are shouldering when fulfilling their duty in providing the data to the BIM platform. With the consequence of breaching the contract clearly stated in the contract, such provision may act as the mechanism to control the acts of the project team member. Hence, this study agreed with the opinion given by IV-4, that the emphasis on providing data beyond LOD as a breach of contract needs to be stated in the contract.

Due to the fact that the electronic data in BIM model are at risk of being corrupted, degradated and hacked by external parties, the interviewees were asked about the data security issue. This issue is considered as important due to the fact that in PF2 projects, the BIM electronic data need to be maintained for a lengthy time period until the end of the PF2 contract duration. Even though PAS 1192-5:2015 provided details on how to secure the data, the experts were in the opinion that contractual terms are required in the contract; to support any strategies undertaken to ensure data security as provided by PAS 1192-5:2015. Thus, IV-1 commented that responsibility for managing data security incidents should be established in the contract. By referring to the normal practice in PFI projects implementing BIM, she said, for PF2 projects *"I suspect the government will make SPV responsible. SPV will make FM responsible*" (167). Agreeing with IV-1's opinion, IV-2 said, "*whoever has possibility of the measure, at my place is the FM. Whoever got responsibility on the data. It could be FM"* (240). Supporting these views, IV-6 said, "*I think more work needs to be done with that. In maintaining the data, in maintaining the format of the data, in maintaining the openness as well but at the same time not to compromise data security. I think, at the completion of building, FM should be responsible"* (620). Having FM as the responsible entity means that someone in the FM company needs to be appointed to bear the data security management role. This is the person who was described by IV-3 *"that should be best qualified to make the information protected; it ought to be a person who got the most to lose as a result for the information breach; and it ought to be a person who is best able to respond to it"* (350). However, according to IV-3, *"what I would say is there should be a continuing obligation on all parties during the project construction and during the operation to maintain the integrity of the data*" (349).

The opinions of the interviewees seemed to be in favour of Facilities Management provider to be the one who is responsible in managing the data security incidents. This might be one option during the operational stage of the building. In PAS 1192-5: 2015, it just indicates the requirement to appoint built asset security manager and the list of the roles of the security manager without specifying who is supposed to bear such role and how the appointment procedures should take place. These are the areas that need to be specified in the PF2 contract. However, the researcher believes that such task is not only to be carried out during the operational stage, as the risk involving data security issue can also occur during the design or construction stage of the PF2 project. As mentioned by Boyes (2014), the control and protection of the information in BIM model(s) are crucial during design and construction, and the overall lifecycle of the facility. Indeed, these will become more complex when the supply chain grows towards completing the project and through the outsourcing of the operational services. For this reason, proper security management plan including the when, who and how the Data Security Manager to be appointed need to be established in the contract by considering not only the operational phase of the project but also the design and construction phases.

It was found that the PAS 1192-5:2015 document missed to emphasise the need of having a Data Security Manager during the design and construction phase. This might be due to the understanding that the Data Security Manager role is vested in the Information Manager's role (as listed out in the Outline Scope of Services for Information Management). However, the data security role that the Information Manager has in the said Outline Scope of Services document is very minor in comparison with the list of roles of the Data Security Manager as listed out in PAS 1192-5:2015[13]. Therefore, the study reveals that it is important to clearly state in the contract the position of Data Security Manager within the contractual structure of PF2, whether such role is to be vested in Information Manager, or to be appointed separately due to the massive roles that need to be executed by the Data Security Manager. The former needs contract to specify the details of data security duties that need to be carried out by the Information Manager if he is chosen to carry out such duties, whereas the latter requires the contract to state the demarcation line between the duties of Data Security Manager and the duties of the Information Manager role; in order to avoid any conflict in the future.

Furthermore, to preserve the security of information within the BIM model, IV-2 suggested for a simple clause to be included in the contract about the confidentiality and non-disclosure of information to unauthorised parties (260). Among the project team members, IV-3 suggested that, in order to ensure confidentiality, the parties should be given the information that is needed or requested only for the purpose of the project they are working in (334). He said, *"You should only provide the information that is needed and that's it. You stop after that. So for example, if the FM wants the information that he needs, you provide that and no more"* (334). Hence, this is another concern that the Information Manager needs to be aware of in executing his duties. This finding concurs with the suggestion given in the literature by Udom (2012). According to Udom (2012), such confidentiality agreement should include the following:

[13] See Item 6.2 of PAS 1192-5:2015

a) BIM data cannot be used elsewhere without the agreement of all parties;
b) Identify areas in the BIM model/data to restrict access;
c) Data providers should identify any data that might contain trade secrets that should be accessed in a manner that does not compromise the interest of the data owners;
d) Restrictive rules of access, copying and transmission

Udom's suggestion might be worth to be considered in order to improve the data security management planning within the PF2 project implementing BIM.

6.3.3.3 Status of BIM model

The interviewees were asked about their opinions on the status of BIM model, whether the BIM model can be considered as a contractual document or only to be treated as contract deliverable. Figure 6.6 presents the mind map of the interviewees' opinions on the strategies to manage contractual risks related to the status of BIM model.

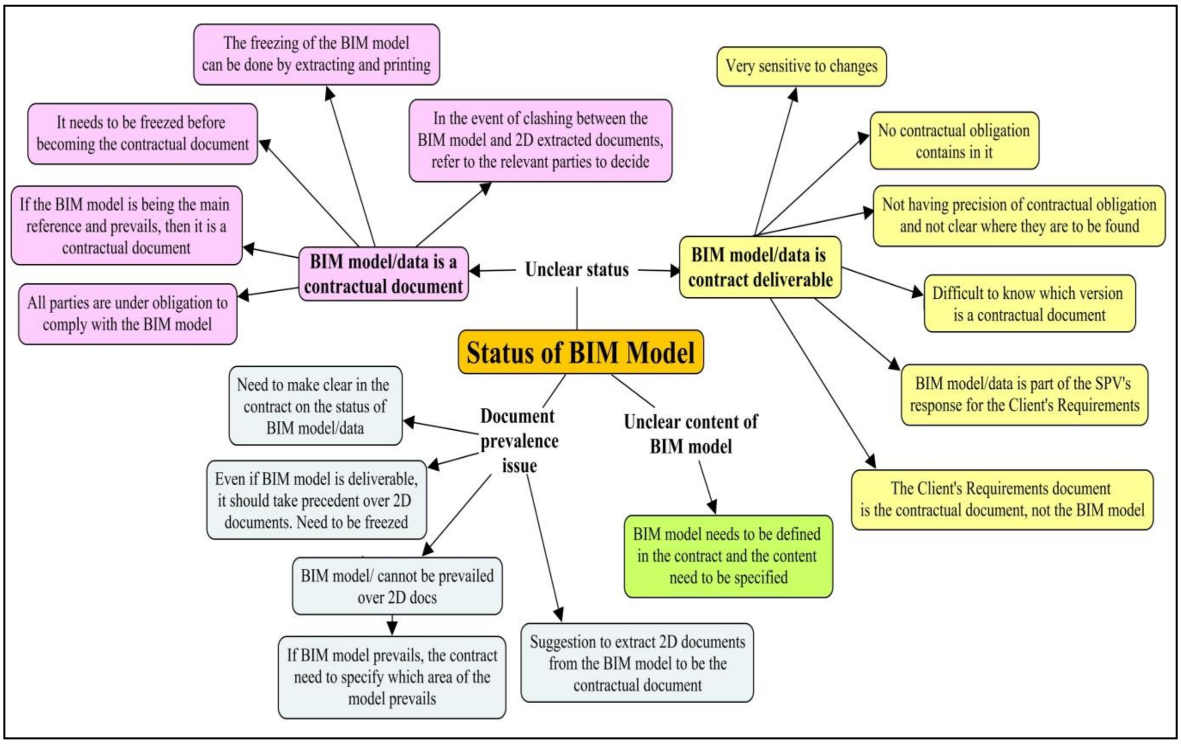


Figure 6.6: Mind map of the experts' view on the strategies to manage contractual risks related to the status of BIM model

From the findings, there were two views given by the interviewees. IV-1, IV-2, IV-5 and IV-6 had the same opinion that the BIM model cannot be a contractual document. On the other hand, IV-4 and IV-3 contended that the BIM model is a contractual document. According to IV-1, BIM model is not a contractual document because there is no contractual obligation in it (143). Even if the model prevails over the 2D extracted documents, it is still not a contractual document because *"you need to know which version, which update of the model at that time because if there is any change after that, then it can't be compared with what they did against the new version"* (144). Sharing the same view, IV-2 stated that for BIM model to become a contractual document, it needs clear contractual obligations and it has to be clear where they are to be found (215) and he said, *"…contract document should contain document that imposes obligation or instruction paper-based. It is probably safer, not to use the model as contract document"* (218, 219). IV-2 further emphasised that *"You can't make somebody contractually liable unless you have precision in the obligations"* (225, 226). Moreover, IV-1 further explained that what constitutes as a contractual document are documents such as

Employer's Requirements or Information Requirements of the buildings that need to be delivered through the performance of the asset (136). Similarly, IV-5 commented, *"the Client's requirements would always be set above our proposals. The BIM model is part of our proposals, so it won't become a legal document but if there's any difference between the two, the client's document always comes first"* (534). He further added, *"what you are looking for is the output specification. Client provides you with the output specification. We provide the details that go behind them as part of our response. And the BIM Model is part of the response"* (535). Thus, EIR takes priority over the BIM model.

The nature of the BIM model which is very sensitive to changes also makes it impossible to become a contractual document, as IV-2 said, if *"if it is still in a development you cannot use it as contract document"*(217). Adding to the statement, IV-2 commented, *"So, it's quite possible to make it as contract but to be fair at what time, at what mode, the contracts become fixed. So, if I'd been given a model, my work is a representative, I got to know that model is fixed"* (216). So, for a BIM model to become a contract document, it has to be a fixed and tangible (223). This view corresponds to the IV-5's standpoint, *"It is a deliverable ... the extracted documents can be contractual documents. People always like to see something on paper because it is more tangible. Maybe we need to provide them with 2D drawings and also give them a full federated BIM model. They have an advisor who then checks that the drawings were from the BIM model. So, we have to give both. But, I think in the future as clients become more comfortable with BIM, when BIM becomes more common, the Client would only want the BIM model. So it has to be a frozen BIM model"* (539).

In contrast with the above opinions, IV-4 had the opinion that BIM model is a contractual document. Furthermore, IV-4 mentioned that if every party is relying on the BIM model and the model prevails over other 2D extracted documents, then it should be a contractual document (428). But for the BIM model to become a contractual document, it has to be frozen so that nobody can challenge it (430, 431). IV-4 also suggested one way to make the data in BIM model frozen is by printing and extracting the data from the BIM model to become 2D documents. *"I think there needs to be a way for something that protects all of the parties. The document that you are contractually tied to then you* *have to fix. I think that is the way to fix at the moment in time, and then printed out, extracted it"*(432). He further commented, "*And it is interesting that the ConsensusDocs have that way ... in the event of any clashing between the BIM model and the 2D documents, such inconsistencies need to be brought to the attention of the relevant parties for them to decide which one should be followed or which one is the correct one"* (433). On the other hand, IV-3 commented that the status of BIM model really needs to be stated in the contract in order to avoid confusion and dispute in the future. According to him, BIM model is not appropriate to become a contract document because *"it does not really make sense because it is prone to changes during the life of the project"* (325). But at the same time, it can also become a contractual document *"as the project team members will be under contractual obligations to comply with various bits of the model at various stages. So, that is yes, it is a contract document meaning that I am a M&E installer, and I have the obligations to put the air-conditioning ducts and lights in exactly the same positions they are all in the model. So, that's one way it is a contract document. And it must be a contract document"* (326).

The varieties of opinions from the interviewees show that the status of BIM model is not clear, thus the position of BIM model in contract needs to be declared. It is common in the construction industry to incorporate varieties of documents to be part of contract; however, normally such incorporation includes written or printed version of the documents such as drawings, specification and others. The implementation of BIM might require slight changes in typical contracting, as the virtual BIM model may be included as part of contract without the need to extract and transform the data from BIM model to 2D documents. The fact is that; contractual documents are not limited to documents expressed in words (Uff, 2013)[14]; therefore, a BIM model can also be interpreted as a contractual document as it specifies the work to be performed (Ashworth, 2012) and the works as built. However, this must be expressly stated in the contract and cannot be considered as implied terms. Whether the federated BIM model is defining the amount of works that need to be performed by the project team member, or as the main reference for the project to be in accordance with the position of BIM model within the PF2 contract needs to be clearly defined.

[14] The 2011 amendments of Housing Grant, Construction and Regeneration Act now also applies to construction contracts including those that are not in writing.

The concept of defining a document to be a contractual document has been explained by May (1995), where even though such explanation was referred to the position of Bill of Quantities within contracts, it is believed that the same concept can also be applied in the context of BIM implementation in PF2 project.[15] An example of the clause that specifies BIM model as part of contract can be seen in Clause 2.3 of ConsensusDocs 301 Addendum:

> Contract Documents as defined in the Governing Contract, is modified to include all Design Models, unless otherwise specified in the BIM Execution Plan.

Notwithstanding the fact that BIM model can be part of the contractual document provided there is clear provision of such setting, it is also important to contemplate the considerable opposition to this fact given by the interviewees. The nature of BIM model which is very much prone to changes, produced in multiple versions and do not contain precise contractual obligations are the reasons given by the interviewees to support their disagreement. Therefore, if the parties decided for BIM model to be part of the contract documents, it may be worth to specifically include in the contract which version, its content and which areas of BIM model that are to be part of the contract documents. Mechanism to freeze the BIM model before it becomes a contractual document should also be included in the BIM Execution Plan. This was mentioned by IV-2 who suggested for BIM model to be defined in the contract on the meaning, versions and what kind of information contained in the BIM model (228), so as to avoid misunderstanding and confusion in the future.

With respect to the precision of obligation that is missing from the BIM model as raised by IV-2, this opinion appears to be in contradiction to the literature. Contract documents for project delivery is not only to include contractual obligations in the conditions of contract but also needs to include other documents, which contains among others the details of the work to be performed, the quality of work required, the cost, the scheduled programme as well as drawings and specifications (May, 1995; Ashworth, 2012; Uff, 2013; Adriaanse, 2016). In a PF2 project implementing BIM, it is impossible for the condition of contract to detail out all the work and services to be performed to the desired

[15] See p. 45, 90, 91 of May (1995).

quality and standard of the Client, which therefore has to be derived elsewhere which in this context is the BIM model. Therefore, the contract must be construed as a whole and not only depending on the contractual obligations contained in the conditions of contract. Lord Atkinson in *Brodie v. Cardiff Corp.* (1919)[16] mentioned in the following excerpt:

> The contract must be construed as a whole, effect being given, so far as practicable, to each of its provision.

There are two stages in construing a contract, firstly to determine which documents are contractual; and secondly, give effect to all the terms and endeavour to reconcile inconsistencies (May, 1995). Therefore, it is vital to clearly express in the contract the documents to be interpreted as a whole contract documents for the PF2 project, and indicate which documents to prevail in the event of discrepancies.

With respect to the issue of prevalence of contract documents, IV-2 did not agree for the BIM model to be prevailed over the 2D extracted documents as what has been stated in the CIC BIM Protocol due to flexibility of BIM model in response to changes and massive information contained in it. For him, if the model prevails, the contract needs to specify which areas in the model shall prevail as there is so much information contained in the BIM model and it is impossible for all the information to prevail (224). It is also important to define which version of the model that prevails (221) due to the sensitive nature of the model to changes. Therefore, IV-2 suggested extracting 2D documents from the model and simply using BIM as a device and method in helping to develop the designs and the other buildings elements (220).

This is in line with the opinion of one of the experts during the informal interview in the exploratory stage who questioned the same issue. On the other hand, this is in contrast with IV-6 who stated that even though the BIM model is contract deliverable only, it still should take precedence over the other 2D extracted documents, provided that it needs to be frozen at a certain stage before becoming the standardised reference for all (618, 619). Such differences of opinion of the interviewees obviously confirmed the need of having clear and robust contractual provisions to specify the documents prevalence or the

[16] *Brodie v. Cardiff Corp.* [1919] A.C. 337, p. 355.

mechanism to address the issue of discrepancies and inconsistencies in the contract documents. For example, Clause 1.9 of ConsensusDocs 301 Addendum stated:

> If any Project Participant becomes aware of a discrepancy between a Model and either another Model or another Contract Document, such Project Participant shall promptly notify the other Party or Parties to that Project Participant's Governing Contract and the Information Manager (IM)

Thus, even though the BIM model prevails over the other documents, the parties are made aware of any discrepancies and the relevant data provider together with the other parties can act accordingly in response to the problems notified to them. As the EIR is supposed to take priority over the BIM model as mentioned by the interviewees earlier, any discrepancies or inconsistencies should be solved with reference to EIR.

Therefore, the study reveals that the position of BIM model in the contract is actually depending on the negotiation between the parties to the contract. Any decision taken by the parties, whether to treat BIM model as part of the contract documents or otherwise needs to be precisely and clearly detailed out in the contract. Notwithstanding any decision materialised through contracts, in the context of PF2, documents related to the Client's requirements such as EIR and PF2 output specification need to take priority over any other documents in the contracts.

6.3.3.4 Intellectual Property Rights

Intellectual property rights issue is one of the contractual risks identified by the experts during the first stage of this research. In this second stage of this research, the interviewees were asked about their opinions on intellectual property rights issues regarding the (1) revocability of copyright licence; (2) ownership of the BIM model/data; and (3) IP for the Information Manager's work. Figure 6.7 presents the mapping of the experts' view on the strategies to manage contractual risks related to the intellectual property rights.

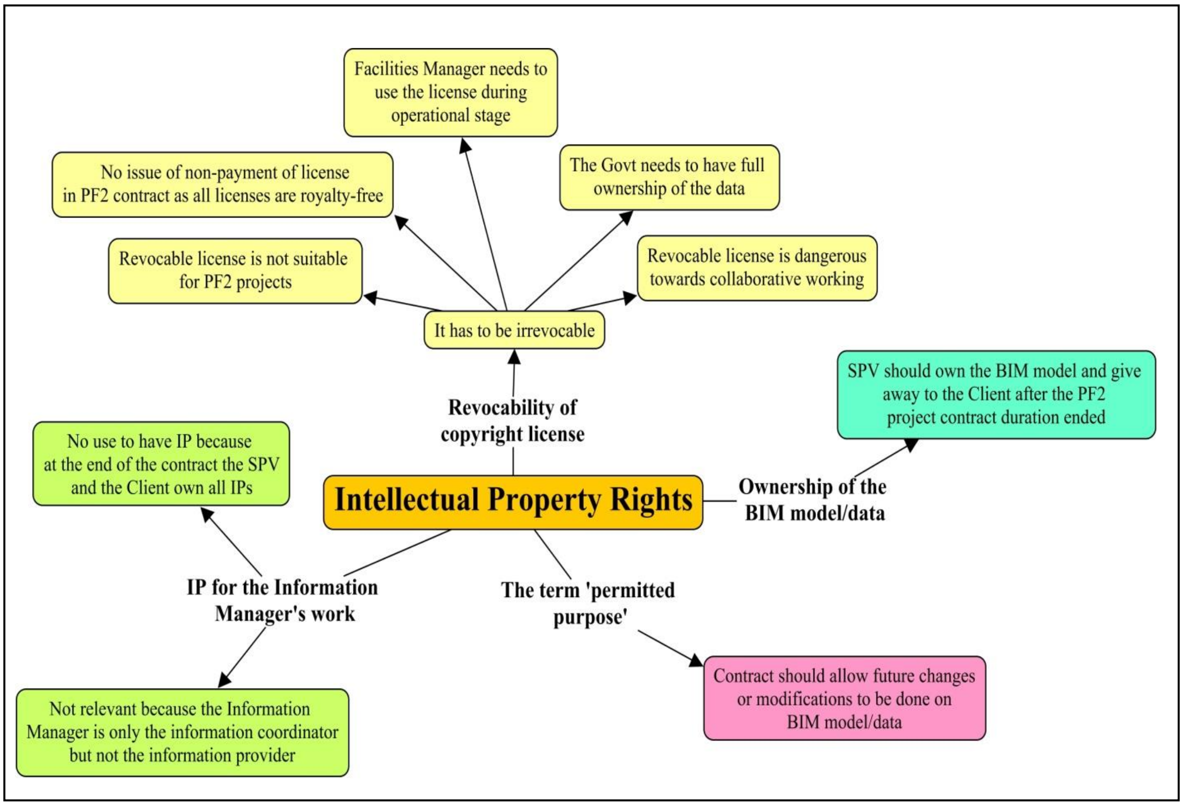


Figure 6.7: Mind map of the experts' view on the strategies to manage intellectual property rights issue

The interviewees were asked regarding the issues of revocability of the copyright license granted by the project team member for the use in a PF2 project implementing BIM. All of the interviewees agreed that the copyright license should be irrevocable as what stated in the Standardisation of PF2 Contracts. They all agreed that revocability of licence as stated in the CIC BIM Protocol is not appropriate to be applied in the PF2 projects. IV-1 stated, *"This is not suitable for PF2 because the licence granted to the Client has to be on a royalty-free, perpetual and irrevocable basis. Under the BIM Protocol, licence is revocable due to non-payment issue. Therefore, this is obviously not suitable for PF2"* (173). Looking from the necessity for the licence to be irrevocable, IV-2 commented, "*The Facilities Manager obviously wants to have a continuing licence to use the data. So, they have to make the licence available to the asset manager over the 20 years or 25 years of the contract duration or the whole life of the facility. The consultants may not be happy to give away their licence, but for PF2 project, Client needs to have full ownership of the BIM data"* (247).

