

A FRAMEWORK FOR THE DIFFUSION OF BUILDING INFORMATION
MODELLING (BIM) ADOPTION STRATEGY FOR THE PRIVATE CLIENT
ORGANISATION

AFIFUDDIN HUSAIRI BIN MAT JUSOH @ HUSSAIN

A thesis submitted in fulfilment of the
requirements for the award of degree of
Doctor of Philosophy

UTM RAZAK School of Engineering and Advance Technology
Universiti Teknologi Malaysia

FEBRUARY 2017

DEDICATION

*Specially dedicated to the construction stakeholders who still believe in the wind of
change in our industry*

ACKNOWLEDGEMENT

My greatest gratitude is to Allah SWT for the successful of this PhD thesis. The preparation of this study has been a tremendous learning experience. I am extremely grateful to the following individuals, groups, and organisations that have supported my involvement in this learning journey.

To my thesis supervisory team for their invaluable encouragement, guidance and productive criticism. I cannot express my gratitude for all of your help. To all of the BIM and Rasch Measurement Model colleagues for their pushing, guidance, and motivation until I managed to complete this study. I hope our friendship will lasts forever! To the BIM and Rasch Professors and experts for their support, guidance, and constructive comments. I hope to have the opportunity to work with all of you in the future. To all my previous teachers and lecturers that have inspiring me to become a valuable person. You will always be my best teacher in my life. To all of my friends and relatives that were with me through all the up's and down's, always lending a helping hand, an ear, and shoulder and uplifting me with your contagious smile through my most stressful times. I could not have done it without you! To all of the respondents for this study, this is your idea, hope and inspiration. It is an honour for me to deliver your notion.

Special thanks go to the whole of my family who have been an important and indispensable sources of spiritual support. Your willing sacrifice, boundless support, and unending love have made this journey possible. For that, I am forever grateful! I do hope and pray that this study will be beneficial to all of the readers out there. In addition, I do wish that this small contribution to the academic world will inspire more people to venture into the world of Building Information Modelling and Diffusion of Innovation research. However, I am the only person responsible for any weakness and flaws in this study.

ABSTRACT

Despite being involved in the global industry and having endorsement from various governments on its advantages, Building Information Modelling (BIM) continues to languish and unable to attract a critical mass of adoption in Malaysian construction industry. Approaching the issue from the interrelated perspectives, this study sought to identify the common components (potential value, expected benefits and challenges of adoption) related to BIM adoption and to suggest diffusion of BIM Adoption Strategy in the Malaysian context. The sample was drawn from the Real Estate and Housing Developers' Association Malaysia (REDHA) listed members from 2012 to 2013. Questionnaires were sent to 925 real estate and housing developers and 152 were returned and analysed using the Rasch Measurement Model. Initially, the following five categories of adopters were identified: Innovators, Late Adopters, Early Majority, Late Majority, and Laggards. Other than that, the findings suggested that although initially there was some resistance, it would be prudent to assume that should there be systematic strategy to support BIM adoption, 58% of the clients' organisation had the potential to adopt BIM within 3 years. It was interesting to report that the ability to increase the turnover of the project has been identified as *de facto* for organisations to employ BIM into their work process. This study also found that lack of direction of BIM will grind for successful BIM adoption in Malaysia. Thus, to support the adoption, this study proposed a Diffusion of BIM Adoption Strategy framework. The framework consists of transformational, operational and human development strategy. The framework also offers a comprehensive deployment of strategies to ensure that rejection will not take place after the organisations have started to adopt BIM. With the right strategies which are implemented in the sound manner, this study believes that BIM adoption in Malaysia will be successful and at par with other early adopter countries.