Hence, this study reveals that the PF2 project is different from the traditional or design and build contracts in which the revocability of license is not suitable to be applied in PF2 contract. This is due to the characteristics of PF2, which is lengthy and requires information to be referenced, retained and sustained for 20 to 30 years of contract duration. If the license is granted by the contractors to the SPV; and SPV to the Client is revocable, it will expose the PF2 project to the risk of losing important information and data about the project, disturbance to the progress of work and interruption of data supply chain among the project team member, which might affect the quality of the PF2 facilities and services provided. Such situation might also open the door for huge disputes in the future, which not only affects the project but also give bad implication to future business relationship. These are the effects that were being considered, therefore as being stated in Standardisation of PF2 Contract, license granted should be royalty-free, perpetual, irrevocable, sub-licensable and transferable (see Clause 33.3 of the Standardisation of PF2 Contract).

As one of the drafters of the CIC BIM Protocol, IV-3 explained, "*We made it revocable under the protocol because it is very broadly reflected to typical arrangement under standard form appointment of consultants, for example architect particularly. Equally there are plenty of employers who say no, I want the licence to not be revocable. So it is just a matter of contract negotiation"* (351). Looking from the context of PF2, IV-3 further added that, *"On the PF2 job, it has to be irrevocable. After the 20 years when it is handed back, the government needs to own the thing fully, they can't hold it with some designer in here"* (352). Other than that, IV-4 commented that the licence for PF2 projects implementing BIM needs to be irrevocable because revocable licence is dangerous towards collaboration. According to him, *"if it can be revoked, I think it is dangerous towards BIM working environment because BIM project relies on the parties continue to collaborate, continue to use each other's works* (450). *It would make the client impossible to use the design possibly for future works or further amendments or during completion"* (451). IV-4 further recommended for the term 'permitted purpose' as what stated in the CIC BIM Protocol to be amended if it is going to be applied in PF2 project, so that it also allows future changes or modifications to be done to the BIM data that inevitably happened to reflect the change of trends of services that need to be provided to the public users in 20 to 30 years of PF2 project duration (447).

The finding of the study again reveals that it is dangerous for parties within the PF2 contract, or for other types of construction contracts, to simply attach and adopt any BIM Protocol without scrutinising every clause contained in the Protocol and checking its compatibility and consistency with the main project agreement. There is no indication in the CIC BIM Protocol that mentions the context in which it is drafted by simply claiming that the Protocol is suitable for all Level 2 BIM projects. Conversely, it is obviously proven by the present study that such BIM Protocol is not suitable to be used for PF2 projects implementing BIM. Indeed, the BIM Protocol takes precedence over the existing contract[17], therefore if the BIM Protocol is attached to the PF2 project agreement, provisions regarding IP in the PF2 contract which are in contrast with the BIM Protocol will be superseded. Such situation will put the PF2 project at risk. This study demonstrates that it is dangerous to have any BIM Protocol to take the priority over the main project agreement as this will create confusion for having two different contracts at the same time. In any situation and in any project, should any inconsistencies happen, the main project agreement should take precedence or such inconsistencies should be referred back to the Project Manager or the relevant contracting parties for it to be decided.

In order to maintain the continuous use of BIM and to avoid the disruption of the information management, the issue of the ownership of the data also plays an important role. In response to this issue, IV-5 gave a lengthy comment, *"The SPV should own the IP licences for all the data created for the project because the SPV made the federated model* (561). *And the reason I think, if something happened to the project, the SPV could still provide the services. In PF2, the last person you want to terminate is the SPV. So, if you leave the licence with the FM provider, you will then have the argument of how to get the licence back if you terminate them. So I think that in our PF2 project SPV should not only retain the licence and the IP but should also own the AIM"* (567). After the completion of the facility construction, he further added that, *"the SPV can give the IP ownership of the BIM model to the Client. There is no point for the SPV to retain the BIM model after the contract period ends* (564) *... and it has to be free of charge because the Client has paid for the services to the SPV for 25 years"* (565). Almost similar to the opinion given by IV-5, IV-6 commented that the SPV needs to own the IP

[17] See Item 2 in Introduction and Guidance of the CIC BIM Protocol, p. iv.

licences until the operation stage of the project, *"because if you have some kind of failure to the supply chain, then it would give them the opportunity to maintain the integrity of the data until they appoint someone else. The Client also should have the right to step in"* (630). As for the ownership of the BIM model after the end of PF2 contract duration, he said, "*I would like the client to own it or at the end of the PFI, the client owns the data. In the event of failure of PFI/PF2, the client should have the right to step-in and the client should have the express right to review the data to ensure the quality of the data"* (631).

The comments given by the interviewees are slightly similar with one of the options given under Clause 33.3 of the Standardisation of PF2 Contract (see discussion of these options in Chapter 4 sub-section 4.4.4). Based on the opinions given, the researcher viewed that the first option, which is to transfer the ownership of the IPs in the Project Data from the SPV to the Client and licensed back to the SPV for the in the project, will give the most secure rights of the IPs in the BIM model to the Client as the Client would not face the risk of discontinued use of licence if in the future, the SPV becomes insolvent. This might be the best option to also address data security issue as discussed in sub-section 6.3.3.2 hereinbefore, so that the Client has full control on the PF2 project. Therefore, PF2 project will be more transparent to the Client as what it is intended for as explained in sub-section 2.6.2 of this thesis.

Moreover, the interviewees were asked regarding the issue that the researcher found in the literature on whether it is needed for the Information Manager to have his own IP as he is working on creating a federated BIM model; all of the interviews felt that such idea is not relevant in PF2 context. As IV-1 said, *"the Information Manager is the coordinator. I don't think he needs to have an IP because he is coordinating works of others"* (181). On the other hand, IV-3 commented, *"yes, he is creating something and there are some intellectual property rights there that need to be managed under his appointment and under the contract* (355). *But, in PF2 context, there is no use to apply for that because at the end, the SPV or the Client will own all the IP licences for the data created for the project"* (356). This finding is in contrast with the recommendation by Currie (2014) as mentioned in sub-section 4.4.4 of this thesis. However, in the context of

PF2 project, the comment given by IV-3 is realistic as in the end all IPs will be owned by the Client.

6.3.3.5 Liability

Liability issue is one of the key contractual risks in PF2 projects implementing BIM which has been identified by the experts during the exploratory stage of this research. The interviewees were asked about (1) liabilities of the project team members with respect to the Clause 5.1; (2) the liabilities of the Information Manager and other parties; (3) insurance; (4) the doctrine of the privity of contract; and (5) the rights of the Client to be involved in the decision-making process. Figure 6.8 presents the mind map of the experts' views on the strategies to manage contractual risks related to liability issues.

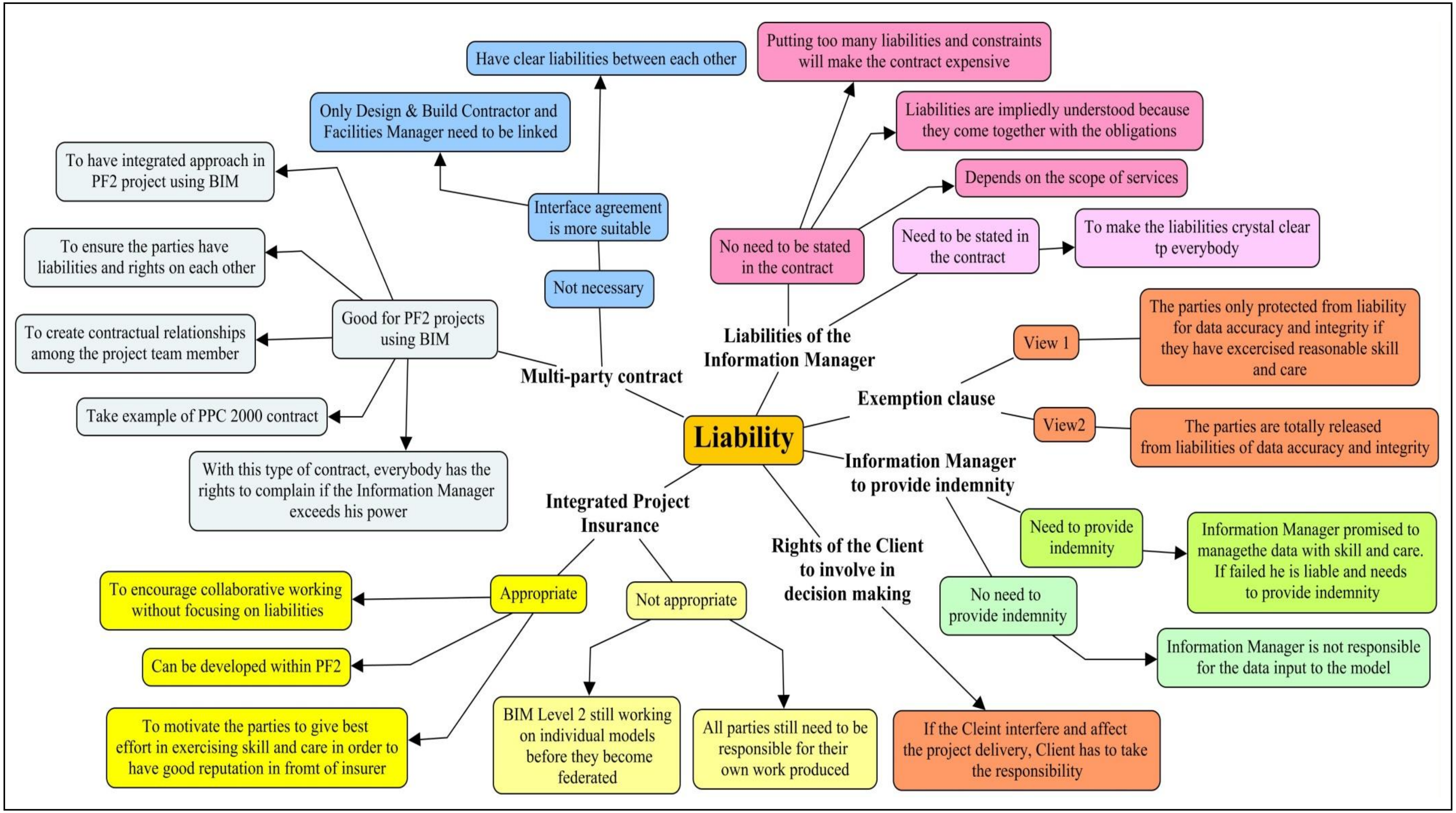


Figure 6.8: Mind map of the experts' view on the strategies to manage liability issue

The interviewees were asked about the effect of Clause 5.1 in the CIC BIM Protocol with respect to the liabilities of the project team member for the accuracy of electronic data contained in the BIM model. The difficulty with Clause 5.1 of the BIM Protocol has been discussed in sub-section 6.3.3.2 of this thesis in relation to the contractual risks of data reliance. In this sub-section, Clause 5.1 is examined in the context of liability risks. According to IV-3, as one of the parties involved in the drafting of the BIM Protocol, *"the reason for that Clause is to say that, problems happen and all the design team or particularly project team have got to do is to exercise reasonable skill and care to stop problems from happening. But if it happens, something goes wrong and nothing I can do about it… it's not by fault, and what it does, what this is a very contentious clause to be put in and I know many people don't like it and so on, because the implication of this, it is the employer's risk. If something goes wrong and it is not by fault then if loses, it goes back to the Employer"* (329). IV-3 further commented, "*I quite agree that the whole purpose of this Clause is to make sure that the Consultants are not responsible, the project team are not responsible for the data corruption."* (344). Similarly, IV-1 had a same view as IV-3 (147, 150, 151, 152). Thus, from the comment given by IV-3, Clause 5.1 is purposely included in order to make the Employer retain the risk of data corruption and accuracy.

Notwithstanding the explanation given by IV-3 in regard to Clause 5.1, other interviewees viewed the Clause differently. IV-4 voiced out his disagreement of the clause, as according to him all parties have to be responsible for the data they provided for the project (435). For IV-4, BIM is only a method to procure the project; therefore, the responsibility of the parties in a project implementing BIM has to be similar with projects without BIM (456). Similarly, IV-2, IV-5 and IV-6 also disagreed with Clause 5.1 to be applied in the PF2 project or other types of project as well. For example, IV-2 argued, *"I think that's wrong. If people are not made responsible, there is a risk that they don't take special care. For me that will be wrong"*(257). Their views concur with Sebastian (2010) and Liszka (2011) as discussed in sub-section 4.4.5, which argued that the use of BIM is not supposed to change the liability position of the contracting parties.

Based on the answers given by the interviewees, Clause 5.1 of the BIM Protocol is considered as ambiguous as there are two interpretations that can be derived from this clause, which are in contrast of each other. The first interpretation is that, the clause is meant for protecting the project team members from the risk of corruption of electronic data that is not due to any parties' fault. Thus, the parties are only protected if they have exercised reasonable skill and care towards providing the data in accordance to the Protocol, and not liable for any corruptibility of the data. Secondly, it was interpreted that notwithstanding any obligations vested in the parties by the contract, they are released from all the liabilities for the accuracy and integrity of the data delivered to the BIM model. Thus, with the unwarranted data, such provision in the contract might affect the collaborative sharing concept in their working process as promoted by PAS 1192-2:2013. This criticism has also been raised strongly by Udom (2013), Klien (2015) and Winfiled (2015) (see sub-section 4.4.2).

Looking from the legal perspective, Clause 5.1 of the CIC BIM Protocol is considered as an exclusion clause as discussed in Chapter 4, sub-section 4.4.5. There is no indication in the clause that mentions that the release of the liability is only if the project team members have exercised reasonable skill and care. Even though that can be impliedly understood as mentioned by IV-3, it is worth to note that the CIC BIM Protocol supersedes any conflicting clauses in the existing contract.[18] Therefore, notwithstanding the obligation to exercise reasonable skill and care as provided by their contracts of appointment, the use of the BIM Protocol may render all liabilities in the appointment clause as ineffective. Thus, the project team members have no liability towards the accuracy of the data provided regardless of whether they exercise reasonable skill and care or otherwise.

Thus, in the context of PF2 project, it is important for the parties to give attention to any exemption clause included in the contract, otherwise all the contracting parties might not be aware that they are relying on the unwarranted data for years. Therefore, it is vital for the contract to be written clearly on the width of the exemption clause, because failure in providing clarity in this area may cause *contra proferentem* and misrepresentation when the parties to the contract are relying on the exemption clause without actually understanding its true meaning. Such situation can happen in contracts between the Client and the SPV, and also between the SPV and the Contractors. The importance of

[18] Item 2, Introduction & Guidance in CIC BIM Protocol, p.iv.

understanding the width of the exemption clause by the contracting parties are explained in the cases of *Photo Production v. Securicor Transport* (1980) and *Curtis v. Chemical Cleaning* (1951) as mentioned in Chapter 4, sub-section 4.4.5. The ignorance on the extent of exemption clause can lead to false impression and misrepresentation. As the remedy might be the possibility that the parties can rescind the contract, in the context of PF2, such action would give huge effect to the project implementing BIM as it might slow down the progress of work, put the services to the public users at halt and consequently affecting the time and money of all parties involved. The right to rescind might be lost if the misrepresentation is known long after the contracts concluded. Hence, it is really crucial for the contracting parties of PF2 projects, including the Client, if they want to apply the similar clause in their contract to make clear and examine the extent of the exemption clause before the contracts concluded. Otherwise, possible disputes might occur in the future that might cause failure to sustain a collaborative working environment.

Therefore, this study suggests that, firstly, any exemption clause related to the data accuracy and integrity needs to be reviewed and adjusted according to what has been agreed and understood between the parties. If the Client wants to give liability exemption for data corruption or data loss due to nobody's fault only, then the wordings of the clause have to be clear so that the project members still have the liability if the incident happens due to the lack of providing reasonable skill and care. The example can be seen as in the case of *Photo Production Ltd v Securicor Transport Ltd*. (1980) on how the exemption clause saved Securicor Transport from liability (see sub-section 4.4.5). It is also worth to note that by having this kind of provision, the PF2 Client will retain the risk of corruption or loss of data even though the Client is also not at fault. Therefore, it depends on the risk allocation that has been agreed between the Client and the SPV, or between the SPV and the Subcontractors. If the Client or SPV does not want to bear the risk, then it is better not to include such exclusion clause in the contract. For example, in the American standard form of contract, Clause 5.1 of the ConsensusDocs 301 BIM Addendum stated:

> Each party shall be responsible for any contribution that it makes to a model or that arises from that party's access to that model. Such responsibility includes any contribution or access to a model by a project participant in privity with that party and of a lower tier that that party.

This is the example when the project team members are not given any exclusion, therefore the parties are still liable in the event of data loss, data corruption or damage.

The interviewees were asked about the liabilities of the Information Manager and the need to state such liabilities clearly in the contract. According to IV-1 the liabilities are sometimes impliedly understood, *"if they have an obligation then the liability comes with that. So, I think it depends on the scope of the services. If they have some obligation and they failed, then liability attached"* (186). IV-1 highlighted the danger of putting too many liabilities in contract. She reminded, *"It is supposed to be a risk of putting too many contract clauses in the project like this because you can kill it if it has too many constraints, too many liabilities, then it becomes too expensive because the more liabilities, the more risks, and price tag gets higher. So I think need to be careful by adding too much more in terms of contract clauses and liabilities* (160). *I think it depends on what goes into the appointment in the contract"* (188). In contrary, IV-4 had put forward his view by saying, *"I think, anybody who is the consultant, contractor, designer, Information Manager or other parties which are crucial to the successful of these project, their rights and liability should be clearly defined and spelled out in the contract"* (456) thus, not only obligations, but liabilities need to be expressed in the contract as well. IV-5 and IV-6 also shared the same thought.

It is understood that the concern raised by the interviewees on the need to specify the Information Manager's liabilities is based on the awareness on the importance of having clear and robust contractual provisions in PF2 projects implementing BIM due to the fact that there might be changes of roles of the contracting parties as the effect of using BIM. As known, working with BIM means working collaboratively by trying the best to avoid involving in adversarial relationship between each other. Therefore, having clear contract terms that specify Information Management liabilities is a way to sustain the collaborative environment. This is because the role of Information Manager can be shifted from one party to another; therefore, the liabilities of the Information Manager are the additional risks that need to be borne by the parties when the role is being put under them. Thus, specifying the liabilities of the Information Manager will mark the demarcation line between the liabilities vested in the existing of the parties and the liabilities vested within the role of the Information Manager.

However, consideration needs to be given to the fact that specifying liabilities is not as easy as specifying obligations in the contract. There are liabilities that are not able to be decided at the time of contracting and can only be decided by the Court. Most of the time, the liabilities impliedly arise from the contract. Liability has been explained in United States law case *Mayfield v. First Nat. Bank of Chattanooga, Tenn.* (1943)[19] as follows:

> Liability is a broad legal term which is usually held to include every kind of legal obligation, responsibility or duty, certainly all that are measured by money obligation. Liability may arise from contract, express or implied, from duty imposed by law, or by judgment of a court, or as a consequence of tort committed.

This definition concurs with the opinion given by IV-1 and also as mentioned by Clough, Sears, & Sears (2005) that liability may arise from obligations. Therefore, the study concluded that it might not be necessary for the liabilities of the Information Manager to be spelled out in the contracts. However, it is necessary and important for contracts to clearly detail out all obligations of the Information Manager with respect to BIM data related matters. As such, the obligations provisions of the Information Manager will indirectly spell out the demarcation line between the roles, liabilities and responsibilities between the Information Manager and the parties to which the role has been shifted. Furthermore, it is also noted that not only obligations of the Information Manager need to be detailed out in the contracts, the obligations of the Data Security Manager also need to be set in advanced to ensure the different liabilities undertaken by the Information Manager and Data Security Manager (see sub-section 6.3.3.2).

Thus, due to the liabilities that the Information Manager bear, all of the interviewees except IV-1 agreed that the Information Manager may need to provide indemnity insurance in the event there is any error due to his negligence in managing the data. IV-4,

[19] *Mayfield v. First Nat. Bank of Chattanooga, Tenn.* [1943] 137 F.2d 1013 (6th Cir. 1943).

for example, commented, *"It depends on how the errors arose. If the errors are in the design, then the designer should be liable. If the error arose because of the Information Manager cannot transfer data correctly, then that would cause the Information Manager to be liable for that. So, in that case he should provide indemnity or assurance because in the contract he said that he will manage the information with skill and care"* (462). However, IV-1 argued that the insurance is not needed as *"the Information Manager is not responsible for the data input to the model"* (185).

The role of Information Manager comes with obligations, therefore there are liabilities attached with such role. Even though the Information Manager is not responsible for the data provided to the BIM model, he/she is the one who promised under the contract to manage the data appropriately. A PF2 project implementing BIM heavily relies on outstanding data management as a small data management error may have far-reaching consequences to the parties and to the future of the project, therefore the importance of the role of the Information Manager cannot be questioned. The impact towards the project might be major if the Information Manager failed to perform his duties well. Hence, due to all of these reasons and the agreement of the majority of the interviewees, it is necessary for the Information Manager to provide indemnity insurance. Furthermore, the roles of Information Manager most probably need to be attached to the existing parties' roles; this will increase the liabilities of the Consultants in the PF2 project. There has been attempt to address the concern on insurance issue following the use of BIM in CIC Best Practice Guide for Professional Indemnity Insurance document. Generally in the said document, the BIM Project contracting parties are advised to disclose their involvement with Information Management role to the insurance broker, and provide sufficient knowledge to the insurance broker on the risks they are holding. Thus, this is why it is vital to specify in detail in the appointment contract of the Information Manager the duties and obligations that need to be performed under the contract for the said role, so that the insurance broker can evaluate the risks accordingly.

Besides that, another suggestion given by the interviewees is to have a multi-party insurance regime or can also be named as integrated project insurance for the PF2 projects implementing BIM. This is to reduce the parties' focus on liability issues and give more attention to work collaboratively in the effort to have a successful PF2 project.

IV-1 explained this type of insurance, *"it means that if something happened that triggers a claim covered by the policy, the policy just pays and it doesn't matter who is responsible. It collectively insures all parties to the contract including the Client and it replaces individual professional indemnity insurance. It waives the rights of subrogation against all the insured parties"* (192). She further explained that such insurance will motivate the parties to put the best effort in exercising reasonable skill and care because if they had too many claims in the previous project, that will affect their reputation in the eyes of the insurer, hence causing very high price for the insurance policy of the next project (193). Similarly, IV-2 and IV-3 also had the same view, as IV-2 commented that such type of insurance is like an *"alliance contract with the project insurance which can be developed within the PF2 contract"* (210). However, when this idea was brought to IV-5, he argued that the integrated insurance is not appropriate for PF2 projects that employ BIM Level 2 as everybody is still working on individual models before they become federated and "*designers still need to be responsible for faulty design"* (575).

The suggestion given by the interviewees actually corresponds to the model of integrated project insurance as recommended in the Government Construction Strategy 2011 (HMSO, 2014). Even though there are many benefits echoed in the literature on the benefits of having the integrated project insurance, the suitability of the insurance model to be used for PF2 projects implementing BIM is still in question. Currie (2014) has highlighted some of the drawbacks, such as the possibility of the insurance policy to be very expensive due to the waiver of subrogation rights that increases the insurer's risk. Therefore, critical examination is needed to see the compatibility of such insurance model in the context of PF2 projects, as the increment of cost that needs to be borne by the insurer may increase the cost of the services to be provided by the public users. Thus, such critical examination may be worth to be carried out in detail in the future research.

As there are a myriad of parties involved in a PF2 project, the interviewees were asked about the effect of the doctrine of privity of contract to collaborative working using BIM. The interviewees acknowledged the problem in the contractual relationship as the common law rule of the doctrine of privity provides that only the persons who have direct contractual relationship are affected by the contract (Whittaker, 1996; Ashworth, 2012; Wright, 2016; Adriaanse, 2016). This doctrine has been discussed in sub-section 4.4.5 of this thesis. In reference to contractual structure of PF2 as presented in sub-section 2.7.1, the Client has a direct contractual relationship with the SPV but has no connection with the consultants and contractors within the SPV. As within the SPV, all consultants and contractors have direct contractual relationship with the SPV but have no contractual link among each other. Such arrangement will affect collaboration working as desired in BIM. In fact, a research by Badi and Pryke (2015) on PFI contracts concluded that disintegration in internal contractual relationships leads to ineffective communication among design, construction and operation disciplines.

Due to such problem, the interviewees suggested for a multi-party contract to be used for PF2 to ensure the parties have liabilities on each other. IV-1 explained, *"But the issue here is that the project team members don't have contracts between each other. So, there's no contractual requirement as between for example mechanical electrical designer and structural designer they don't have a contract with each other* (158) *... that's why we need a multiple parties contract. So that everybody has liabilities and rights between each other across disciplines and that would give you some sort of remedy here if someone got it wrong"* (159). Agreeing with this view, IV-4 commented that multi-party contract is good for BIM project. He said by having this type of contract, *"everybody can complain if the IM is exceeding his powers from his existing roles,"* (461) thus, it can be a mechanism to control the power of Information Manager. He further emphasised by saying that BIM requires *"... a new way of looking at its contractual obligations with a much more integrated approach. And a multi-party contract does give that integrated approach"* (409). IV-4 also suggested taking the Project Partnering Contract (PPC2000) as an example of contract that responds to BIM needs and encourages collaboration (408). In contrary, IV-5 and IV-6 argued that a multi-party contract is not necessary. Based on their experience involving in PFI projects implementing BIM, they preferred PF2 project to employ interface agreement (512). Interface agreement is the agreement between the Design and Build Contractor and the Facilities Manager or O&M Operator excluding the SPV. It is for both parties to have contractual relationship and have clear liabilities between each other to help them to work collaboratively (512, 513, 605, 606).

With respect to the multiparty contract, the suggestion was found to be consistent with the suggestion given by Pishdad & Beliveau (2010), Lahdenperä (2012), and King's College London (2016) for a multi-party contract to be used for BIM projects. With the implementation of multi-party agreement, all of the parties are interlinked by means of a single contract; therefore the parties are bonded with standardised contractual provisions that apply to all. The potential of this type of agreement for BIM project in creating collaborative platform in BIM projects was demonstrated by Cookham Wood Project when the project employed PPC2000 standard form of contract, which encourages such collaborative environment (King's College London, 2016). In the said project, apart from using multi-party contracting in a single contract, it also combined early contractor involvement, collaborative working and BIM. The BIM Execution Plan was developed in detail during the pre-construction stage with all the deadlines agreed by all parties. The agreed deadlines and the detailed activities by each team member at each stage of design development were set out against a single agreed set of integrated deadlines. The parties also agreed to be responsible to each other for errors and discrepancies of their contributions as well as agreed to give early necessary warning to each other in regard thereto. In terms of intellectual property rights, a set of mutual intellectual property licences were directly entered into between all team members. Furthermore, the contract for the said project also does not include any exclusion, limitation or exemption clause (as Clause 5.1 in the CIC BIM Protocol) arising from the adoption of BIM. The Cookham Wood Project proved significant cost saving of 20% resulted from the multi-party contract arrangement that they had.

Despite having no known experiment on any PPP project, the benefits of the use of multiparty contract in PF2 project may be foreseeable based on the study done by Badi and Pryke (2015). In their study, empirical examination on the quality of collaboration in PF1 projects reveals that fragmented internal contractual relationship weakens the collaboration within PFI where such situation renders ineffective communication. This study underlines the need for seamless contractual instrument to address the fragmentation; hence having a multi-party contract might be the solution for PF2 projects implementing BIM to avoid those problems from happening. With interface agreement that is currently practiced in the PFI procurements might as well be considered as option to be used in PF2 projects implementing BIM, the findings may suggest that multi-party contract is also worth considering as it offers single layer contractual interface for all parties to be bonded at the same level, consequently making it more seamless from the interface agreement. This hypothesis can be forwarded to future research.

Apart from that, due to the position of the Client in the SPV and having rights to involve in the decision making process, IV-2 suggested for the contract to specifically address the situation where the Client interferes with the decision-making process that affects the delivery of the project. IV-2 said, *"If you do interfere then you have to take responsibility. You can't cause interference without responsibility the co-investor, the authority is not expected to interfere in project delivery decisions, it is about the model if they do then there would be pressure on them to take some of the responsibility"* (253). Client interference in the decision-making process of a project has always been one of the reasons mentioned in the literature as contributing to project delay (Turner & Simister, 2001; Shen, Platten, & Deng, 2006; Sambasivan & Soon, 2007). Such interference might be relevant as the purpose of the PF2 project is to give quality services to the public users, and at the same time control the government's expenditure. Thus, the Client is the person to define the needs and requirements of the project so that the PF2 project meets its purpose. However, the issue raised by IV-2 is also relevant because significant interference during project execution might slow down the progress of project delivery in which consequently putting other parties at risks in terms of time and money. Therefore, it might be worth to consider IV-2's suggestion to include provisions in the contract on the extent of Client's interference that is considered as reasonable and the remedy if the Client goes beyond such limit. This is another area that needs to be negotiated between the Client and the SPV before the contract is concluded.

6.3.4 Synthesis of the validations in the Research Stage Two

The semi-structured interviews conducted has validated and refined the findings of Research Stage One. Based on the findings of the semi-structured interviews presented hereinbefore, eighteen key contractual risks associated with PF2 projects implementing BIM categorised under the five main headings as identified from the literature (see sub-section 6.3.3) have been finalised. These contractual risks appeared to be inter-related with some of the CSFs identified in sub-section 6.2.2 of this thesis. Table 6.9 presents the matrix of the effect of contractual risks towards achieving the critical success factors. The table illustrates how the contractual risk give implications to PF2 projects implementing BIM if the risks are not avoided or mitigated.

Based on Table 6.9, it shows the importance of having robust and clear contractual provisions in order to mitigate the contractual risks. The table also indicates that if the contractual risks are not being addressed, it can give adverse effect to the effective collaboration and systematic workflows, coordination and integration in the PF2 projects. As Information Manager is a new role emerging from BIM implementation; having clear duties, liabilities and procedures related to Information Manager and information management appeared to be another vital factor that needs to be in place to ensure the smooth running and management of the PF2 projects implementing BIM. Other than that, poor management of contractual risks would also make the parties become unsure on how to establish good communication, to have standardised work procedures, to manage the knowledge and intellectual capital and to have a basis for good information sharing. The matrix shows the seriousness of the effect of the contractual risks towards the success of the PF2 projects.

Having known the needs to address the contractual risks, the next step is to see whether the strategies to manage contractual risks identified through the semi-structured interviews comprehend aspects of the critical success factors. Table 6.10 presents the matrix of the strategies to manage contractual risks against the CSFs of PF2 project implementing BIM.

Contractual risk category	Contractual risk	Critical Success Factors													
		Good communication	Effective collaboration	BIM Manager / Information Manager	Detailed project planning and evaluation	Systematic workflows, coordination and integration	Standardised work procedures for BIM	Management of knowledge and intellectual capital	Good financial resources	Favourable legal framework	Robust and clear contractual provision	Information sharing protocol	Technical competence	BIM training programme and education	Good understanding on BIM
Information Management	Unclear role and responsibilities of IM			●							●				
	Unclear duties and powers of IM			●							●				
	Unclear appointment procedures for IM			●		●	●				●				
	Unclear procedures for information sharing	●	●			●	●				●	●			
Data reliance	Reliability and integrity		●								●				
	Information overload		●			●	●				●				
	Data security		●			●					●				
	Unclear procedures for data changes	●	●			●	●				●	●			
Status of BIM model	Unclear status of BIM model in the contract		●			●					●				
	Unclear content of BIM model	●									●				
	Documents prevalence issue	●	●			●					●				
Intellectual property rights	Revocability of copyright licence		●			●		●			●				
	Unclear ownership of BIM model/data							●			●				
	No allowance for future changes										●				
Liability	Unclear liabilities of IM			●							●				
	Ambiguous exemption clause		●								●				
	Unclear rights of client to be involved in decision making		●								●				
	Insurance										●				
	Doctrine of privity of contract										●				
Total risks		**4**	**10**	**4**	**0**	**8**	**4**	**2**	**0**	**0**	**20**	**2**	**0**	**0**	**0**

Table 6.9: Matrix on the effect of contractual risks towards achieving the critical success factors

Contractual risk category	Strategies to manage the contractual risks	Critical Success Factors													
		Good communication	Effective collaboration	BIM Manager / Information Manager	Detailed project planning & evaluation	Systematic workflows, coordination and integration	Standardised work procedures for BIM	Management of knowledge and intellectual capital	Good financial resources	Favourable legal framework	Robust and clear contractual provision	Information sharing protocol	Technical competence	BIM training programme and education	Good understanding on BIM
Information Management	Specify the roles and responsibilities of IM			●							●				
	Specify the duties and powers of IM		●	●							●				
	Procedures of IM appointment			●			●				●				
	Procedures on information sharing	●	●			●	●				●	●			
Data reliance	Warranty on data integrity and reliability		●								●				
	Systematic data checking procedures					●	●				●				
	Provision on information overload		●			●	●				●				
	Confidentiality agreement										●	●			
	Change Protocol	●	●			●	●				●	●			
Status of BIM model	Express clause on the status										●				
	Specify the content of BIM model	●									●				
	Specify document prevalence	●									●				
	Mechanism for documents discrepancy										●				
Intellectual property rights	Non- revocable copyright licence							●							
	Specify the ownership of the BIM data										●				
	Allow for future changes & modification					●					●				
Liability	Specify the obligations of the IM			●							●				
	Specify the width of exemption clause		●								●				
	Indemnity insurance for IM										●				
	Integrated project insurance		●								●				
	Specify the extent of Client's intervention	●	●								●				
	Multi-party contract		●								●				
Total strategies		**5**	**9**	**4**	**0**	**5**	**5**	**1**	**0**	**0**	**21**	**3**	**0**	**0**	**0**

Table 6.10: Matrix on the strategies to manage the contractual risks to achieve the critical success factors

Contractual risk category	Strategies to manage the contractual risks	BIM Risk Factors																	
		Lack of skilled personnel	Resistance to change	Little knowledge & experience	Lack of collaborative work process	Integrity of BIM model	Defective integration between softwares	Inadequate top management commitment	Ownership of BIM model	High initial cost to implement	Lack of BIM standards and guidelines	Liability issues	Data security	Existing legal system not equipped to support BIM	Lack of guidelines for contractual agreements	Model management difficulties	Time consuming to become proficient	Status of BIM model	Unclear position, duty, responsibility and liability of the IM
Information Management	Specify the roles and responsibilities of IM			●											●				●
	Specify the duties and powers of IM			●	●										●				●
	Procedures of IM appointment										●				●				●
	Procedures on information sharing										●				●				
Data reliance	Warranty on data integrity and reliability		●		●	●						●			●	●			
	Systematic data checking procedures					●	●					●	●			●			
	Provision on information overload				●	●					●				●	●			
	Confidentiality agreement												●		●				
	Change Protocol				●	●					●				●	●			
Status of BIM model	Express clause on the status														●			●	
	Specify the content of BIM model			●		●									●	●		●	
	Specify document prevalence														●			●	
	Mechanism for documents discrepancy										●				●			●	
Intellectual property rights	Non- revocable copyright licence				●										●	●			
	Specify the ownership of the BIM data								●						●				
	Allow for future changes & modification				●										●	●			
Liability	Specify the obligations of the IM			●											●				●
	Specify the width of exemption clause				●							●			●				
	Indemnity insurance for IM											●			●				
	Integrated project insurance				●							●			●				
	Specify the extent of Client's intervention			●	●			●			●	●			●				
	Multi-party contract				●							●			●				
Total risk		**0**	**1**	**5**	**10**	**5**	**1**	**1**	**1**	**0**	**6**	**7**	**2**	**0**	**21**	**7**	**0**	**4**	**4**

Table 6.11: Matrix on the strategies to manage the contractual risks to mitigate the BIM risks factors

As presented in Table 6.10, the study has identified twenty-two strategies to manage contractual risks for PF2 projects implementing BIM, all of which have been discussed in sub-section 6.3.3. The matrix in Table 6.10 depicts these strategies and their relationship with the critical success factors, as these strategies can be used to achieve the CSFs for PF2 projects implementing BIM. Most of the strategies are to achieve robust and clear contractual provisions which subsequently increase the anticipation to achieve good communication and effective collaboration among the contracting parties, as well as other CSFs as shown in the Table 6.10. From fourteen CSFs identified in this study, the strategies identified are expected to achieve eight critical success factors. Thus, this table indicates the potentials of these strategies to increase the chances of having successful and systematic PF2 projects through the use of BIM.

Besides that, the strategies to manage contractual risks as identified by this study also have the potential to mitigate the BIM risk factors. Table 6.11 presents the matrix on how the strategies can help mitigate the BIM risks factors. By adopting these strategies, it is anticipated that most of the BIM risks factors associated with lack of guidelines for contractual agreements and collaborative work process can be reduced. This is based on the large numbers of strategies that are related to these two risk factors as shown in Table 6.11. This is also due to the gist of the strategies which is to provide clear and robust contractual provisions. Other than that, clear procedures and protocols as recommended by these strategies also have the potential to reduce other BIM risk factors such as little knowledge and experience, integrity of BIM model, lack of BIM standards and guidelines, liability issues, and model management difficulties. Based on the matrix, it shows that most of the BIM risk factors can be addressed by the implementing the strategies as only four BIM risks factors are not related and relevant to the strategies. Even though these strategies are only a recommendation by the present study, without any case studies to proof their robustness, Table 6.10 and 6.11 indicate the potential of these strategies to improve the chances of having successful PF2 projects implementing BIM. Notwithstanding the potentials that the strategies have, it is recommended for the strategies to be empirically tested in future real life PF2 projects implementing BIM in future research.