ABSTRAK

Walaupun terlibat dalam industri global dan mendapat pengesahan daripada pelbagai kerajaan berkenaan kebaikan-kebaikannya, penggunaan Maklumat Pemodelan Bangunan (BIM) terus layu dan tidak dapat menarik penggunaan besar-besaran secara kritikal dalam industri pembangunan di Malaysia. Dengan pendekatan untuk melihat isu ini dari pelbagai perspektif, kajian ini bertujuan untuk mengenal pasti komponen utama (nilai potensi, jangkaan manfaat dan cabaran-cabaran pelaksanaan) yang berkaitan dengan BIM dan mencadangkan strategi penggunaan BIM dalam konteks Malaysia. Sampel telah diambil daripada ahli-ahli Persatuan Hartanah dan Pemaju Perumahan Malaysia (REDHA) dari tahun 2012 hingga 2013. Soal selidik telah dihantar kepada 925 pemaju hartanah dan perumahan. 152 borang soal selidik telah dikembalikan dan dianalisis dengan menggunakan Model Pengukuran Rasch. Pada mulanya, lima kategori pengguna tersebut telah dikenal pasti: Pembawa Pembaharuan, Pengamal Lewat, Majoriti Awal, Majoriti Lewat dan Pengguna Terkemudian. Selain itu, dapatan kajian ini mencadangkan walaupun terdapat beberapa halangan pada peringkat awal, dengan strategi yang sistematik untuk menyokong penggunaan BIM, dijangkakan 58% daripada organisasi klien berpotensi untuk menggunakan BIM dalam tempoh 3 tahun. Adalah menarik untuk melaporkan bahawa keupayaan untuk meningkatkan perolehan bagi projek merupakan faktor utama untuk menyokong penggunaan BIM dalam proses kerja dalam sesebuah organisasi. Kajian ini juga mendapati kekurangan halatuju penggunaan BIM di dalam industri merupakan punca utama kepada penolakan penggunaan BIM. Justeru itu, kajian ini mencadangkan sebuah rangka kerja strategi penerimaan bagi penggunaan BIM. Rangka kerja itu merangkumi strategi transformasi, operasi dan pembangunan manusia. Rangka kerja turut menawarkan strategi yang komprehensif untuk memastikan proses penolakan tidak berlaku selepas organisasi mula menggunakan BIM. Dengan strategi dan cara pengendalian yang betul, kajian ini percaya bahawa penggunaan BIM di Malaysia akan berjaya dan kadar penggunaanya akan setanding dengan negara-negara pengguna awal yang lain.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	i
	DEDICATION	v
	ACKNOWLEDGEMENT	vi
	ABSTRACT	vii
	ABSTRAK	viii
	TABLE OF CONTENTS	ix
	LIST OF TABLES	xvi
	LIST OF FIGURES	xix
	LIST OF ABBREVIATIONS	xx
	LIST OF APPENDICES	xxii
1	INTRODUCTION	1
	1.1 Research Background	1
	1.2 Problem Statement	3
	1.3 Research Aim, Questions, and Objectives	5
	1.4 Significance of study	6
	1.5 Scope of the Study	6
	1.6 Overview of Research Process and Methodology Framework	8
	1.7 Structure of the Thesis	9
2	BIM ADOPTION IN CONSTRUCTION ORGANISATIONS	11
	2.1 Introduction	11
	2.2 BIM Adoption in Construction Industry	11
	2.2.1 Overview of BIM Implementation	12

2.2.2	Review of the Definition of BIM	13
2.2.3	Revolution of BIM Adoption in the Construction Industry	17
2.2.4	Worldwide BIM Adoption	18
2.2.4.1	United States	21
2.2.4.2	United Kingdom	22
2.2.4.3	Singapore	25
2.2.5	An Analysis of the Direction of BIM Adoption in Malaysia	27
2.3	Clients In Construction Project	30
2.3.1	Who is Client in Construction?	31
2.3.2	Issues of the Client Organisation	33
2.4	BIM implementation in Clients organisation	35
2.4.1	BIM Uses	35
2.4.2	Business Benefits of BIM Adoption	37
2.4.2.1	Improve Productivity	37
2.4.2.2	Improve the Design and Construction Process	44
2.4.2.3	Manage the Construction Information	46
2.4.2.4	Improve the Collaboration Process	47
2.4.2.5	Improve the Organisation's Competitiveness	48
2.4.2.6	Enable Off-site Construction	48
2.4.3	Challenges of BIM Adoption	50
2.4.3.1	People Factors	51
2.4.3.2	Process Factors	54
2.4.3.3	Technology Factors	57
2.5	Chapter summary	59
3	DEVELOPMENT OF THE FRAMEWORK	60
3.1	The Diffusion of BIM Adoption	60
3.1.1	Diffusion of Innovation in Organisation	60
3.1.2	General Analysis on the Model/Theory of Organisations Adoption of Innovation.	62
3.1.2.1	Enterprise Adoption Decisions Theory	62