6.4 Summary

This chapter empirically analysed and discussed the findings of the survey research from Research Stage One and Research Stage Two. The data were analysed using descriptive and inferential statistics, content analysis and thematic analysis. During Research Stage One, literature review, questionnaire survey and informal interviews with the experts were carried out to gather views from the construction industry. Consequently, the critical success factors, significant BIM risks factors, contractual risks and some strategies to manage contractual risks for PF2 projects implementing BIM were obtained. The results obtained were then used to develop the preliminary conceptual framework. This preliminary conceptual framework was then set as the basis to conduct the Research Stage Two, which is semi-structured interview with the experts. In Research Stage Two, the CSFs for PF2 projects implementing BIM and BIM risks factors were validated. Besides, the study has also identified the contractual risks and the strategies to manage the risks.

Overall, the relationship between the critical success factors, BIM risks factors, contractual risks and the strategies to manage the contractual risks BIM risks factors has been established. Most of the BIM risks factors impacting the PF2 projects could be mitigated by addressing the contractual risks. Most of the strategies to manage the contractual risks identified in this study comprehend the CSFs therefore adopting the strategies can potentially direct to the successful of PF2 projects implementing BIM. The succeeding chapter provides answers to the research questions and presents the finalised version of the conceptual framework of the critical success factors and contractual risk for the strategic management of PF2 projects implementing BIM.

CHAPTER 7

RESEARCH FINDINGS

7.1 Introduction

The objective of this chapter is to present the overall findings obtained from Research Stage 1 and Research Stage 2 which have been discussed in Chapter 6. The key findings include the critical success factors, BIM risks factors that have significant impact on PF2 projects, the contractual risks and the strategies to manage contractual risks for PF2 projects implementing BIM. The rationale of presenting the findings in a separate chapter is to show and explain clearly the relationship of the findings in answering the research questions of this study. Finally, the finalised conceptual framework of the critical success factors and contractual risk for the strategic management of PF2 projects implementing BIM as aimed by the study is presented.

7.2 Re-addressing the Research Questions

This study addresses the general question of "How to manage contractual risks in PF2 projects implementing BIM?". This question subsumes several underlying questions which are:

1. What are the critical success factors for PF2 projects implementing BIM?
2. What are the BIM risk factors that have significant impact on PF2 projects?
3. What are the contractual risks in PF2 projects implementing BIM?
4. What are the strategies to manage contractual risks in the PF2 projects implementing BIM?

7.2.1 Research Question 1: What are the critical success factors of PF2 projects implementing BIM?

The research question on – '*what are the critical success factors of PF2 projects implementing BIM'* - has been answered in Chapter 6 (sub-section 6.2.1, 6.2.2, and 6.3.1). This list was firstly derived from the literature in Chapter 2 (sub-section 2.7.2) and Chapter 3 (sub-section 3.6), by combining the CSFs of PPP/PF2 projects and the CSFs of BIM. After the list underwent questionnaire survey and validation by the experts during the semi-structured interviews, fourteen CSFs for PF2 projects implementing BIM were obtained. These are:

<u>Alliance</u>

1. Good communication
2. Effective collaboration among the project participants

<u>Management</u>

3. BIM Manager/Information Manager
4. Detailed project planning and evaluation
5. Systematic workflows, coordination and integration
6. Standardised work procedures for BIM
7. Management of knowledge and intellectual capital
8. Good financial resources

<u>Legal</u>

9. Favourable legal framework
10. Robust and clear contractual provisions
11. Information sharing protocol

<u>Competency</u>

12. Technical competence
13. BIM training programme and education
14. Good understanding on BIM

Each of these factors and its relevancy to PF2 projects implementing BIM has been discussed in sub-section 6.2.2. From the fourteen CSFs listed above, the experts highlighted the five most dominant critical success factors, which are: (1) *"systematic workflows, coordination and integration"*; (2) *"good understanding on BIM"*; (3) *"technical competence"*; (4) *"robust and clear contractual provisions"*; and (5) *"effective collaboration among the project participants"*.

These findings were concluded using descriptive analysis (mean ranking), inferential analysis (Kruskal-Wallis and Mann Whitney-U tests), and thematic analysis. The findings of this study revealed that most of the CSFs chosen by the respondents are from the management category. This describes that effective management of the people, information and resources are vital to the success of PF2 projects implementing BIM. From the analysis of the ranking based on the three groups of respondents who are: only involved in PFI/PF2 projects; involved in PFI/PF2 projects and BIM; and only involved in BIM projects, the results are different. The lack of homogeneity in perceptions among the groups suggests that the CSFs are perceived differently based on the experiences the respondents have and the perspectives they were looking from. For example, *"effective collaboration among the project participants"* was ranked within top five for respondents who have experience involving in BIM, while such factor being rated ninth place by respondents who have no experience in BIM. Hence, it shows lack of understanding on the nature of working with BIM among the construction industry players who have no experience with BIM. In future, the government may want to consider gearing up BIM training programme and education before encouraging private sector involvement in PPP or PF2 projects.

7.2.2 Research Question 2: What are the BIM risk factors that have significant impact on PF2 projects?

The research question on – '*what are the BIM risk factors that have significant impact on PF2 projects'* - has been answered in Chapter 6 (sub-section 6.2.3, 6.2.4 and 6.3.1). Based on the literature, twenty-four BIM risk factors were identified. After the list was presented to the respondents of the questionnaire survey and validated by the experts, eighteen BIM risk factors that have significant impact on PF2 projects are identified as follows:

1. Lack of available skilled personnel
2. Resistance to change
3. Little knowledge and experience
4. Lack of collaborative work processes
5. Integrity of BIM model
6. Defective integration between software tools
7. Inadequate top management commitment
8. Ownership of BIM model
9. High initial cost to implement
10. Lack of BIM standards and guidelines
11. Liability issues
12. Data security
13. Existing legal system not equipped to support BIM
14. Lack of guidelines for contractual agreements
15. Model management difficulties
16. Time consuming to become proficient
17. Status of BIM model
18. Unclear position, duty, responsibility and liability of the Information Manager

From the above list, validation by the experts revealed six BIM risks factor that have the most significant impact on PF2 projects. These are (1) *"lack of available skilled personnel"*; (2) *"resistance to change"*; (3) *"little knowledge and experience"*; (4) *"model management difficulties"*; (5) *"lack of guidelines for contractual agreements"*; and (6) *"liability issues"*. All of these risk factors have been discussed in sub-section 6.2.4 and sub-section 6.3.4. The findings were derived from the analysis using descriptive analysis (mean ranking) and inferential analysis (Kruskal-Wallis and Mann Whitney-U tests). The findings revealed that the significant BIM risks factors are more weighted to risks related to contractual and competency issues. Thus, it verified the need of having contractual risks management framework as one of the ways to mitigate risks in PF2 projects implementing BIM

7.2.3 Research Question 3: What are the contractual risks in the PF2 projects implementing BIM?

The research question on – '*what are the contractual risks in the PF2 projects implementing BIM?'* - has been answered in the discussion in Chapter 6 (sub-section 6.2.5, 6.2.6, 6.3.3 and 6.3.4). Based on the literature, informal interviews and semi-structured interviews with the experts, there are twenty contractual risks identified by the present study which have been categorised under five main headings as follows:

Category	Contractual risks
Information Management	Unclear role and responsibilities of Information Manager Unclear duties and powers of Information Manager Unclear appointment procedures for Information Manager Unclear procedures for information sharing
Data reliance	Reliability and integrity of the electronic data Information overload Data security Unclear procedures for data changes
Status of BIM model	Unclear status of BIM model: contractual document or deliverable Unclear content of BIM model Document prevalence issue
Intellectual property rights	Revocability of copyright licence Ownership of BIM model/data IP for the Information Manager's work No allowance for future changes in BIM model
Liability	Unclear liabilities of the Information Manager Ambiguous exemption clause on the liabilities of the data providers The extent of the rights of the Client to intervene Insurance Doctrine of privity of contract

Table 7.1: Contractual risks in PF2 projects implementing BIM

Looking at the list in Table 7.1 and the discussion in Chapter 6, most of the contractual risks in PF2 projects implementing BIM were found to be similar to the contractual risks faced by other construction projects implementing BIM as found in the literature (see Chapter 4). However, in the context of PF2, such contractual risks become more complicated due to the myriad of parties involved in the PF2 contractual structures, the lengthy contract duration for BIM usage to be sustained and the extension of the risks to the operational stage of the PF2 projects. These are how the contractual risks for PF2 projects implementing BIM additionally differ from other construction projects. In addition, the nature of the PPP-type of projects is normally incomplete as discussed in Chapter 4 (sub-section 4.3), making the situation more challenging for PF2 projects implementing BIM. Even though in certain areas, the incompleteness of PF2 contract can be reduced by the implementation of BIM as discussed in sub-section 4.3, they are not being solved thoroughly. The emergence of BIM in PF2 projects potentially brings benefits but at the same time brings more contractual risks to be handled and making the projects more complex if such risks are not being handled properly. These are the additional risks to be put under consideration when implementing BIM in PF2 or any other PPP-type projects.

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7.2.4 Research Question 4: What are the strategies to manage the contractual risks in PF2 projects implementing BIM?

The research question on – '*what are the strategies to manage contractual risks in PF2 projects implementing BIM?'* - has been answered in Chapter 6 (sub-section 6.3.3) of this thesis. Based on the semi-structured interviews and the analysis of the data using thematic analysis, twenty-two strategies to manage the contractual risks emerged from the data obtained as presented in Table 7.3. The following provides the summary of the strategies gathered from the data.

Category	Contractual risks	Strategies to manage the contractual risks
Information Management	Unclear role and responsibilities of Information Manager Unclear duties and powers of Information Manager Unclear appointment procedures for Information Manager Unclear procedures for information sharing	Specify the roles and responsibilities of IM in the contract Specify the duties and powers of IM in the contract Describe the procedures of IM appointment in the contract Describe the procedures on information sharing in the contract
Data reliance	Reliability and integrity of the electronic data Information overload Data security Unclear procedures for data changes	Warranty on data integrity and reliability Systematic data checking procedures Provide provision in the contract on information overload Confidentiality agreement Include Change Protocol in the contract
Status of BIM model	Unclear status of BIM model: contractual document or deliverable Unclear content of BIM model Document prevalence issue	Provide express clause on the status of BIM model Specify the content of BIM model Specify document prevalence in the contract Provide mechanism for documents discrepancy
Intellectual property rights	Revocability of copyright licence Ownership of BIM model/data IP for the Information Manager's work No allowance for future changes in BIM model	Non- revocablity of copyright licence specified in the contract Specify the ownership of the BIM data in the contract IM does not need IP for his work Allow for future changes & modification
Liability	Unclear liabilities of the Information Manager Ambiguous exemption clause on the liabilities of the data providers The extent of the rights of the Client to intervene Insurance Doctrine of privity of contract	Specify the obligations of the IM in the contract Specify the width of exemption clause Specify the extent of Client's intervention Indemnity insurance for IM Integrated project insurance Use multi-party contract

Table 7.3: Strategies to manage the contractual risks

(a) Information management

As discussed in Chapter 6 (sub-section 6.3.3.1), most of the contractual risks on information management are related to a new role emerging due to the implementation of BIM, which is the Information Manager. In order to mitigate these risks, it is recommended for the project agreement to specify in detail the roles, responsibilities, duties and powers of the Information Manager. The CIC Scope of Services of Information Management document is an example of such details that can be included in the contract. Apart from that, procedures of the appointment of the Information Manager need to be specified in the contract. There are three suggestions for the procedures of the appointment of the Information Manager, obtained from the data collected from the semi-structured interviews, which are:

Suggestion 1

1. The BIM Advisor becomes the Information Manager.
2. The BIM Advisor is firstly appointed by the Client, then upon the financial close the BIM Advisor is novated to the SPV as the Information Manager.
3. Within the SPV, the Information Manager is put under the Designer during the design stage and transferred to the Builder during the building stage by means of novation or sub-contracting.
4. During the operational stage, the Information Manager is sub-contracted or novated under the Facilities Manager.

Suggestion 2

1. Clients to appoint independent consultants to become the BIM Advisors cum Information Managers that will manage the information of the projects from the beginning until the operational stage, throughout the whole contract duration.
2. SPV could also recommend to the Client, any other party to become the Information Manager.
3. It is better if the SPV appoints the party from the existing project team member, most probably the Facilities Management provider.

The recommendation for BIM Advisor (if any) to become the Information Manager is because the knowledge that the BIM Advisor has while helping the Client to develop the EIR can facilitate him to manage the information as required by the Client.

<u>Suggestion 3</u>

1. The role of the Information Manager to be shouldered by the Project Manager.
2. The Project Manager can employ somebody else as the Information Manager to take over his duties by means of sub-contracting or delegation of duties and powers to the existing project members.

With respect to the information integration issue which includes the unclear procedures of information sharing, the strategy recommended is to describe the procedures of information sharing in the contract. The procedures suggested include:

1. The emphasis that all parties need to be committed to share information.
2. Meeting to discuss and give inputs.
3. SPV to have the custody of the project data and have the full control for the whole contract duration. The Client can only access the data.
4. Flow of information starts from passing the data to the SPV/Project Manager, then from the SPV/Project Manager to the Information Manager.
5. Integration of the Information Requirements during construction and post-construction.
6. Transfer BIM model to AIM for Facilities Management provider to continue managing the data.
7. Proper data delivery timetables for design, construction and post-completion stage.
8. Facilities Management or Operation and Maintenance providers need to specify what and when information is needed from the design and construction team and vice versa.
9. Requirement for parties to fill in a data template when providing information.
10. Data template to be stored systematically and modelled with other attributes provided by other parties.
11. All parties need to enter confidentiality agreement.

(b) Data reliance

The strategies to manage contractual risks on data reliance have been discussed in Chapter 6 (sub-section 6.3.3.2). Firstly, with regards to the issue of reliability and integrity of the BIM data, the strategy recommended by the study is for the data providers, including Information Manager, to provide the warranty on data reliability and integrity. This warranty needs to be spelled out in the contract. This is to be in line with the fundamental BIM concept in PAS 1192 where the parties need to share the information and to trust the information they receive from the BIM data/model. This is also to preserve a collaborative working environment amongst all the contracting parties in PF2 projects and to avoid reluctance in using the data they obtained from BIM. Furthermore, in order to ensure reliability and integrity, the study recommends systematic data checking procedures to be carried out before any information is disseminated to other parties within the projects, and spelling out the requirement to have these procedures in the contract. Based on the data obtained, the procedures recommended are listed as follows:

1. The data checking procedures need to be carried out by the Information Manager.
2. Periodic continuous checking throughout the contract duration.
3. Use relevant software to check for errors.
4. Undergo the checking procedures before handing over the project to the Client at the end of the contract period.

Secondly, as for the issue of information overload due to data provided more than the defined LOD, the strategy recommended by the study is to address this issue by emphasising the requirement of the parties to adhere to the LOD defined in the contract. Consequences of breaching this requirement need to be stated in the contract. Therefore, the parties are more aware on the repercussion if they provide more information or data than what is required. This is one mechanism to facilitate collaborative working in PF2 projects implementing BIM as all parties need to work at the same level of detail to make BIM works for the projects.

Thirdly, with respect to data security issues, the findings suggest implementing a confidentiality agreement to be attached to the main project agreement. Even the procedures for data security have been established in PAS 1192-5, the provisions in the confidentiality agreement is to support PAS 1192-5 by specifying who will be the Data Security Manager, to establish responsibility for managing data security incidents and to emphasise the obligations of all parties to maintain data integrity and security during design, construction and operation. Moreover, information that is considered confidential needs to be listed out in the contract, so that access to such information can be limited only to the relevant parties within the project.

The final point on the issue of unclear procedures of data changes is recommended to be addressed by including Change Protocol in the contract. The Change Protocol is different from Information Sharing Protocol as discussed hereinbefore (another strategy to address information management issues). The Change Protocol is to communicate any change that happens to the BIM data/model to all the contracting parties. This is to ensure all parties are referring to the correct version of BIM model/data while working on their parts. It is suggested by the experts for the Change Protocol needs to be included in the project agreement of PF2 and to be passed down by the SPV to the sub-contractors which are the Designer, Builder, and Facilities Management provider. The procedure in the Change Protocol need to be supported by proper project management by highlighting the role of Project Manager to lead any changes to be done on the project. The procedure for Change Protocol suggested by the experts is as follows:

1. Proposal for changes using variation template form.
2. Estimate the time and cost affected.
3. Approval for such changed to be carried out.
4. Instruction from the Project Manager.
5. Necessary amendment to EIR.
6. Notification from the Information Manager to all parties.
7. Data stored for future reference.
8. Link the changes with CAFM system.
9. Update the data every year to reflect any changes.

This procedure can be used when the change order coming from the Client or the change is recommended by the project team member or the SPV to the Client.

(c) Status of BIM model

The strategies to manage contractual risks related to the status of BIM model have been discussed in Chapter 6 (sub-section 6.3.3.3). Firstly, it is suggested for the express clause to be provided in the contract to confirm the status of BIM model whether it is considered as a contractual document or deliverable. However, the status of BIM model needs to be firstly agreed on by the contracting parties. If the BIM model is agreed to be one of the contractual documents, the extent to which the model could stand as the contractual document needs to be specified in the contract. This includes when the BIM model can be considered as the contractual document, and which areas in the model to be considered as contractual document. As there is a lot of information included in the BIM model, it is suggested for the content of BIM model to be specified in the contract. If the parties decided to only consider certain parts of the BIM model to become the contractual document, then these parts need to also be specified in the contract. Furthermore, with regards to the problem of document prevalence, it is also suggested for the contract to specify which document takes precedence over the other in the event of any discrepancy or consistency. This is to facilitate any conflict or dispute that may happen in the future. Notwithstanding the provision on document prevalence, mechanism for the event of document discrepancy or inconsistency needs to be established in the contract. For example, all parties need to be notified on such incident and it is up to the parties to collaboratively decide on how to solve the problem.

(d) Intellectual property rights

The strategies to manage the contractual risks on intellectual property rights were discussed in Chapter 6 (sub-section 6.3.3.4). Based on the data obtained, revocable copyright license was found to be unsuitable for PF2 projects. Therefore, the study recommends the non-revocability of copyright licence to be specified in the contract and made known to the parties. So that, all parties are aware of this before they enter into a contract, and must be willing to give away their licence for royalty-free, perpetual, irrevocable, sub-licensable and transferable as stated in the Standardisation of PF2 Contract document. As for the ownership of the BIM model/data, such ownership is suggested to be specified in the contract. The experts suggested for the ownership of the BIM model/data to be given to the SPV during the course of the contract as the SPV is the one who is going to build and operate the facility until the end of the contract duration. After the contract period ended, the SPV is to give away such ownership to the Client without any cost as the SPV has gained its profit from the unitary charges paid by the Client throughout the contract duration. Even though in the Standardisation of PF2 Contract document, three options of ownership are given, the suggestion given by the experts is considered the most appropriate to avoid risks and conflict in the future.

Moreover, it has been agreed by all of the experts in the semi-structured interviews that the Information Manager does not need to have IP for his work. This is also the stand of the study due to the fact that at the end of the PF2 contract duration, all of the IPs will be owned by the Client. Besides, the Information Manager is not producing any new work, as he simply coordinates the information received from others. Finally, another strategy suggested from the findings is to allow future changes and modification to the BIM model in the PF2 project as it is inevitable for the SPV and the Client to face changes in the project as the time passes. Therefore, the term 'permitted purpose' as stated in the CIC BIM Protocol needs to be amended to suit the PF2 context.