3.1.2.2	The ICT Implementation Process Model	63
3.1.2.3	Process Theory	65
3.1.2.4	A Rationale for Employing the Diffusion of Innovation Theory	65
3.1.3	Theory of Diffusion of Innovation (DoI)	67
3.1.3.1	The Diffusion of Innovation (DoI) Model at a Glance	67
3.1.3.2	Elements of Diffusion of Innovation	70
3.1.3.3	The Innovation-Decision Process	78
3.1.4	Diffusion of BIM Adoption in Malaysian Construction Industry	80
3.2	The Research Framework	84
3.3	Chapter Summary	89
4	RESEARCH METHODOLOGY	90
4.1	Overview of the Research Design and Methodology	90
4.2	Research Phase	92
4.2.1	Stage 1: Empirical Study	92
4.2.1.1	Justification of the Population	92
4.2.1.2	Ethical Consideration	93
4.2.1.3	Instrument Development	94
4.2.1.4	Content Validity	97
4.2.1.5	Pilot Study	98
4.2.1.6	Rasch Measurement Model	99
4.2.1.7	Outcome from the Pilot Study – Construct Validity	101
4.2.2	Stage 2: Model Development	102
4.3	Summary	103
5	ANALYSIS ON THE DIFFUSION OF BIM ADOPTION IN MALAYSIA	104
5.1	Introduction	104
5.1.1	Response Rate	105
5.1.2	Analysis of Non-response Bias	107

5.2	Descriptive Statistical Analysis	109
5.2.1	Organisation Demographic Profiles	109
5.2.2	The General Respondents' Demographic Information	110
5.3	Rasch Measurement Analysis	112
5.3.1	Objective 1: To Profile BIM Adopters and the Potential Values of BIM Based on its Uses	112
5.3.1.1	Goodness-of-Fit of the Data	112
5.3.1.2	Profiling the Potential of Clients' Organisation towards Adopting BIM in Malaysia	116
5.3.2	Objective 2: To Measure the Benefits that the Organisations Expect to Gain from BIM Adoption	120
5.3.2.1	Analysis on Goodness-of-Fit of Data	120
5.3.2.2	Measure the Clients' Expected Benefit for BIM Implementation in Malaysia	123
5.3.3	Objective 3: To Categorise the Challenges for Organisations Who Wish to Adopt BIM	128
5.3.3.1	Goodness-of-fit of the Data	128
5.3.3.2	Analysis for Categorising the Challenges for the Implementation of BIM	131
5.4	Qualitative Analysis on Open-Ended Question	136
5.4.1	Identification of the Significant Organisations Expected Benefits from BIM Adoption	136
5.4.1.1	Constructive Comments on BIM adoption	137
5.4.2	Identification of the significant organisations challenges for BIM adoption	140
5.5	Analysis on the expected benefits and challenges for BIM adoption	143
5.6	Summary	145

6	DISCUSSION AND MODEL DEVELOPMENT	146
6.1	Demographic Analysis	146
6.2	Response Rate	147
6.3	Discussion Profile of the Respondents and Their Organisations	148
6.4	Research Objective 1: To Profile the Potential of BIM Adoption Based on BIM Uses	150
6.4.1	Profile 1: Innovators	150
6.4.2	Profile 2: Early Adopters	151
6.4.3	Profile 3: Early Majority	152
6.4.4	Profile 4: Late Majority	153
6.4.5	Profile 5: Laggards	154
6.5	Research Objective 2: To Measure the Benefits that the Organisations Expect to Gain from BIM Adoption	157
6.6	Research Objective 3: What Are the Challenges Faced by the Organisations in Adopting BIM?	159
6.6.1	Challenges of Transformational Strategy	160
6.6.2	Challenges for Human Development Strategy	162
6.6.3	Challenges of the Operational Strategy	163
6.7	Research Objective 4: How to Diffuse BIM Adoption in Malaysia?	165
6.7.1	The Development of BIM Decision Process Framework	165
6.7.1.1	Stage 1: Knowledge	167
6.7.1.2	Stage 2: Persuasion	170
6.7.1.3	Stage 3: Decision	172
6.7.2	Formulating the Strategy for Deployment of BIM Adoption	175
6.7.2.1	Transformational Strategy	177
6.7.2.2	Human Development Strategy	179
6.7.2.3	Operational Strategy	180
6.7.2.4	Deployment of BIM Adoption Strategy Framework	182

6.8	Framework Validation	187
6.8.1	The Validation Process	187
6.8.2	Response Rate	189
6.8.3	Respondents' Characteristics	189
6.8.4	Empirical Results and Analysis	190
6.8.5	Thematic Analysis on the Feedback from the Respondents	193
6.9	Overall Discussion on the Development of Conceptual Framework	195
7	CONCLUSION, CONTRIBUTION, LIMITATIONS AND RECOMMENDATIONS	197
7.1	Revision of Research Aim and Process	197
7.2	Achievements of the Research Objective	199
7.2.1	Research Question 1: To Profile BIM Adopters and the Potential Values of BIM Based on Its Uses	200
7.2.2	Research Objective 2: To Measure the Benefits that the Organisations Expect to Gain From BIM Adoption	201
7.2.3	Research Objective 3: To Categorise the Challenges for Organisations that Wish to Adopt BIM	201
7.2.4	Research Objective 4: To Propose the Diffusion Of BIM Adoption Strategy for Private Client's Organisation in Malaysia	203
7.3	Contribution and Implication	205
7.3.1	Theoretical Contribution	205
7.3.2	Knowledge Contribution	206
7.3.3	Practical Contribution	207
7.3.4	Methodological Contribution	208
7.4	Limitation of the Findings in Relation to the Present Knowledge	208
7.5	Recommendations for Further Research	209
7.6	Closing Remarks	211

REFERENCES	217
APPENDICES A - C	235 - 247

LIST OF TABLES

TABLE NO.	TITLE	PAGE
2.1	Analysis of the theme definition of BIM	14
2.2	Definitions of BIM according to the National documents	16
2.3	Available BIM Guide	20
3.1	The ICT implementation process	64
3.2	Previous study that employed DoI	67
3.3	Adopter categories	73
3.4	Expected benefits from BIM adoption	85
3.5	Challenges for BIM adoption	86
4.1	Summary of the instrument	96
4.2	Response rate	98
4.3	Matrix of summary of validity analysis for pilot study	101
4.4	Summary of research stage	103
5.1	Response rate	106
5.2	Respondents demographic information	110
5.3	The general respondents demographic information	111
5.4	Analysis for profiling the potential of organisation towards implementing BIM in Malaysia	112
5.5	Standardised residual variance (in Eigenvalue units) for profiling the potential of organisation towards implementing BIM in Malaysia	114
5.6	Final analysis for profiling the potential of organisation towards implementing BIM in Malaysia	114
5.7	Item misfit order of item for profiling the potential of organisation towards implementing BIM in Malaysia	116
5.8	Measure order of the items for profiling the potential of organisation towards adopting BIM in Malaysia	117

5.9	Matrix of categorisation for profiling the potential of an organisation towards adopting BIM in Malaysia	118
5.10	Final analysis for profiling the potential of organisation towards measuring the clients' expected benefit for BIM implementation in Malaysia	121
5.11	Standardised residual variance (in Eigenvalue units) for profiling the potential of organisation towards implementing BIM in Malaysia	122
5.12	Misfit order of item statistics for measuring the clients' expected benefit for BIM implementation in Malaysia	123
5.13	Measure order of the items in measuring the clients' expected benefit for BIM implementation in Malaysia	124
5.14	Matrix categorisation of the clients' expected benefit for BIM implementation	126
5.15	Matrix categorisation of the item for the expected benefit for BIM implementation	127
5.16	Final analysis for categorising the challenges for the implementation of BIM	128
5.17	Standardised residual variance (in Eigenvalue units) for benefit of organisations implementing BIM in Malaysia	129
5.18	Misfit order of the items for categorising the challenges for the implementation of BIM	130
5.19	Measure order of the items for categorising the challenges for the implementation of BIM	131
5.20	Matrix of categorisation for categorising challenges for BIM implementation	134
5.21	Matrix of challenging item measures and categorisation of benefits	135
5.22	Matrix of qualitative analysis on expected benefit and challenges of BIM adoption	143
6.1	Demographic profiling	155
6.2	Critical benefits for BIM adoption	157
6.3	Matrix of challenges and category of challenges	160