(e) Liability

The strategies to manage the contractual risks that are related to liability issues have been discussed in Chapter 6 (sub-section 6.3.3.5). In summary, the study suggests for the unclear liabilities of the Information Manager to be addressed by specifying in detail the obligations of the Information Manager in the contract. This is because liabilities come with obligations, and by specifying the obligations, it does not only make the liabilities shouldered by the Information Manager to be known crystal clear, but it can also draw the demarcation line between the Information Manager and other roles in the project such as Architect and Data Security Manager. Due to the liabilities borne by the Information Manager, it is also suggested for the Information Manager to provide indemnity insurance to prepare for any event in the future that happens due to his negligence in managing the data. Secondly, with regard to the problem of ambiguous exemption clause as what the CIC BIM Protocol is having now that blurs the liabilities of the data providers; the study suggests if the PF2 projects implementing BIM would like to have the same kind of provision in the contract, the width of the exemption clause needs to be clearly specified in the contract. The width of the exemption clause is important in order to avoid misrepresentation and false impression on the liabilities of the data providers that may cause the contract to be rescinded. If this happens, it will give major effect to the progress and collaborative working in the PF2 projects implementing BIM. Furthermore, it is also suggested by the study for the extent of the Client's rights to intervene in the decision making process to be specified in the contract together with the solution if the Client acts beyond the limits given under the contract. This is to avoid delay to the project and services delivery; however, such limits need to be negotiated between the SPV and the Client before the contract is concluded.

With regards to the issue of doctrine of the privity of contract, the study suggests two mechanisms to address this issue. Firstly, it is suggested for the parties to use integrated project insurance. With this type of insurance, all parties are insured against each other's' liabilities and it waives the subrogation rights against all insured parties. Therefore, there is no fear in terms of liability issues that always become blurry as the impact of using BIM, and the parties can continue working collaboratively for the success of PF2 projects. Secondly, it is suggested for the parties to be bonded in a multi-party contract. With the multi-party contract, all parties are contractually interlinked by a single contract, therefore making it easier for the provisions of contract to be standardised and applied to all evenly. Therefore, communication among the parties can be improved and seamless contractual arrangement can become a reality. However, both recommendations need to be further explored and tested to ensure their suitability to be applied to PF2 projects implementing BIM. These are the areas that are found crucial for further research to consider.

7.3 Finalising the Conceptual Framework for the Critical Success Factors and Contractual Risk for the Strategic Management of PF2 Projects Implementing BIM

Based on the findings presented above, the conceptual framework of contractual risks management for PF2 projects implementing BIM was finalised. The development of the conceptual framework started with the preliminary conceptual framework developed from the literature review, questionnaire survey and informal interviews with the experts during the Research Stage One. The preliminary framework was the basis to conduct the semi-structured interviews in Research Stage Two, which leads to finalising the conceptual framework. Figure 7.1 presents the finalised version of the conceptual framework of the critical success factors and contractual risk for the strategic management of PF2 projects implementing BIM.

The aim of the conceptual framework is to provide practical strategies that can be employed by the public and private sectors who are involved in PF2 projects to manage the contractual risks that arise due to the implementation of BIM. Such strategies are hoped to help the industry to achieve successful PF2 projects through having seamless and collaborative contractual instrument. The conceptual framework was developed with the purpose of providing guidance for the people involved in the drafting of the contract for PF2 projects implementing BIM. It highlights the key contractual risks that need to be highly considered due to the effects that can occur in the future and the key strategies that can be done at the pre-contract level to mitigate such risks. The key strategies highlighted in the conceptual framework also include the areas that need to be focused on by the Project Manager when managing the people, the flow of the information throughout the contract duration and the continuity of collaborative working for lengthy period of time.

The finalised conceptual framework comprises three main components as follows:

- The critical success factors
- The contractual risks
- The possible strategies to manage the contractual risks

The framework illustrates the relationships of these components in achieving the CSFsof PF2 projects and subsequently to attain a robust conceptual framework to manage the contractual risks. The conceptual framework is produced from the present study which is exploratory in nature, therefore future studies are recommended to field-test or validate its robustness.

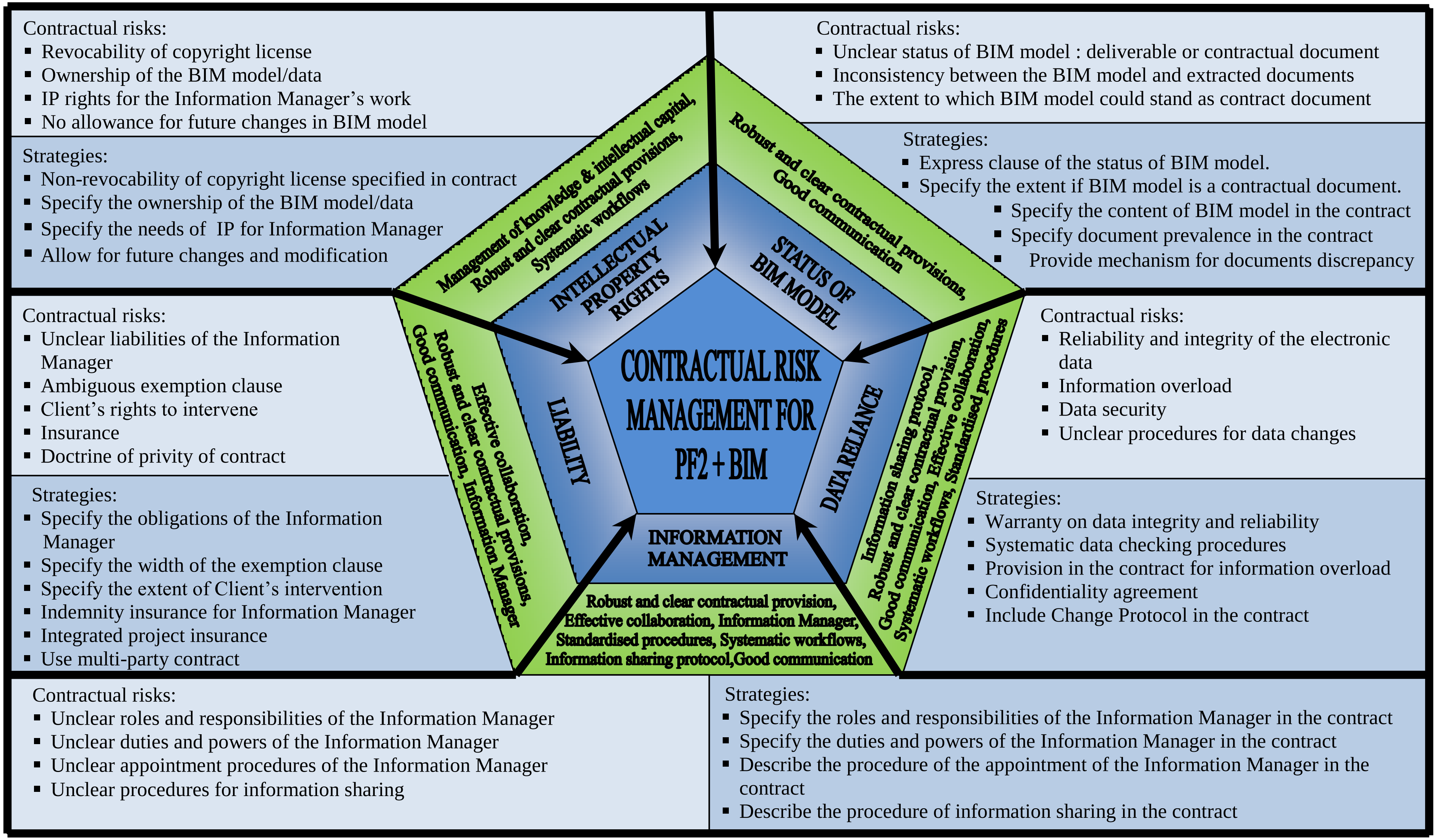

Figure 7.1: Finalised conceptual framework for the critical success factors and contractual risk for the strategic management of PF2 projects implementing BIM

7.4 Summary

This chapter provides answers to the research questions that determine the direction of this research journey. This chapter also provides the overall findings of the research obtained from Research Stage One and Research Stage Two. Based on the findings, the conceptual framework of the critical success factors and contractual risk for the strategic management of PF2 projects implementing BIM was finalised. Consequently, the aim of the study was addressed.

The findings of the study reveal fourteen CSFs for PF2 projects implementing BIM; eighteen significant BIM risks factors for PF2 projects; twenty contractual risks; and twenty-two strategies to manage the contractual risks. The research findings suggest that the strategies to manage the contractual risks can be carried out from the pre-contract stage, during the drafting of the PF2 contracts. It is also suggested by the findings of the study; that the strategies to manage the contractual risks not only depend on the way the contract is drafted but also require commitment and dedication of the parties to willingly share information and work collaboratively continuously for a lengthy period of time. Robust contractual framework for PF2 project implementing BIM also depends on the right decision in determining the procurement framework of PF2 projects.

The following chapter of this thesis draws up the conclusion to the present research by linking the findings to the objectives of the study. Subsequently, the theoretical and practical implications of the study are also presented. Additionally, further research in future which are thought to be necessary are also recommended.

CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusion

The study focuses on developing a conceptual framework of the critical success factors and contractual risk for the strategic management of PF2 projects implementing BIM. This study has been carried out to achieve four objectives of the study, namely:

1. To establish the critical success factors for PF2 projects implementing BIM;

2. To investigate the BIM applications potentials in a project life-cycle and the BIM risk factors that can give significant impact to PF2 projects;

3. To investigate the contractual risks and the management strategies associated with PF2 projects implementing BIM;

4. To conceptualise and validate a conceptual framework that interlinks the critical success factors, contractual risks and the management strategies of PF2 projects implementing BIM.

This research has achieved all of its objectives. In relation to the first objective of the study, an investigation was carried out via in-depth review of the literatures concerning articles, books, government documents and contractual documents of PF2 and BIM. Based on the literature, the list of the possible CSFs was obtained by combining the list of the CSFs of PF2 and CSFs of BIM. Following that, CSFs was addressed by carrying out a questionnaire survey amongst the people in the industry who are involved in PFI/PF2 and BIM projects. The findings suggest fourteen CSFs for PF2 projects implementing BIM related to alliance, management, legal and competency. From these fourteen factors, the study reveals that the success of the PF2 projects implementing BIM rely heavily on factors related to effective management. Another factor which is found as dominant in determining the success of PF2 contract is having robust and clear contractual provisions. Such factor is considered critical as the implementation of BIM exposes the PF2 projects to additional risks which are mostly related to contractual matters, thus robust and clear contractual provisions are vital to mitigate those contractual risks. The findings have been presented and discussed in Chapter 6 (sub-section 6.2.2 and 6.3.1) and Chapter 7 (sub-section 7.2.1).

In relation to the second objective of the study, the investigation was carried out through an in-depth review of the literatures concerning articles, books, and government documents on BIM. The findings indicate the vast benefits and potentials that BIM can offer during pre-construction phase, construction phase, and post-construction phase. This is attributed to the capabilities of BIM in generating visualisation; fabrication drawings; code reviews; forensic analysis of a building or facility; tools to assist facilities management; cost estimating; schedules for construction sequencing; systems to visually check conflict, interference or collision; and system to monitor the construction progress. The study also reveals that apart from BIM being able to mitigate risks in PF2, the implementation of BIM also brings new additional risks to PF2 projects. This is due to the fact that BIM also has its own risks that need to be addressed before it can give optimum benefits to the projects. From the twenty-four risks factors identified from literature, the study highlighted eighteen BIM risks factors that can significantly affect PF2 projects. This is based on the results obtained from the experiences and opinions of people in the construction industry through the questionnaire survey. Most of these risks are related to the competency and contractual issues. This has been presented in Chapter 6 (sub-section 6.2.3) of this thesis.

In relation to the third objective of the study, the study suggests twenty key contractual risks for PF2 projects implementing BIM which is related to the issues on information management, data reliance, status of BIM model, intellectual property rights, and liability. The contractual risks are firstly identified through the literature and have then been refined in informal interviews and validated in semi-structured interviews with the experts. Afterwards, the strategies to manage the contractual risks were also recommended. The findings are presented in Chapter 6 (sub-section 6.2.5) and Chapter 7 (sub-sections 7.2.3 and 7.2.4).

Finally, as for the fourth objective of the study, the development of the conceptual framework began by developing the preliminary conceptual framework based on all of the findings from Research Stage One. This includes the contractual risks, some strategies to manage the contractual risks; and the link of these two with the critical success factors. The process of developing the framework continued further identifying the strategies to manage the contractual risks in Research Stage Two. In this stage, the preliminary framework underwent further refinement and validation based on the semi-structured interviews with the experts involved in PFI, PF2 and BIM. Finally, the conceptual framework is finalised. These have been discussed in Chapter 6 (sub-section 6.3.3, 6.3.4) and Chapter 7 (sub-section 7.2.4 and 7.3). In doing so, the aim of the present study was addressed. The discussion on the conceptual framework for PF2 projects implementing BIM was presented in Chapter 7 (sub-section 7.3). The finalised conceptual framework is provided in Figure 7.1, whereas the details of the key contractual risks and the strategies are provided in Chapter 7 (sub-section 7.2.3 and 7.2.4).

As the concluding remarks, the highlights of the study are as follows:

1. PF2 projects implementing BIM need a seamless contractual instrument that is able to link all stages in the project delivery and make the project contractually well-organised for lengthy period of time
2. PF2 projects implementing BIM need collaborative contractual instrument to ensure the collaborative environment can be sustained throughout the project duration.
3. In the context of Level 2 BIM, the implementation would not significantly change the liabilities and responsibilities of the parties involved in a PF2 project, unless the parties are also attached to the roles of Information Manager and Data Security Manager as identified in this research.
4. Robust contractual framework is one of the important elements to support BIM implementation. However other factors such as BIM competency, effective management, mutual trust and cooperative environment are also important to make PF2 projects implementing BIM successful.

5. The strategies recommended in the conceptual framework may also be relevant for application in other PPP-type of projects. However, the framework needs to be tested in future research on the real live PF2 projects to confirm its robustness.

8.2 Research Contribution

In the journey of developing the conceptual framework of the critical success factors and contractual risk for the strategic management of PF2 projects implementing BIM, this study has made several valuable contributions to the body of knowledge and to practice. The following sub-sections present the contributions made by the study.

8.2.1 Contribution to academic works

Contributions made by the study to academic works include:

a) The study expands the literature in three main areas: (1) the implication of BIM implementation in PPP-type of projects; (2) the CSFs specifically for PF2 projects implementing BIM; (3) the contractual risks and strategies to manage the risks specifically for PF2 projects implementing BIM. By merging and expanding the theories of the aforementioned subject areas, the study provides deeper understanding on the implementation of BIM not only in PF2 but in other PPP projects.

b) No known empirical research has ever examined the effect of BIM risks to PPP-type projects, including PF2. Most studies found focus on PPP and BIM separately. Therefore, the present study is an attempt to fill such gap by looking at the phenomenon of BIM from the contractual perspective, from the lens of PF2 project.

c) There is also no known study that has carried out empirical research on the CSFs specifically for PF2 projects implementing BIM. Thus, this study contributes to the theory by deriving CSFs for PF2 projects implementing BIM and identifying specific CSFs that are relevant to the management of contractual risks.

d) The study also suggests that the contractual risks appear mostly due to the lack of detailing in the contractual provisions; fragmentation of the stages in project delivery, flows of information and contractual structures; and lack of understanding in working within a collaborative environment. These are actually the main factors for the contractual risks in PF2 projects implementing BIM to occur, and these might be relevant to other projects using BIM as well. The key management strategies suggested in this study include solutions to address these risk factors in order to ensure the smooth flow of the information throughout the contract duration and the continuity of collaborative working for lengthy period of time.

e) The study concludes that PF2 projects implementing BIM need seamless and collaborative contractual instruments. Thus, the conceptual framework as proposed in this study can be considered as an aid to achieve such needs.

8.2.2 Contribution to Practice

This research contributes to practice in the following areas:

a) This study developed CSFs for PF2 projects implementing BIM, thus it provides practical insight on how the Clients and PF2 Contractors can improve their way of working in BIM environment in order to optimise the benefits of BIM and improve the project delivery performance.

b) The study also highlighted the contractual risks and strategies to manage contractual risks as guidance on the practical implementation for PF2 projects implementing BIM. Hence, this acts as a reminder to the Clients and PF2 Contractors and therefore, facilitates them in their endeavour to mitigating those risks. Furthermore, understanding on the implementation of BIM through the lens of PPP projects will be enhanced and the current contractual framework for BIM within the construction industry can be improvised.

c) Hence, this research can serve as guidance to facilitate the Clients (public organisation) and PF2 Contractors (private organisations or SPV) in setting up their BIM contractual provisions for PF2 or PFI projects. The findings can also be the basis for setting up seamless and collaborative contractual instrument not only for PF2 projects implementing BIM, but for other PPP-type procurement system.

8.3 Limitations of the study

This study is constrained by limitations in terms of time, financial, human resources and research methodology. Even though the aim and the objectives of the study have been adequately achieved, it is necessary to highlight the limitations surrounding the present study, thus the findings presented in this thesis should be evaluated under the light of these constraints:

1) This research is only limited to investigating the implementation of BIM in PF2 projects from the contractual perspective.

2) At the time of conducting this research, BIM and PF2 are considered very new to the industry. Thus, the research is conducted without including live PF2 projects implementing BIM as there were no known completed PF2 projects that used BIM.

3) There were inherent shortcomings arising from the research methodology used especially in the method of sampling of Research Stage 1 and the interviewees in Research Stage 2. The convenient sampling used might not be the representative of the population of construction industry players. There were also a very limited number of experts as the interviewees. This happened because of the absence of database on PFI/PF2 projects involved with BIM and low voluntary participations from the construction industry. The results of this research might

be different if other method of sampling is used and more experts participated in the interviews.

8.4 Recommendations for further research

The findings indicate that there should be more research conducted on the topic of BIM implementation in PPP-type of projects. Apart from contributing to the body of knowledge, the rationale of having more research in this area is to provide references and guides to improve the understanding and practical implementation of BIM in the construction industry. Some recommendations for the area of further research which the researcher feels appropriate to be conducted are as follows:

1. Further research should be conducted to test the conceptual framework on real live PF2 projects implementing BIM.
2. Further research should be conducted to confirm the findings of this research with larger sample size comprising academics and practitioners involved in the subjects of PF2 and BIM.
3. Further research should be conducted to investigate the suitability of integrated project insurance to be used within PF2 projects implementing BIM.
4. Further research should be conducted to investigate the suitability of using multi-party contract for PF2 projects implementing BIM.
5. Further research should be conducted on contractual risks management for PPP-type projects implementing BIM in other countries in comparison with what have been done in the UK.

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APPENDIX A QUESTIONNAIRE

Siti Nora Haryati Abdullah Habib
University of Salford
Maxwell Building
Salford, M5 4WT
UK

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

<u>QUESTIONNAIRE SURVEY</u>

My name is Siti Nora Habib. I am currently undertaking a research on **Contractual Risk Management for Private Finance 2 (PF2) Projects Implementing Building Information Modelling (BIM)**. This study is a requirement for the completion of my PhD. This study aims to develop a conceptual contractual risks management framework for PF2 projects implementing BIM.