6.4	Matrix of challenges, strategy category and objectives of proposed strategy	176
6.5	Matrix of BIM adoption strategies	182
6.6	Demographic information	190
6.7	Summary statistics	191
6.8	Agreed with the proposed framework	193
6.9	Suggestion for improvement of framework	194

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
1.1	Overview of research process and methodology framework	8
3.1	Summary of the various stage of model/theory of organisation adoption of innovation	66
3.2	The ‘S’ DoI curve (Roger, 1995; 2003)	69
3.3	The Newton ball diffusion acceleration effect, Meloney (2010)	74
3.4	The Chasm (Moore, 1991)	75
3.5	The Innovation-Decision process	78
3.6	Conceptual framework	84
5.1	Data collection waves	107
5.2	Organisation DIF t-Value	108
5.3	Organisation DIF size	109
5.4	Profiling the potential of an organisation towards adopting BIM	119
5.5	A distribution map of the organisations’ expected benefit for BIM implementation	125
5.6	A distribution map of the organisations’ challenges for BIM adoption	133
6.1	BIM Decision Process Framework	166
6.3	Validation map	193
6.4	Conceptual framework	195
6.5	Research framework	196

LIST OF ABBREVIATIONS

2D	-	2 Dimensional
3D	-	3 Dimensional
4D	-	4 Dimensional
5D	-	5 Dimensional
AEC	-	Architectural, Engineering and Construction
AGCA	-	Associated General Contractors of America
AIA	-	American Institute of Architects
ASCE	-	American Society of Civil Engineers
BIM	-	Building Information Modeling
C&S	-	Civil and Structure Engineering
CAD	-	Computer-aided drafting
CIDB	-	Construction Industry Development Board
CIFE	-	Center for Integrated Facility Engineering, Stanford
CIMP	-	Construction Industry Master Plan
CITP	-	Construction Industry Transformation Programme
CREAM	-	Construction Research Institute of Malaysia
EPU	-	Economic Planning Unit
ETP	-	Economic Transformation Programme
GDP	-	Gross domestic product
IBS	-	Industrialised Building System
ICT	-	Information & Communication Technology
IFC	-	Industry Foundation Classes
IPD	-	Integrated Project Delivery
IS	-	Information System
MEP	-	Mechanical, Electrical and Plumbing
MP	-	Malaysia Plan
MPC	-	Malaysia Productivity Corporation

n-D	-	n Dimension
NIBS	-	National Institute of Building Standards
PEMANDU	-	Performance Management and Delivery Unit
PWD	-	Public Work Department
R&D	-	Research and Development
RICS	-	Royal Institute of Chartered Surveyor
ROI	-	Return on Investment
U.K	-	United Kingdom
U.S	-	United States
VDC	-	Virtual Design Construction

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Questionnaire (Pilot Survey)	235
B	Questionnaire (Full Survey)	239
C	Questionnaire (Validation of Framework)	244

CHAPTER 1

INTRODUCTION

1.1 Research Background

In Malaysia, the construction industry is unquestionably one of the most productive sectors and it has constantly been one of the engines of national economic growth. Given that Malaysia aims to become a fully industrialised nation by 2020, the construction industry needs to provide the economic and social infrastructure to facilitate industrialisation. Existing evidence indicates that the construction industry has a strong correlation with economic development and made significant contributions towards the growth of Gross Domestic Product (GDP) rate, rising from RM19.82b in 2010 to RM26.90b in 2014 (Malaysia Productivity Corporation, 2015). This suggests that the construction industry in Malaysia has a vital role to play in the country's development as construction productivity flows across other industries.