I have produced the attached questionnaire and I would like to invite you to participate in this survey, to share your views and opinion based on your knowledge and experiences in BIM, PPP, PFI or PF2 projects. This survey is part of the ongoing research work with the objectives:

1. To anticipate the critical success factors if BIM is implemented in PF2 projects.
2. To examine the significance of impact of BIM risk factors on PF2 projects.

The questionnaire survey should take about 10 to 15 minutes to complete. Kindly be informed that only the principle investigator, Siti Nora Habib, will have access to the data. No other individuals will be involved in the data analysis or in writing the final report. Participation in this study is voluntary. Any information that you provide would be treated as strictly confidential will not be used other than this research.

If you have any enquiries on the survey, please do not hesitate to contact either Siti Nora Habib (Tel: 07459279357, and email: ctnora_uia@yahoo.com) or Dr. Yusuf Arayici (email: y.arayici@salford.ac.uk). Your response to this questionnaire would be crucial to the research. Kindly complete and return the questionnaire before 18th December 2015.

Thank you for your time and consideration.

Yours sincerely,

SITI NORA HABIB

CONSENT FORM

CONTRACTUAL RISKS MANAGEMENT FOR PRIVATE FINANCE 2(PF2) PROJECTS IMPLEMENTING BUILDING INFORMATION MODELLING (BIM)

1. I have read and understood the attached invitation letter giving details of the project.
2. My decision to consent is entirely voluntary and I understand that I am free to withdraw at any time without giving reason.
3. I understand that data gathered in this project may form the basis of a report or other form of publication or presentation.
4. I understand that my name will be kept in anonymity and will not be used in any report, publication or presentation, and that every effort will be made to protect my confidentiality.
5. I understand that my personal details will be kept in confidential and the data that I will provide for the study will be kept in locked drawer and password protected in computer and it will not be used other than this research.

Participant's Signature: Date:

Participant's Name:

Researcher's Signature: Date:

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QUESTIONNAIRE FORM

SECTION A: RESPONDENT'S BACKGROUND INFORMATION

1. Name of organization *(optional)* : ______________________________

2. Address *(optional)* : ______________________________

   ____

3. Number of years you have work with your organisation:

   ☐ 1 – 3 years ☐ 4 - 6 years ☐ 7 - 9 years ☐ > 10 years

4. Your position in the organisation:

   ☐ Project Manager ☐ BIM Manager ☐ Director ☐ Academician

   ☐ Architect ☐ Engineer ☐ Quantity Surveyor ☐ Construction lawyer/ Legal advisor

   Others (*specify*) : ____________________

5. Your experience in the construction industry:

   ☐ 1 – 3 years ☐ 4 - 6 years ☐ 7 - 9 years ☐ > 10 years

6. Which of the following you have been involved with:

   ☐ PF2 projects implementing BIM. ____________ years.

   ☐ PF2 projects without BIM. _________ years.

   ☐ PFI projects implementing BIM. __________ years.

   ☐ PFI projects without BIM. _________ years.

   ☐ Other construction projects implementing BIM. ___________ years.

   ☐ Other construction projects without BIM ________ years.

SECTION B: CRITICAL SUCCESS FACTORS FOR THE IMPLEMENTATION OF BIM IN PF2 PROJECTS

1. Success factors are defined as the set of circumstances/factors which influence the attainment of the success criteria (e.g. time, quality, cost targets) of research projects. From the literature review, success factors of PPP project and success factors of BIM project are identified and presented in **Table A**. Based on your experience, please tick (✓) the most appropriate scale regarding the importance of the success factors for the implementation of BIM in PF2 projects.

	Success Factors	*Unimportant*	*Less important*	*Moderately important*	*Important*	*Very important*	*No Opinion*
1	Government guarantee						
2	Good governance						
3	Community outreach						
4	Good communication						
5	Clear shared authority between public and private sector						
6	Robust business case						
7	Detail project planning and evaluation						
8	Thorough and realistic cost/benefits assessment						
9	Appropriate risk allocation						
10	Robust and clear contract agreement						
11	Competitive and transparent procurement process						
12	Effective management control						
13	Strong and reliable project team						
14	Expert advice and review						
15	Favourable legal framework						
16	Effective collaboration between project participants						
17	Systematic workflows, coordination and integration						
18	User/Client and stakeholders involvement in decision making process						
19	Information sharing protocols						
20	BIM Manager / Information Manager						
21	Good financial resources						
22	BIM training programs and education						
23	Trust on completeness and accuracy						
24	Standardised work procedures for BIM						
25	Data security						
26	Technical competence						
27	Selection of project delivery methods						
28	Establish conflict resolution process						

Table A: Success Factors

2. Other than the factors stated above, what do you think would be the critical success factors for the PF2 project implementing BIM?

____

____

3. Based on your answer in (2), why do you think they are critical?

____

____

SECTION C: BIM RISK FACTORS AND THEIR IMPACT ON PF2 PROJECTS

1. **Table B** is the list of BIM risk factors. Please tick (✓) the most appropriate scale regarding the significance of risks to give impact on PF2 projects.

Risk Level	Risk Subgroup	Risk Factors	Not Significant	Less significant	Moderately Significant	Significant	Very Significant	No Opinion
Macro	Social	• Resistance to change						
		• Lack of available skilled personnel						
	Legal	• Existing legal system not equipped to support BIM						
	Political	• Change of BIM policies						
	Technological	• Lack of BIM standards and guidelines						
Meso	Contractual	• Liability issues						
		• Ownership of BIM model						
		• Status of BIM model						
		• Unclear position, duty, responsibility and liability of Information Manager						
		• Lack of guidelines for contractual agreements						
		• Intellectual property rights						
		• Unclear allocation of risks						
		• Privity of contract and third party reliance						
		• Integrity of BIM Model						
		• Data Security						
	Financial	• High initial cost to implement						
		• Time consuming to be proficient						
Micro	Process	• Increase short-term work load						
		• Lack of collaborative work processes						
		• Inadequate top management commitment						
		• Defective integration between software tools						
	Technical	• Errors in the model						
		• Little knowledge and experience						
		• Model management difficulties						

Table B: BIM Risks Factors

Thank you for your cooperation and help

APPENDIX B INTERVIEW GUIDE

INFORMATION SHEET

CONTRACTUAL RISKS MANAGEMENT FOR PF2 PROJECTS IMPLEMENTING BUILDING INFORMATION MODELLING (BIM)

Aim and Objectives of the Study

The research concerns on developing a conceptual contractual risks management framework for PF2 projects implementing BIM. The objectives of the study are:

1. To investigate the key characteristics of PFI/PF2 model in relation to the concept, contractual structures, risk factors and critical success factors.
2. To investigate the BIM applications potentials in a project life-cycle including the risk factors and the critical success factors of BIM.
3. To critically synthesis BIM implementation in PFI/PF2 projects.
4. To establish the critical success factors for BIM implementation in PFI/PF2 projects.
5. To identify the contractual risks for PFI/PF2 projects implementing BIM.
6. To develop a conceptual framework of contractual risks management for PFI/PF2 projects implementing BIM.

Your Commitment

This study involves semi-structured interview.

1. The interview will last approximately 1 hour.
2. Check the validity of the transcript prepared by the researcher.

Confidentiality

The information collected during the interview will be used solely for the present study. No personal information such as names and contacts will be disclosed to the third party.

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INTERVIEW QUESTIONS

SECTION A: INTERVIEWEE'S BACKGROUND

1. How many years of experience after your academic qualification?
a. Construction industry (if any): ………. years
b. Legal (if any): ……..…years
c. Total (a) + (b) from above: …….. years

2. What is your professional background?
a. Architecture/town Planning/landscape architecture/interior designing
b. Building/construction
c. Engineering
d. Legal
e. Management
f. Quantity surveying
g. Other: ………………………

3. Based on the following, what is your primary area of work?
a. Construction professional e.g. architect, engineer, quantity surveyor
b. Adjudicator or Arbitrator or Mediator
c. Solicitor or Barrister
d. Contractor
e. Government or government owned companies
f. Private client; e.g. developer
g. Legal advisor to a contractor/subcontractor organisation
h. Academia
i. Others : …………………………………………….

4. Have you ever been involved in PFI/PF2 projects? If yes, how many years have you been involved in PFI/PF2 projects?
……………………………..

5. Have you ever been involved in BIM projects? If yes, how many years have you been involved in BIM projects?
……………………………

6. What is your primary role/involvement in PFI/PF2 or BIM projects?
……………………………

SECTION B: OVERVIEW OF THE CONTRACTUAL FRAMEWORK FOR PF2 PROJECTS IMPLEMENTING BIM

7. What are your views on the current contractual framework for projects implementing BIM?
8. What are your views on the PF2 projects implementing BIM?

9. Is the current BIM contractual framework supporting the implementation of BIM in PF2 projects?

SECTION C: STRATEGIES TO MANAGE CONTRACTUAL RISKS IN PF2 PROJECTS IMPLEMENTING BIM

Critical Success Factors for PF2 Projects Implementing BIM

10. Do you agree that these factors are critical to the success of PF2 projects implementing BIM?

CSF category	Critical Success Factors
Alliance	Good communication
	Effective collaboration among the project participants
Management	BIM Manager / Information Manager
	Detail project planning and evaluation
	Systematic workflows, coordination and integration
	Standardised work procedures for BIM
	Management of knowledge and intellectual capital
	Good financial resources
Legal	Favourable legal framework
	Robust and clear contractual provisions
	Information sharing protocol
Competency	Technical competence
	BIM training programme and education
	Good understanding on BIM

Significant BIM Risk Factors towards PF2 projects

11. Do you agree that these BIM risk factors have significant impact towards PF2 projects implementing BIM?
    1) Lack of available skilled personnel
    2) Resistance to change
    3) Little knowledge and experience
    4) Lack of collaborative work processes
    5) Integrity of BIM model
    6) Defective integration between software tools
    7) Inadequate top management commitment
    8) Ownership of BIM model
    9) High initial cost to implement
    10) Lack of BIM standards and guidelines
    11) Liability issues
    12) Data security
    13) Existing legal system not equipped to support BIM
    14) Lack of guidelines for contractual agreements
    15) Model management difficulties
    16) Time consuming to become proficient

17) Status of BIM model
18) Unclear position, duty, responsibility and liability of the Information Manager

Information Management

12. How the Information Manager role rests within the contractual structure of PF2?
13. Do you think that it is difficult to determine how the role of Information Manager interacts with the rest of project team?
14. Do you think that there should be an express provision requiring each member of the professional team to comply with the request/instruction made by the Information Manager?
15. Do you think that there are unclear procedures on the appointment of the Information Manager?
16. In your opinion, should a procedure for the appointment of the Information Manager be stated in the contract?
17. (If 'yes' for Q16) In the context of PF2, what do you think need to be included in the processes and the procedures of the appointment of the Information Manager? (The following points are among the issues to be discussed):
    a. When to appoint the Information Manager?
    b. Who should appoint the Information Manager?
    c. Appoint stand-alone Information Manager or from the existing project team members?
    d. How to appoint : Nominated by client? or Delegation of roles/powers? or Contract novation?
    e. Need consent/Inform from/for all parties?
    f. Information Manager during the operational stage of the facility.
18. Do you think that it is necessary for the Information Requirements during design/construction stage to be related/linked to the Information Requirements during operational stage? Or should they be treated separately?

Reliance of BIM data

19. The CIC BIM Protocol states that "…the Project Team Member does not warrant, expressly or impliedly the integrity of any electronic data delivered in accordance with this Protocol" (Clause 5.1). Should the clause be amended in order to avoid confusion, as well as to ensure data reliability throughout the whole PFI/ PF2 project duration?
20. Would a Change Protocol be required to facilitate any changes in the BIM federated model/data, Information Requirements and, Model Production and Delivery Table that might happen during the course of the contract in order to avoid other parties relying on out-of- date model/data?
21. (If 'yes' for Q20) What would be the procedures that need to be included in the Change Protocol? (The following points are among the points to be discussed):

a. Notification from the Project Leader.
b. Notification from the Information Manager to all parties.
c. Estimate of the time and cost affected.
d. Determine who can amend the model/data.
e. Approval of such changes.
f. Payment for time and cost spent for the changes.

22. Would the Updating Model/Data Protocol be required to facilitate the evolution of the facility during the operational stage?
23. Clause 4.1.1 of the CIC BIM Protocol requires the Project Team Member to produce models to the Level of Detail (LOD). However, there is no provision on what actions to be taken if the design goes further than the LOD, hence might cause the other parties rely on the model's accuracy more than the defined LOD. Is there a need for a clause in the contract to explain this situation?
24. Would it be a risk for PF2 project implementing BIM as it might be difficult to secure the data for such a lengthy period to avoid data degradation and data hacking?

The status of BIM Model

25. The status of BIM model or electronic data is not stated in the CIC BIM Protocol or Standardisation of PF2 Contract. Should the BIM model/data be treated as part of contract documents?
26. (If 'yes' for Q25) How to ensure which stage or at which time the model is fixed to become a contract document?
27. (If 'no' for Q25) Clause 2.2 of the CIC BIM Protocol states that any conflict or inconsistency between the Model(s) and any document or information extracted from the model, the BIM model/data shall prevail. In the context of PF2, how to rely on BIM model/data for such a lengthy period of time but, after all, the BIM model/data are not contract documents?
28. Should the 2D documents extracted from the BIM model/data be treated as part of the contract documents? How to make this clear in the contract?

Intellectual Property Rights

29. Copyright licence granted to the Client is revocable under the CIC BIM Protocol (Clause 6.4) in the event of non-payment of licence. It is, however, irrevocable under the Standardisation of PF2 contract (Clause 33.5.1). In your opinion, which one is more appropriate in the context of PF2?
30. There is no limit to sub-licensing in the CIC BIM Protocol. In the context of PFI/PF2 project, should this provision be retained? Or do you think, perhaps such limit should be set up to one or two defined levels in order to obtain consent from the IP creators and include this in the contract?
31. In PF2 project, the BIM Model/Data are going to be used after the works completed for the purpose of facilities management. Should there be a clause in the contract to

determine the Employer is the owner of the federated BIM Model/Data? (In other words, the Employer owns all the IP rights)?

32. Do you think that the Information Manager needs to have his own IP as he is working in creating federated BIM model?

Liability

33. In your opinion, is the exclusion clause like what we are having in CIC BIM Protocol (Clause 5.1) is appropriate to be used in PF2 context? What would be the effect towards the project?
34. Should the liabilities of the Information Manager be spelled out in the contract? If yes, what would be the liabilities of the Information Manager? (The following are subjects to be discussed):
    a. Errors in BIM model/data due to the poor management of the integration of the data given by other project team members.
    b. Errors in providing required data or information to the project team members
    c. Loss of data due to negligence
35. In a situation where there is error in the BIM model, should the Information Manager be liable to the other parties and provides indemnity or assurance?
36. In the context of PF2 implementing BIM, would it be appropriate for multi-party agreement to be executed so that the Employer, SPV, and project team members have a direct contractual relationship with each other; hence having enforceable obligations between them concerning licensing, confidentiality, and liability?
37. In the context of a PF2 implementing BIM, would it be appropriate for the integrated professional indemnity insurance to be employed in order to have more collaborative environment in delivering the project?
38. In your opinion, what would be the effect of the doctrine of privity of contract to the collaborative working using BIM in PF2 project?
39. In your opinion, do you think the Client in the SPV and has rights to involve in the decision making process in PF2 projects implementing BIM? What would be the effect towards the liabilities of the parties in the project?
40. Other than the contractual risks and strategies that have been discussed, are there any other contractual risks that you think might occur due to the implementation of BIM in a PFI/PF2 project which you believe need to be addressed?

Thank you for your cooperation and help

APPENDIX C SAMPLE OF INTERVIEW TRANSCRIPT

SECTION B: OVERVIEW OF THE CONTRACTUAL FRAMEWORK PFI/PF2 PROJECTS IMPLEMENTING BIM

SN: What are your views on the current contractual framework for projects implementing BIM?

IV-4: From what we have seen it is not very clear. On the projects we have looked at, including the recent PF2, the BIM Requirements have been very small on the projects. And I think the reason for that is that the client whether they are work for the council, government or even large government department like the department of education, don't understand really what is BIM and what it can deliver for. If you look at the biggest document that we received in PFI contract is the Employer's Requirements or Authority Requirements. And that will tell us all the things that we need to provide in the proposals and we probably have one page, if you are lucky, of BIM Requirements.

SN: But when the government wants BIM to be implemented throughout of the country for public projects, is it also included PPP projects?

IV-4: Yes.

SN: Last April I read in the news about school projects in Edinburgh that got some problems, I think it is about structural problems.

IV-4: It is about very simple problem actually. And the problem is that you have your two layers of brickwork, and normally at the end of your brickwork is your structural layout. And the outer layer of the brickwork is partially structural and it is more aesthetic.. nice to see. And as you building both, you tie both these together with what you called a wall tie, very simple piece of wire. And the builder decided to build the wall without the wall ties. That wall tie cost maybe cost about GPB1.20, and as they building the wall, they didn't install the tie. So, there is no lateral stability between these two brickwork blockwork. Therefore, at some point, the wall has become worse and collapse. And when they look at the workmanship on site there is no wall ties. I don't know whether the design should wall ties or whether they didn't. But traditionally, when you build a cavity brickwall you use wall ties. It is not because the project is PFI the walls failed, if even it is not PFI the walls still have failed.

SN: When I read that news I wonder are they using BIM. If they are using BIM, so why this happen? Are they using BIM for that project?

IV-4: No, because those schools were built in 2005, they are not very old schools but they are not new schools in the last few years. I think they were made between 2005 and 2006, and the schools about maybe 8 or 9 years old. Of course they are not using BIM, but that is not an excuse. Either the design wasn't show the wall ties or the builder didn't use the wall ties.

SN: Based on your experience in any of the PFI or PF2 projects implementing BIM, what are the strategies being used to make these projects BIM-enabled?

IV-4: Firstly we rely on what the client is looking for in terms of BIM, sometimes you get quite detail BIM requirements, sometimes you get maybe nothing. So, what we tend to is we tend to take whatever the authority is looking or the client is looking for in terms of hard and fast requirements, and we make sure that our deployment plan meets those requirements. If we think that the requirement is very low, as a group XXX, we will look at the authority's requirements for benefits. And there are lots of benefits to be gained by looking to improve the level of BIM used in the project. For example, we can employ BIM 4D, we are looking at building BIM model where the project programme and test can the building be built in two years. What would happen if we delete certain area, what impact to our whole programme. The client might not want that. But as a group we would say this would help us remove some risk of the project. So we will do that for ourselves. So, we will write in our BIM deployment plan, that we will do BIM 4D. But that is what our benefits. The client will also obviously gets the benefits as well. But they haven't ask for it. But we decide that as a group. XXX would not dictate that the BIM construction because we are the company so we will meet on the project and we will agree, does the client's BIM requirements … if we think the requirements are very low, we then discuss should we improve the BIM requirements.

SN: So, in your case, XXX is actually who decide which level is actually BIM for that project, not the Employer?

IV-4: We need to meet the level that the Employer has set… because if we don't then we wont win the project because we are bidding with other companies. So, as part of the evaluation process, if we just asked for the model and the drawings then we will provide that. Or we might say, we just go for the 4D or 5D… and look at how we can use the BIM model to help with the placing of the projects which is 5D. So, we will decide that ourselves, but we will still meet what the client is looking for. Apart from one project we never really set a very high level of BIM on the project, we never had to go back to the client and say you asking too much. We always have, for our own benefits, over specified BIM on the BIM level.

SECTION C: STRATEGIES TO MANAGE CONTRACTUAL RISKS IN PFI/PF2 PROJECTS IMPLEMENTING BIM

Critical Success Factors for PF2 Projects Implementing BIM

SN: Do you agree that these factors are critical to the success of PF2 projects implementing BIM?

IV-4: Yes, these are all important. Technical competence is important, from what I've seen the contractors and consultants are not ready technically. That is dangerous because you are dealing with softwares and data, of course you need technical competence. Apart from that, somehow people are worrying about merging liability, somehow that is what people are worrying about BIM, they worry that BIM will blurring the lines of people's contractual obligations. So we need to have robust and clear contracts.

Significant BIM Risk Factors towards PF2 projects

SN: Do you agree that these BIM risk factors have significant impact towards PF2 projects implementing BIM?

IV-4: Yes. As I said we need people who are technically competence and robust contractual provisions to mitigate these risks.

Information Management

SN: About the Information Management, based on your experience how normally the procedures to appoint the IM? In PAS 1192 and BIM Protocol also don't really mention how to appoint the IM. Do we really need IM?

IV-4: I think probably, that is due to the fact that XXX is the one group of project. The IM is actually anonymity person within the design and build contractor which is XXX Construction. So, what we do as for the PFI project we have XXX PPP as the owner of the SPV and then we subcontract the design and build to XXX Construction, and we subcontract facilities management for the next 25 years to XXX FM.. another XXX company, we have an FM company. And together we make those decision jointly on how the proposal work. So, for example, if XXX Construction goes to chose to say that I want light fitting… XXX FM tells them the best light fitting to use in terms of its whole life cost. So, it is not just the cost of the light fitting to buy, but also the reliability, replacement… the cost of all that in 25 years. So, everything that has the running cost, operating cost … XXX Construction as the design and build contractor will buy it and install it but they won't specify it …. XXX FM will specify that and they will say to XXX Construction. For example, this is the best carpet to buy… it is easier to clean, I can easily replace it and it is 5 miles from the shop etc etc… I want that light fitting, because it got cheaper electricity, I can buy cheaper bulb easily and if it breaks I can fix it quite easy as well. So, everything that goes in to the building is specified by all the XXX companies. We meet together and do all that. So, from the design and build perspective, XXX Construction has the responsibility but relies on others. When it comes to BIM, the design and build company manages the information. They don't employ anyone except the XXX company. We employ people within the company who XXX people to be the BIM Information Manager. So, everything is controlled by the XXX company.

SN: What about during the operational stage… is it the same design and build company?

IV-4: What happen when comes to your specific question, but when the building is handed over, the BIM model is transferred to what we call an Asset Information Model. The XXX FM will manage the AIM and as the building progresses for the next 25 years any works that done to the building, whether it is a change… and we got a lots of change in our project. Sometimes very big changes. But sometimes, even placing heating systems or even just replacing carpets that is reflected in the AIM. So, at the end of each year, you can go to the AIM and you will be able to see items which bought four years ago, its cost and is due to be replaced in another 6 years. That information will be in the AIM. Will be managed by XXX FM.

SN: Do you have a clear procedures on the appointment of the Information Manager? As you said just now like how it change from design and build to FM?

IV-4: We do. In our business we have what we call as Interface Agreement. And that Interface Agreement exist between the Design and Build Contractor and the FM Provider.

SN: Only both of them?

IV-4: Yes, only both of them and when we first started this 14 or 15 years ago the SPV also have this Interface Agreement and lets just say that … emm…within the first year of operation, if the heating system start to fail and the client starts to deduct money from the FM through the PPP/PFI contract, what would happen is the FM provider will go to the SPV and ask the SPV to take those penalties from the construction company. And then, we will then get the money from the construction company and pay that to the FM provider. So, we basically sat in the middle and over time when we have found this SPV doesnt really need to be in the Interface Agreement. Both companies can work together and do that themselves, without the SPV company. So what we have set, you need to set out in the Interface Agreement what you need in order to operate the project. So, what XXX FM will do is they will set out from day one their BIM or their Asset Information Requirements. So they will say to the XXX Construction, when you make the BIM model we would like CoBie data to be at this level. We would like the level of detail to be Level 400, Level 200 etc. They will then say we would like also the federated model to have 'this', so that we can then transferred into the AIM. And they can continuously use that. Once the BIM becomes operational, XXX FM will become responsible for maintaining the asset and AIM and BIM model.

SN: In your opinion, should a procedure for the appointment of the Information Manager be stated in the contract?

IV-4: For our benefit, NO. But if you are looking for external provider to be the IM then yes you probably need that. But for us , no.

SN: Did you face any problem to determine who and when the IM?

IV-4: No. because it is very clear.

SN: In the context of PFI/PF2, what do you think need to be included in the processes and the procedures of the appointment of the Information Manager? (The following points are among the issues to be discussed):

a. When to appoint the Information Manager?
b. Who should appoint the Information Manager?
c. Appoint stand-alone Information Manager or from the existing project team members?
d. How to appoint : Nominated by client? or Delegation of roles/powers? or Contract novation?

e. Need consent/Inform from/for all parties?
f. Information Manager during the operational stage of the facility.

IV-4: Even, not for the XXX employee, I would say that IM should come from the existing project team member. Having someone externally creates interfaces. And from experience I would say that, the less number of interfaces you have, when building contract… the better that would be. Not just legally but also practically. And by giving one company full responsibility for the design and building, you cant have an argument that the building does not being designed very well, so we couldn't build very well…no… you are responsible for the design and also the building. For XXX Construction, employs directly the Architects, the Engineers and every other professional consultants and advisers that they think they need to design the building. And leave that responsibility with that one group.

SN: I read about IM don't have designer role but now you are appointing the designer to be the IM… so how to differentiate these two roles?

IV-4: What we have, we just have one individual whose appointed BIM Manager and that person is responsible for managing and updating of the federated BIM model. So, we have one person who sits at the computer and he basically pulls all the models in from the Architects, Engineers and anyone else and brings all those models together and create a federated BIM model. There is a lot of work done in terms of checking the clashes… the clash detection and also to make sure that everyone is working from the same version of the BIM model and then everything should be where it is. On top of that we also use a lots of checking software, and later we talk about Solibri.. this is a software that can check to see if something in the model which just doesn't look right. Very very cover software. But the BIM Manager who continually verify the model to make sure that everything is ok. Once the BIM has federated model, and that is correct, he will then reassured to all the parties. He will reassured on the Engineer, to the Architect… and more design development will be done on those models. And the timescale is depending on how long the process would take. But maybe the model will be run every 2 weeks. So, you set those parameters, and you say every two weeks we will receive models from each of the professional advisors and the BIM Manager will then control that. I mean on the project of Grenge Gormon, we had two separate college buildings being designed, and we had a BIM Manager on each building.

SN: Is there any conflicts between these two roles?

IV-4: No, we are not asking them to design, we are seeking them merely to manage the BIM information. Both of them are a very good designers but we didn't say to them,.. you design the building. But what we are saying to them, you are checking the designs from all of the other disciplines … all matched, all works from the same level, all are from the same data point, data sets are common for all those models. But, don't get me wrong… they can see things on the screen and they can see if something is not right. For example they can see there is a staircase here which comes up and it appears here … I mean they could see those things. But they wont make the changes. They will send back and say, no that is wrong and you have to change. XXX Construction as a company, we don't employ our own Architect or our own Engineers. We are purely a construction company and therefore as a construction company we employs the BIM Manager.

SN: How the Information Manager role rests within the contractual structure of PPF2? This is typical structure of PF2. So, you mean the IM is here? (refer to the diagram – under DnB contractor)
IV-4: Yes, absolutely. And that is XXX PPP as the SPV. So, we basically control all this (mark the diagram – DnB and Fm contractors) and we also control this (mark the diagram-funders) which is the investment of the equity because we invest our own money and we also organise the external funding whether that be from banks, bonds or other institutional investors.

SN: If the project is using BIM is it affects funding?

IV-4: Not yet. What we are trying to do and what we are trying very hard to do that is we are trying to explain to the banks that they can give us better terms because we are trying to take much risks of the project as we are possibly can by using BIM and using as much the dimensions of BIM that we possibly can. So, we say we checked the programme because we views BIM 4D and we can sure that there are no critical paths and which will delay the project. We tested the cost because of 5D BIM. We think that the banks and funders … it doesn't mean anything to them. We continually try to say to them, we are taking more and more risks by using BIM. So what we are started to do is … funders will always employs a technical advisor on PFI project. And we are started to approach their technical advisors to say you need to report to the banks that the risks level on projects is becoming less and less because we are using BIM. Unfortunately, not all technical advisors are up to skills with BIM. Some are better than others. But there is no hard to sell that we are trying with the technical advisors, it is to explain to them that from XXX model we are using BIM as much as we possibly can.

SN: If the IM rest here (refer to the diagram- under DnB), what about the contractual relationships in terms of … because IM needs to issue instructions about BIM matters. So, how can they comply with IM's instructions if they don't have contractual relationship with the IM?

IV-4: They do.

SN: Ooo you have the Interface Contract?

IV-4: Ya. And what we have on here is we've got suppliers ad you got subcontractors but you don't have designers. And would normally happen is that designers we sat here (refer to the diagram), and same goes to the builders as well. So, you have here (refer to the diagram), and there is goes as well (refer to the diagram). So when XXX Construction appoints the Architect, as part of the appointment package they would say to them … these are the BIM's requirements, here is the BIM deployment plan. And that BIM Deployment Plan will take the Architect and everything he needs to know about how BIM will be used for the project. He calls all of the walls in the drawings will be red, all the ceilings will be blue, there is the scale of the drawings that we provide … that will all be stated in the BIM Deployment Plan. And the process that BIM will be managed will also be in the BIM documents. So the Architect will know, he will need to provide his model to the IM every two weeks. He will need to share that model, maybe, with the Engineers … maybe he wont or maybe he just give his model to the IM, and IM will ensure that model with the Engineers. But that will be set out in their appointment document.

SN: But in the other party's contract, is there any clause saying that they have to oblige with the instructions given by the IM?
IV-4: I don't think they have the clause saying that they have to oblige with the IM. It probably would just say that they need to comply the instructions from the design and build contractor.

SN: Do you think that the contract need to specify the relationship between the Information Requirements documents, Model Production and Delivery Table and other contract documents or provisions? (For example, how these relate and affect key sectional completion dates; delay and extension of time; or remedies if not in compliance with the BIM requirements).

IV-4: I think it probably does, Nora. But I just don't know the level of which we do it. All I know from the projects that I've worked on, the BIM Deployment Plan contains lots of information to cover those things. And that is what the designers are signing up to when they reach the appointment with XXX Construction. So, Things like the Model Production Table and all the LOD are all set up. I think the Designer needs to know what the BIM has to provide because there still a lots of Designers out there who are struggling to deliver BIM.

SN: Do you think that it is necessary for the Information Requirements during design/construction stage to be related/linked to the Information Requirements during operational stage? Or should they be treated separately?

IV-4: Yes. If you are looking BIM being used during the operational stage… then, yes you do. And you need to link the Asset Information Requirements to the Building Information Requirements. And this is why we then ask XXX FM and XXX Construction, and say this is how we want the BIM Model to look when you give it to us. So, we can easily transfer to the AIM. We can now link the AIM to the CAFAM system. Basically the CAFAM System is your computer facilities management system. We call it something like a helpdesk, where everything that happens on project from the operational perspective is recorded on the CAFAM system. But basically when someone phones the helpdesk and says, door no 5 is isn't working, could I get that repaired? You will log that on the CAFAM system and you can automatically log in the CAFAM system to the AIM which you go and look to think Door No 5… it will then tell you what kind of the door is, will tell you if it is so strong, instructions on how to fix it or replace it. And what you do as you replace the door, it recorded in the CAFAM system that it has been replaced and that update the AIM. So, we have the AIM which talk to the helpdesk, and you have the helpdesk that talks to the AIM. For us, we thinks that meets Level 2 BIM. And we don't think that many people who can do that.

The status of BIM Model

SN: Based on your experience, how the status of BIM model being determined in PFI project? Is it contract documents or deliverables?

IV-4: It is a deliverable. So you have client to ask for to prepare for the proposal, so that we prepare that as part of our proposals. What happen is, it would be frozen when we sign the contract before we start construction. And that is ultimately if there is no more changes that will be deliver for the client. So therefore it becomes our legal document but it is not an authority's requirement document. The authority's requirements are not very much prescriptive of what the client wants. For example, the client would say … I would like a table at the meeting room, our proposal would say we will give you a wooden table, it has wheels and etc. So the client's requirements are prescriptive, very high level … our proposal specify much more detail. Ultimately, the only document that is legal is the Client's Requirements. He asked for the table.

SN: So the model is not a contractual document?

IV-4: It is not but it is form part of the contract. It is just another hierarchy. The client's requirements would always set above our proposals. The BIM model is part of our proposals, so it wont become a legal document but if there's any difference between the two, the client's document always comes first. So in the court if you are argue what was in the client's document, what really about in our document. What you are looking for is the output specification. Client provides you with the output specification. We provide the details that goes behind them as part of our response. And the BIM Model forms part of the response. But just because it is in BIM model it doesn't mean that it is 100% correct. Hospital is really a very good example. Hospital got a lots of relationship between spaces. And the client's document it would say the operating theatre next to be next door to recovery ward. So, people can go our from the operation theatre straight to the recovery ward. Although the BIM model shows the operating theatre here and the recovery ward a way of here (far more away), it is still a legal document but it is not correct. As there are any dispute about you haven't made any requirements, we cant say we have provide you with a BIM model. The reality is the client's requirement was those spaces need to be together. So, that would always take precedent. And the BIM model, it will become a legal document.

SN: So you say BIM model is not a legal document?

IV-4: Well, it will become a legal document. The reality is, what you are saying at financial close will be different from what different from what you have ultimately at handover when the building is complete. There would be changes … the client will ask for changes and you might produce design development … so the design will continually move, maybe small changes. But the BIM model is what you get at the completion of the building that would be different from the model that you are saying before construction.

SN: Just now you said you extract drawings from the BIM model, so is that means that the extracted drawings the contract document?

IV-4: Yeah. I think one day we wont produce paper drawings anymore to put in our contract. We probably just put the BIM model into the contract document. But at the moment a lot of clients don't know how to use BIM. I mean they don't know how to set them in the computer, and say can take me from this section to the meeting room. Clients, they are not able to do that.

SN: I know that you are not using BIM Protocol, but just an example in the BIM Protocol where it says that any event if the 2D documents conflict with the BIM then the

BIM model shall prevail. So, in your case, based on your experience, is that situation happens so which one is actually prevails?

IV-4: On the ABC project that we worked on, that the BIM model prevailed.
SN: Even though it is not a contract document?

IV-4: We never won the project unfortunately but had we wont the project it would have become a contract document. They wanted the building to be fully BIM, and the honours is on them to check that the drawings came from the BIM model. We also need to provide them with 2D drawings as part of our proposals. But we also give them a full federated BIM model. But they had an advisor who then check that the drawings were from the BIM model. So, we have to give both. I think in the future as clients become more comfortable with BIM, and BIM becomes more common, I think the client would only want the BIM model. But people always like to see something on paper because it is more tangible. The thing in PF2 it was … there is something that is difficult to explain to client is we are still here for 25 years so they really don't need to have all the information that they normally have in traditional build. Normally we had to give at the end of the project the operation and maintenance manuals, so that every instructions for every components of the building normally you have to put that in the folder and you give client a folder. Maybe 10 folders. Whereas now, it is all on the desk, it is all on the cloud or it is all in the BIM model. And what we say to the client was, we manage the building for you for the next 25 years, so you don't need to have this. We can let you have access, you can look, you can do whatever but the reality is we are going to control the BIM model or the AIM for the next 25 years. And the clients think that is difficult to understand, the clients still think where is my o&m manuals? Why am I not get the drawings? … we managing the building, so ..

SN: BIM model is subject to change, very sensitive to changes. So, how to make it a contract document. Can it be freeze?

IV-4: Well, you can. We have the Employer's Requirements that had set up from Day 1, during the construction stage if there is any changes made by the client, the requirements need to be updated. For examples, we have several schools that we operate, some are about 10 years old, and the school had asked us to extend the schools. There are more children, the is school is very popular, so they come and say, can you build 20 more classrooms? So, in the old days, we are going to change the electronic version of the drawings and then we add on the 20 classrooms. Now we have BIM models, we can easily go to the BIM model and we can add the 20 classrooms. And we can update that model. We can then calculate all the calculations that deals with it, in terms of daylight heating, energy consumption, we can do all those things in the BIM model but we need also to go back and we need to update the Authority's Requirements as well. So, the Authority's Requirements change as well. But that is occasionally a school with 80 classrooms, now they want a school with 100 classrooms. So, the Authority's Requirements change the BIM model would probably change and vice versa. To change the BIM model, you need to change the Authority's Requirements. So, both need to change as well. What we have said to XXX FM in all of our contracts is at the end of each year we would like the BIM model or the AIM to be updated. So if you carried out any lifecycle, if you make any changes to the building, carried out any paint work… anything, we want that be recorded in the BIM model every year. For example, school… there is only certain times in a year that you can carry out works… when the school is not in operation. So everytime during school holiday XXX FM can do most of the maintenance and the lifecycle. So, everytime they do that it would be unfair to say to them … can you update the BIM model? What did you do last week? When we replace the carpet in room no 4, okay you need to update the BIM model … it's a lots of effort just to do that one thing. So, what normally we do.. for what the things you have done in a year and make sure the BIM model reflects what you have done. So at the end of the year, we now have a model which is accurate and representing what is being done.

Reliance of BIM data

SN: Based on your experience… do you face any problems in data reliance?

IV-4: No, because XXX controls the management of BIM model and federated model process. We continually using the software like Solibri to make sure that the data is reliable.

SN: In the BIM Protocol, you know they have this a disclaimer saying that "…the Project Team Member does not warrant, expressly or impliedly the integrity of any electronic data delivered in accordance with this Protocol" (Clause 5.1). Should the clause be amended in order to avoid confusion, as well as to ensure data reliability throughout the whole PFI/ PF2 project duration?

IV-4: We don't use the CIC Protocol. I am not saying we tend to write our own rules, but there are something that we are retaining back control by ourselves, we don't push that level of complaints and that level of reliability from the designers.

SN: So, you mean in your case this clause is not needed? Because you control it?

IV-4: Absolutely. We don't say it is inappropriate for us but then it will depend on how much client wants to apply that protocol on project. And for us, our deployment plan covers all sorts of things.

SN: Clause 4.1.1 of the CIC BIM Protocol requires the Project Team Member to produce models to the Level of Detail (LOD). However, there is no provision that mentions what actions to be taken if the design goes further than the LOD, hence might cause the other parties rely on the model's accuracy more than the defined LOD. Is there a need for a clause in the contract to explain this situation? Have you experience this?

IV-4: I have to be honest… we never experience this, Nora. We had a Table with all the LOD that required, we have LOD from 100 to (I think) 500. And we have never had problem about either meeting that level or exceeding that level. I think maybe in one or two projects the clients tell us the level of detail that we need to looking for but that is very2 rarely. Our client says I am looking for this level of detail etc. As part of their requirements they would say can you provide us floor plan to scale of 1:100. Rather than say, can u give a floor plan to a level of detail 400. We don't get that. We are asked to provide drawings as the set scales for the BIM model that can be in any scale. You can print the drawings to 1:50 or 1:100 or 1:1000. And we still get to ask for that. Can you provide the level of detail… etc.

SN: What about the other parties rely on the … I mean the model is more that the level of detail and the other party is rely on that model? What happen if it is going to be like that?