The government, through top-down approaches, has introduced a number of policies and initiatives, such as the Economic Transformation Programme (ETP) that are specifically designed to facilitate the construction industry in meeting its objectives of nation building. More precisely, increase in productivity at the macro level has emerged as one of the top priorities in the 10th and 11th Malaysian Plans (BNM, 2015b; CIDB, 2015; MOF, 2015; PMO, 2015). Specifically to overcome some of the weaknesses that are inherent in productivity in the construction industry, Construction Industry Transformation Programme (CITP) 2016–2020 has implemented several strategic thrusts to resolve productivity issues (CIDB, 2015). They are as follows: (1) to integrate the construction value chain, (2) to strengthen the construction industry image, (3) to develop human resource capabilities and

capacities, (4) to innovate research and development in the creation of new construction methods, (5) to leverage on information and communication technology in the construction industry, and (6) to benefit from globalisation. Ultimately, CITP 2016–2020 envisions that the construction industry in Malaysia will soon become a world-class, innovative, and knowledgeable global solution provider.

Although the government has introduced and implemented policies and initiatives to enhance productivity in the Malaysian construction industry, these have been conducted at a slower pace compared to that of other developed countries. Previous researchers have highlighted that these issues are due to the heavy reliance on human capital (Othman and Jaafar, 2013; Ramayah *et al.*, 2009) and the reluctance to adopt new technology (Abidin, Yusof, and Othman, 2013; T. K. Chan, 2009; Masrom *et al.*, 2013). Given the foregoing discussion, the Malaysia Productivity Corporation (Malaysia Productivity Corporation, 2015) has concluded that Malaysia has yet to utilise the bulk of the productivity-enhancing systems. Apart from being expensive, the implementation of these systems may involve prohibitive cost, which may also lead to a shortage of skilled workers.

The recent advance of digital technology has revolutionised the productivity landscape of the global construction industry (Bricogne *et al.*, and Ducellier, 2011). Although this is seen as a global phenomenon, the present study argues that digital technology can be capitalised until this leads to a digital revolution which may mitigate productivity issues in the Malaysian construction industry. The digital revolution of the construction organisation is regarded as a major impact with small beginnings.

It is imperative that more construction organisations should continue to search for a methodology to take advantage of this digital revolution to increase their productivity in a more strategic and conscientious manner. The digital revolution is also transforming the industry setting, in which the evolution of design and construction process has enabled the transition from electronic drafting to high technology of digital modelling process (also known as Building Information Modelling). The numerous benefits gained from BIM adoption have led to the wave

of changes that are now happening in the construction industry at a global scale. Indeed, a large number of early adopter countries have embraced and gained the benefits of BIM adoption.

1.2 Problem Statement

Despite the fact that BIM has been adopted globally, there is still room for improvement for the construction industry in Malaysia. In spite of encouragement of the Malaysian government through various strategy and policies, the uptake for BIM adoption at the national level is still slow. Therefore, there are several key issues that need to be elucidated to address the current issues of BIM adoption:

- i. BIM has the potential to improve productivity due to its global success. A number of early adopter countries have mandated BIM. Nevertheless, the current climate worldwide does not provide the impetus for BIM to grow rapidly in Malaysia. As a result, the Malaysian construction industry is indecisive with regard to BIM adoption. Hence, it is argued that there is a need to first explore the rationalisation of BIM adoption in Malaysia in order to understand the characteristics of the organisations that are ready to adopt BIM and those organisations that are not. This may be one reason why the adoption of BIM is still in its infancy.
- ii. Since most studies suggest the tendency to concentrate on the success of BIM adoption in developed countries, little is known about its adoption in developing countries such as Malaysia. Hence, it appears that information regarding the BIM adoption, in terms of potential values, benefits, and challenges to Malaysia, is very scarce which points to a marked knowledge gap of the subject.
- iii. Clients play a major role in the transformation of the construction industry (Ahbabi & Alshawi, 2015; Karathodoros, 2013). However, the existing body of BIM work has not been explored from the perspective of client organisations especially in Malaysia, where BIM has not been fully implemented. In this regard, previous studies have argued that clients are faced with the decision-making dilemma of whether or not to utilise BIM due to the many speculative

benefits that BIM is expected to bring (Ahhabi and Alshawi, 2015; Murphy, 2014; Sebastian, 2011). These types of organisational behaviour and the vital role played by client organisations form the basis for examining the antecedents of client organisation prior to their adoption of BIM. The limited literature on the antecedents of client organisation is another problematic issue, which provides a clear justification for the present study to be conducted.

- iv. Even though there have been several studies on BIM adoption, the present study makes an assertion that while they may seem pertinent, the authenticity and generalisability of the findings of such studies to Malaysian construction organisation are still considerably a question of debate. There seems to be a void in the currently available body of literature that highlights the role of client organisations in ensuring the success of BIM adoption at the micro level and the future direction of BIM at the national level. Therefore, there is another need to uncover the reasons as to why Malaysia lags behind other early BIM adopter countries and to propose how the situation can be transformed by engaging client organisations to play an active role in the transformation process. In effect, the deployment of a BIM adoption strategy is vital in attempting to foster BIM implementation as it presents a new innovative technology within the construction industry.
- v. It appears that, to date, no research has been conducted in Malaysia regarding the strategic level of BIM adoption. This signifies that the strategy to induce the BIM adoption in the emerging Malaysian construction market has not yet been entirely investigated. Hence, comprehensive research to explore the reason for the slow uptake of BIM in the Malaysian construction industry is crucial.

1.3 Research Aim, Questions and Objectives

The problem discussed in the earlier section highlighted a few interlinking questions in terms of the BIM adoption strategy. Therefore, the aim of this study is to develop a framework for the diffusion of BIM adoption strategy for the client organisations.

In response to the research problem and aim, this study sought to answer the following research questions:

- i. How do the organisations perceive the value of BIM use towards BIM adoption?
- ii. What benefits do the organisations expect to gain from BIM adoption?
- iii. What are the challenges for organisations that wish to adopt BIM?
- iv. How can BIM adoption be diffused in Malaysia.

These questions were formulated to achieve the following research objectives:

- i. To profile BIM adopters and the potential values of BIM based on its uses;
- ii. To measure the benefits that the organisations expect to gain from BIM adoption;
- iii. To classify the challenges for organisations that wish to adopt BIM; and,
- iv. To develop the diffusion of a BIM adoption strategy for private client's organisation in Malaysia.

1.4 Significance of Study

At present, the application of BIM is used widely in many countries including developed nations. Because of the adoption of BIM is relatively new in the Malaysian scenario, this study is carried out to analyse the viability of BIM in the Malaysian construction industry. At a theoretical level, it adds to the body of literature related to BIM adoption. At the practical level, the finding of this study will help policy makers to formulate new regulation based on informed decision.

1.5 Scope of the Study

While the findings of this study meant to provide a basis for generalisations to other settings and contexts, the scope of the present study needs to be identified in the following aspects:

- i. The respondents: The setting of this research work involved 975 housing and property developers (subsequently referred to as clients) in Malaysia. The sample was drawn from a list of Housing and Property Developers over 2012–2013 periods, published by the Real Estate and Housing Developers' Association (REHDA) in Malaysia. Since this study concentrated on client organisations, this limitation constrained the findings to be generalised to other stakeholders. The details of justification for selection of clients are discussed in Section 2.3.
- ii. Data collection period: The time setting for data collection was from March 2014 to January 2015. During this period, no government agency or body had mandated the usage of BIM. Research into BIM was also scarce as none of the academic institutions had set up a unit or department to look into BIM-related matters. In addition, although there were national scale reports or surveys on BIM usage, they were mainly conducted in developed countries and such was not the case with Malaysia (Mohd-Nor and Grant, 2014).
- iii. Research approach: At the time that this study was conducted, BIM adoption was an exclusive and complicated field to explore. Thus, this study explored the

surface of the adoption, as there was no exploratory study conducted on the BIM adoption by client organisations. To fulfil the exploratory nature of the present study, the quantitative approach was employed to identify the attributes of clients' organisation towards adopting BIM.

1.6 Overview of Research Process and Methodology Framework

In order to fulfil its aim and objectives, this study has three phases; the first is the conceptual study, followed by the empirical study, and lastly the development of diffusion of BIM innovation framework.