IV-4: We have example where we were produce some model, say at back stage where the heating system will be at the level of detail until 200. We then bring subcontractors, heating engineer companies and we say to them.. we produce the BIM model at level 200, we will now bring you and board to bring the level of detail to 400, but we also want you to install the heating system as well. So, the BIM model actually gets better as we go through the construction stage. You know, we put in the model that decision and says we provide the heating system that will provide so many kilo watts of heating to the building, when we get to the construction stage, we then have a provider on board, now that person come and says I can give you 100 kilowatts and this is the system that I will provide and I will put that into BIM for you, I will take the BIM model and I will start put my level of detail on. And what we think of our project is that our own BIM model is very generic at this stage, but when we start go through the construction, we then start to bring all the subcontractors details on boarb and out that into the model. And our Architect for example will design of the building, but they won't design the detail of how that goes together, you know like curtain walling system … you need to go to the supplier for that level of detail. So the model at this stage would always be a lower level than how the BIM model will finish. Ultimately, what you want when you get at the end of the project will be is a model that is as detail as it possibly can. But as I say it is different from the model that you sign up at the financial close.

SN: Based on your experience, how the changes in the BIM federated model/data, Information Requirements and, Model Production and Delivery Table that might happen during the course of the contract being managed?

IV-4: It is being managed by the dedicated BIM Manager… by the design& build contractor. So, that IM is managing all that for you.

SN: But do you have a Change Protocol to facilitate the changes?

IV-4: Yes, we do we are using form for client to use for formal changes. And we also have forms for D&B contractors and the designers, where the designers start to look at design development. So, for example, the Architect make come back and say the door at that position is not very beautiful, we are going to move the door from there to there. That would be recorded. It is also in our Change Protocol that it would be recorded in the change form. But they will need to go a long process to move the door from one position to another. But if you are saying that we need more that one door for this room, we don't need large sliding partition, that that need to do a much more detail Change Protocol. But we do have Change Procedures on projects. And there is only two ways that can be generated 1) is request by the client, 2) request by the design and build contractor internally. But both have to be recorded.

SN: How generally the procedures in the Change Protocol?

IV-4: Basically, if it is a client's change, they will inform the SPV, the SPV will then go to the D&B Contractor and say that the client would like to change this meeting room into a kitchen, can you tell us how this can be achieved? So, the D7B contractor will response and say this is how we make that change and get it back to the client. The client will then to go ahead with the change, we will then put that change into place and that would be four rooms which have lots of boxes and all that … people are sign off different stages, and that it contains the cost of the change if there is a cost, not just the cost just now but the cost for 25 years and then what would need to be done from the design perspective, from the legal perspective in order to capture that change. It works in reverse if it is a change for the D7B contractor wants to make… if he says I don't think that this heating system chosen is a good heating system, no, I think we should change the heating system, … he will tell the SPV and the SPV will tell the Client. But it would be almost the exact same form. And then it would say whether the client would agree? Whether it would cost more money? … the client does not need to accept the change, he can refuse the change but again it would set out what changes that need to be made to the BIM model, what change that need to be made to the contractual documents, etc.

SN: What about during the operational stage? Do you have the change protocol for the operational stage?

IV-4: Exactly the same. We have the FM provider, if they want to change they will issue the form as well, or if the client wants to make the change he will issue the form to the FM. So it is exactly the same process.

SN: So, everything about forms and all, do you put these in the BIM data?

IV-4: Not yet, but ultimately we will. At the moment the change process is controlled by us, the SPV. We have, in all of our project we have what we call a General Manager and the General Manager is responsible for ensuring that the projects runs smoothly, efficiently, and we are meeting the client's requirements. So that person reports in to the client almost every 2 or 3 days. And they meet with the FM company almost everyday to make that everything is working okay.

SN: Does CoBie works well with the project that you have been involved?

IV-4: Yes, we used CoBie in all of our projects. And we found that by using CoBie we can now deliver full Level 2 BIM. We have the BIM model and AIM talking direct to the CAFAM system. I don't know how we manage that, but we seemed to found a short cut doing it very very quickly. We have an enterprise agreement with Autodesk, and we had about 6 or 7 years… we are actually work in partnership to create the CAFAM system for Autodesk and building up straight to the CoBie data set and vice versa. And what we found is that we can build the CoBie dataset quicker than we have ever done before and then we can transfer that to the CAFAM system. So we spent a lot of time developing it with Autodesk, but it amazing…. absolutely amazing.

SN: So, XXX developing it with Autodesk? Do you think in other company they have that?

IV-4: We know lots of company who claimed that they can do that. And we are trying, about 4 or 5 years ago, we are trying to do that in the UK… we are trying to do it with a company called Concept, and Concept they have a product in the market called Product Evolution which was their CAFAM system. And basically what we are trying to is we are trying to take the product that is already existed, and we tried to push it and squeeze it and manipulate it to try and read CoBie data, and we spent a lot of time and a lot of money. And it don’t really worked. So, what we found was rather than trying to adjust the CAFAM software, what we thought we go to the BIM Software people and say can you produce CAFAM system that meets your software, and that is what we did. I have a case study which I can give you if you want. It is a very good case study in terms of what we have achieved.

SN: What project is it?

IV-4: It is a school project in Ireland called School Bundles Four. And Ireland they bring this school as a multisect project, so they have normally four sects schools and bundled, and we bid for all the school bundles and we won bundle 3 and 4. And on 3, we try to adjust the old CAFAM system to read BIM, but it didn’t work. So, we started from scratch and we took Autodesk system and we are trying to work with them to keep with the CAFAM system. And that seems to work very well. And it is a PFI project as well. I can send it to you.

Intellectual Property Rights

SN: PFI/PF2 contract is a lengthy contract, to be operated and maintained for more than 20 years. Should the definition of “Permitted Purpose” in the CIC BIM Protocol be amended so that licences can be used for the addition and extension of the data/design of the facility?

IV-4: This is what happen when you use the Protocol. XXX owns the licence for our project because that is our federated model. We employ IM to manage the model, so basically we are the owner of the BIM model. What happened then, if will hand the model to the XXX FM… so it goes from XXX company to a XXX company. The IP really remains with the XXX companies.

SN: What happen after the PFI contract ends?

IV-4: Well, we can give the BIM model to the client.

SN: So the client will get the ownership?

IV-4: What we are probably think was in 25 years of time BIM will change. So the BIM model would probably be, I am not saying out of date, it would be accurate as the information we feed in but we probably in such a different version of BIM in 25 years time and the client probably wont want to have BIM in that format. I don’t what would be the format would be, but that would be something which is completely different. But if the Client want to use BIM in whatever ways recognised…

SN: So, is that being stated originally in the contract that client is going to take ownership of the BIM model?

IV-4: There is no point in retaining the IP to yourselves, there is nothing to be gained from that. So there is no reason why you just say … well, you maybe don’t want the client to know that you changed things, when you had to change things more often than supposed… but reality is the way the PFI contract works, if things don’t working in the building, the client would know because they will see it and they will report it. So client will know that maybe the heating system has never been agreed in the meeting, so you can't hide it. I think I can't see why people would not want to give it to the client at the end of the period. Like Zahar Hadid when she designed the phenomenal building, but in 25 years time we will have new architects probably design even better buildings. So, if you like to think of it Architect relying on its IP for 25 years ago, that is really much have been done in the last 25 years ago. I think certainly in PFI, I think the Architect would not be agree if the IP been transferred.

SN: If the IP is going to be transferred to the client is going to cost more for the client to pay?

IV-4: No, I don't think so. I mean, the money has already been spent on the services, the client has paid the SPV and the FM company over 25 years, so the fact of to give him the building which is almost but not entirely but almost in the same condition as it was on Day 1 when it was completed. I think the client should deserve it.

SN: There is no limit to sub-licensing in the CIC BIM Protocol. In the context of PFI/PF2 project, should this provision be retained? Or do you think, perhaps such limit should be set up to one or two defined levels in order to obtain consent from the IP creators and include this in the contract?

IV-4: I think the IP should remain with the XXX Group regardless who retains. Honestly we never formally recorded who owns the licence and it is part of the discussion with a company just now. And the reason being as that we are in opinion XXX PPP should retain the licence. And the reason we think we should retain it is that if something happen to the project the XXX FM company could provide the service. In PFI the last person you want to terminate is the SPV. You want to terminate the FM provider before the SPV but it is a disaster to terminate the SPV. So, if you leave the licence with the FM provider, you will then have the argument of how to get the licence back if you terminate them. So what we have said, we think that out PFI project we should not only retain the licence and the IP but we should also own the AIM. Now, the FM provider they will manage it, they will maintain it, every year they will update it and they will give the copy to SPV. So we will own it, so we still haven't got this formally agreed. But the SPV should own the model, so if anything is to happen and it could be anything, if we had to terminate the FM provider we have to amend that model and give that to the replacement FM provider and maintain the model.

I don't know if we have but I never come across any client requires to own the BIM model when the project has finished. But if you have a building and you know that the company have maintained it for 25 years and you got the report every year that they are operating well, then does it give you any more comfort as have the BIM model as well. I don't know maybe some clients just think well, I've been here for 25 years, I've seen the building been maintained, I've seen how the building perform, so do I need to have the BIM model as well? to show me what has been done. And its come back to why giving me something that I may haven't think because BIM haven't been changed, it is not in different format, not in different software … it is a bit like when we are still using Microsoft word 2007 in 25 years … I got this document written in Microsoft Word but I am not going to use them.

SN: When you said that XXX owns the IP, so for example your designer here (refer to the diagram) when he design, the design is owned by the SPV?

IV-4: Yes, that is what I like to see.. yes.

SN: Because it is under your contract?

IV-4: Yes. And when you think about it, all the designs all of the Architects' IP is the form of the building. Most Architects would say. Like Zaha Hadid, she would say I design that museum in Glasgow … it is really a good example because she never say that is the museum built by the XXX Group. She said on the project, I want the project to be black and zink. We then had to go to subcontractors who could design a zink cladding system to go on with that building . But the question is who has the IP for the zink cladding system? It is not Zaha Hadid, it si the subcontractor who has the IP. It is their system. If you in ten years time went to XXX FM Provider and said U want you to replace that zink cladding, they want go to the Architect and ask them to do it, they will go to zink clad subcontractor. Zaha Hadid owns the IP for the design of the whole building, that is her IP. But when it comes to maintaining the building, as well as put it in the BIM model, there are lots of IP that belongs to other people as well.

If we have an external provider, for example the external design & build company, we may look at IP differently. But because we are just within XXX, we haven't record as what we probably should.

SN: Copyright licence granted to the Client is revocable under the CIC BIM Protocol (Clause 6.4) in the event of non-payment of licence. It is, however, irrevocable under the Standardisation of PF2 contract (Clause 33.5.1). In your opinion, which one is more appropriate in the context of PFI/PF2?

IV-4: We don't have, we don't record this formal licence for BIM, it never came across us.

Liability

SN: Should the liabilities of the Information Manager be spelled out in the contract? If yes, what would be the liabilities of the Information Manager? (The following are subjects to be discussed):

d. Errors in BIM model/data due to the poor management of the integration of the data given by other project team members.
e. Errors in providing required data or information to the project team members
f. Loss of data due to negligence

IV-4: I think if you are employing the external IM, then you probably yes. We obviously don't, so all those things are under the responsibility of design & build contractor.

SN: In that case if the design & build is the IM , should the Information Manager be liable to the other parties and provides indemnity or assurance?

IV-4: If it is external, I think we probably need to provide indemnity insurance. I have to be honest, looking ahead to the future, and as the market matures I can't make up my mind … will you have more companies providing this role externally? Or will you have more d&b contractors managing it themselves, I don't know the answer. I know our company who provide the IM but we never use them. I just wonder in the context of PFI where you have a very simple arrangement where you have two sub-contractors to the SPV… by introduce to another party you make things difficult. I just don't know as the market become more mature will dnb contractors do that themselves.

SN: In the context of PFI/PF2 implementing BIM, would it be appropriate for multi-party agreement to be executed so that the Employer, SPV, and project team members have a direct contractual relationship with each other; hence having enforceable obligations between them concerning licensing, confidentiality, and liability? Is it appropriate for PFI/PF2?

IV-4: We don't have multiparty agreement, as what I mentioned earlier, I just use the existing appointment to reflect the BIM req. rather than having one multiparty BIM contract document. I suppose that is actually the deployment plan which everyone gets a copy of. And in our deployment plan it contains what every person must provide. So the arch, engineer etc get the same plan… and it would say in that plan what each party is responsible for. So, each party … the architect will see what the Engineer's responsible for and etc as well. But other than that we don't have standard multiparty contract. We don't use that.

SN: But in your opinion, is that appropriate because this multiparty agreement being used in PPC 2000 contract when they use PFI.

IV-4: I have no idea about it. I suppose there is no harm of having something … normally in PFI contract, you don't have contracts that go more than 2 levels. So let say you have project agreement from here to here (refer to the diagram) and then, stepping down you, you step down the project agreement into the building contract and into the FM agreement. You won't have a contract which would capture all of those people under one contract. And supposed part of that the interest of the SPV. You see, you don't want to have a contract with … if this person broke the contract , contract breaks for everyone. By breaking down the contracts to separate contracts, you always preserve what happen in the project activities. I would say that the bank might have issue with that because the banks care most after themselves is the SPV. The SPV has to be protected all the time, even if these people disappear, the SPV must be protected. So, if you have an agreement, which captures just these people, it is going to be difficult but if you have an agreement that captures all of these people then it becomes a real problem. So that is why you need to step down from the project agreement.

SN: In the context of a PFI/PF2 implementing BIM, would it be appropriate for the integrated professional indemnity insurance to be employed in order to have more collaborative environment in delivering the project?

IV-4: There is one thing that is always we worry about BIM that if it is doesn't absorb the designers of the design responsibility. So, Architect shouldn't stops be responsible for design just because someone is managing the BIM model. The managing of the BIM model is separate from the process of designing, so the Engineer can say the BIM model didn't work, well because you manage the BIM model. No, the BIM model doesn't work because of the structural engineering wasn't designed properly. So, for me, what needs to be ensured is the level of design… the level of the design needs to be maintained. And I think Architects and Engineers need to know that the implementation of BIM doesn't stop them to be responsible for design. So, for having insurance the professional indemnity insurance is necessity for maintaining design to the right way we want. When we are talking about insurance and BIM model, it become more difficult… because BIM model is merely the way we have the information comes together. All I would say the designers cant be … we cant take the responsibility from the designers.

SN: When I read about the integrated insurance, the purpose is to have collaborative environment.

IV-4: But we are not yet in the collaborative environment. When we works with BIM, we work with Level 2 BIM. That collaborative, you are working on one model at the same time. So Level 2 is not fully collaborative because what happen is the federated model is made up of lots of models and come together and build on top of each other. Whereas when you get to Level 3 BIM, what would happen or should happen is one single model and everyone is working on that single model at the same time. It certainly more collaborative … I don't know who you are looking to, but if you have someone in the insurance industry that is certainly worth.

SN: Should there be a compensation for failures to comply with the BIM Protocol during design, construction, as well as operation of the project?

IV-4: It depends who is looking for the compensation, so let say the client is looking for compensation, you haven't design the BIM model to whatever level, we will ask that to be reflected in the payment mechanism. The payment mechanism is the model to which the payment submit to the SPV on a yearly basis, so if the room wont available you will be penalised. If the clean service isn't up to standard, you will be penalised. We will then ask if any non-performance related to the BIM model, again that should be reflected in the payment mechanism. So that is contractually informally recorded rather than the client say if you have not given me something then I have to penalise you. As between the dnb contractors and designers, I think all penalties are in place. The only thing that I would say that need to reflects the level that value at their appointment. If the appointment fee of the Architect is say GBP200k, penalise them with GBP100k if they don't provide a good BIM model is going to be difficult. It would be better if you just terminate them as oppose to looking for compensation.

SN: Which one you think is more appropriate, to have a BIM Protocol specifically for PFI/PF2 project or no BIM Protocol just standard form of contract for PFI/PF2 contract implementing BIM?

IV-4: I don't think it matters. I think the most important thing is to make sure that the BIM requirements are catered properly and it has been passed down to everyone. Whether it is BIM protocol or SFOC, I don't think it matters. I think the important thing is client make known to the SPV, the dnb contractors what level of BIM they are looking for. Because that is the thing that you need to deliver at the end of the day. So, if the client say I want a BIM model or AIM, and I want the AIM to be linked to the CAFAM system, then that is needed to be in tolerant. Whether it is written down in the CIC

Protocol or SFOC, I don't think it is important. The thing with the CIC BIM Protocol and everything else that is related to BIM, there is no industry standard at the moment. We have PAS 1192, but we don't have that ISO yet … well that will come, but until we have the ISO in place there is no formal doc really. Because there are people who think that the CIC Protocol isn't a good document. Some prefer the AEC version, etc. Until you get the industry standard, then you will continually get the divided opinions.

SN: I would like to know about pre-contract, because you need to prepare the virtual model, at the same time you also need to negotiate about the contract, so, is it going to take long time to prepare everything?

IV-4: PFI competition is very tight. When I first join PFI, PFI bid period is normally 12 weeks. So we need to design building for 60 years in 6 weeks. It takes a long time to build the base of BIM model, but once you built it it is going to be so much easier. If changes happen, it is easy to change. You don't need to take the model away, can just change in front of the client/team members during the meeting. But we finding it becoming more and more difficult to build a BIM model in such a short time scale. A lot of PFI projects, client wants to look at a standard models. So, for instance, for PF2, they look at secondary school, they call them Batch Schools at Luton or Reading it was, there's also schools in Bradford I think… but the client wants is they are looking into two generic forms of design and we can give you a BIM model for a typical school and for this school, we would like you to look at the standard model. And that save a lot of time, so maybe the guys could attend maybe two or three weeks, build a generic model for the school. And that really helps. We pinned ourselves at the couple of locations, designing the schools in 2D and whilst we are doing that we rapidly change to build that the BIM model behind it. So, for the first half of the bid period, we are still looking on electronic 2D information but we can still arrange to have that BIM model, and you can start to have visualisations and you can start with building programmes and etc. It is quite intense to do. But the advantages once you have the BIM model is just endless…. Really2 endless.

SN: Last question, other than the contractual risks and strategies that have been discussed, are there any other contractual risks that you think might occur due to the implementation of BIM in a PFI/PF2 project which you believe need to be addressed?

IV-4: the biggest risk with regards BIM at the moment is client's understanding of what BIM is. And we have received documents that said things like, we would like Level 7 BIM. Client don't know what they are specifying, and if they don't know what they are specifying, you would then ask yourself … how would they marking you in terms of the evaluation. We have found some examples of our project is our Level of BIM compete with other bidders is away in excess,, but can't be marked. There is no way to say you've done a lot better BIM so you deserve to have more marks. The scoring system doesn't allow that to happen. So what we trying do in previous years is trying to help educating the client to say… if you are asking for something, how are you going to mark it? How do you reflect that in the scores? From your research you probably know that to bid for PFI project can cause millions of pounds, so bidders are going to be very worry going to projects where it is clear the client really don't know what BIM is and the benefits of it.

SN: But I thought that clients would normally have their own BIM Advisor?

IV-4: Sometimes they do, but sometimes even their advisors are not very knowledgeable. And reality in the UK, I would say it is a good thing the government mandate about Level 2 BIM, and our project needs to meet that. But I’ve been asked the question before, has the government has supported clients to help they understand what is that means? I don’t think they have. A lot of small government’s departments, small councils, don’t have that expertise. They don’t have that knowledge, they don’t have those skills. And therefore, sometimes, we think because you don’t have a recognised industry standard, you got a CIC BIM Protocol, you got AEC and other different types, then it is very difficult to say that this is what we want, this document is going to use it. Even PAS 1192, we got briefing on how to interpret that documents, because different people interpret them differently. So that is our biggest risk, we spent a lot of money bidding projects, we spent more money on top of that to arrange the project using BIM because we think BIM gives advance advantage. We think BIM gives project the advantage in terms of cost security, design certainty, etc. But ultimately if we don’t win the project we have spent more money probably what we don’t really needed to., and not won the project.

Thank you for your cooperation and help