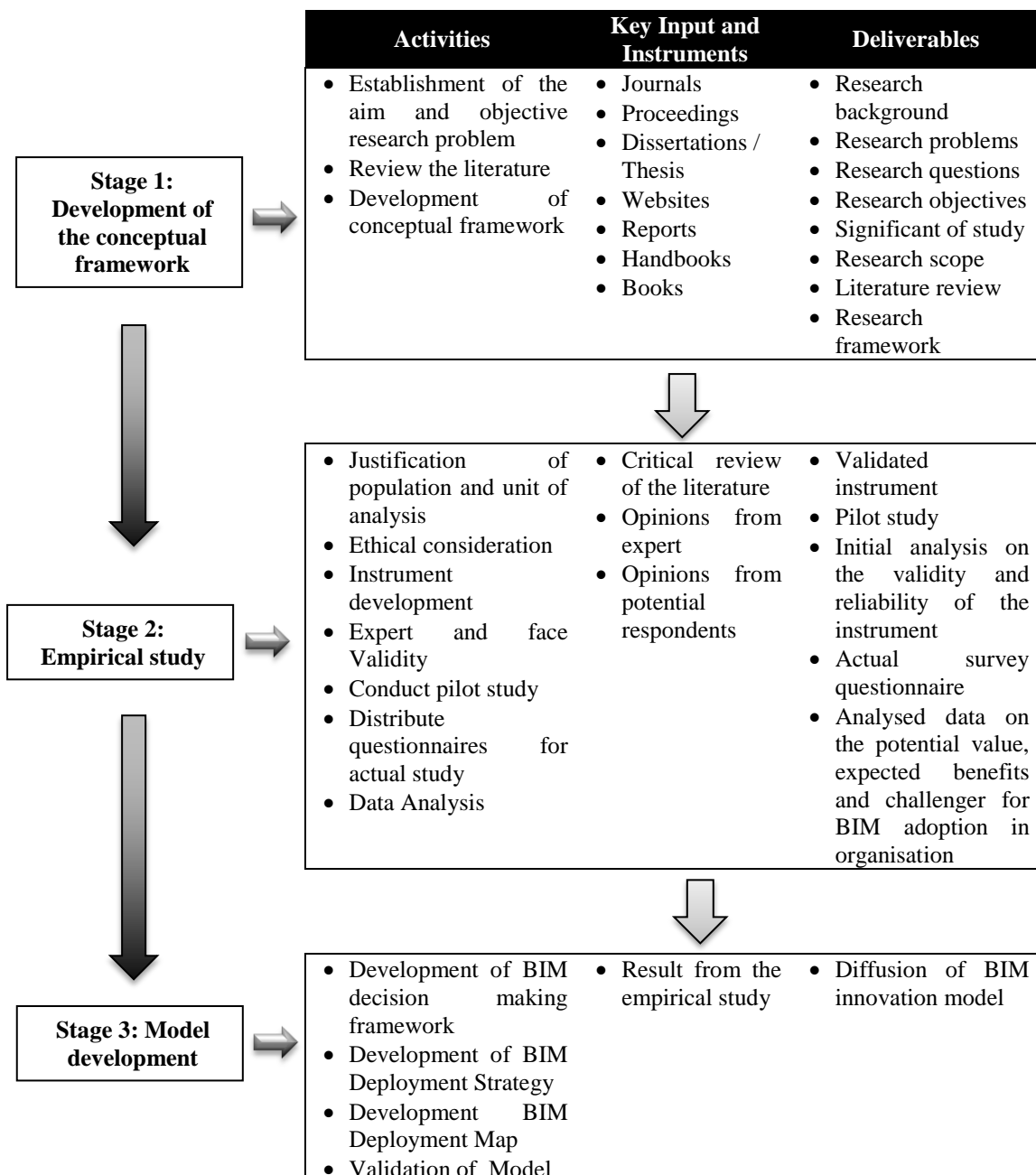


Figure 1.1 Overview of research process and methodology framework

1.7 Structure of the Thesis

Chapter One laid the foundation for this study. It begins with the description of the scenario surrounding the research background, and the discussion further narrows down to the definition of the research problem that justifies the rationale of this study. To support this proposition, the research aim, questions and objectives are presented. This chapter provides the justification regarding the scope of study. It also gives an overview of the research methodology. Finally, the structure of the thesis is presented.

Chapter Two provides a comprehensive review salient literature in the BIM adoption in construction industry at macro level and client organisation at micro level. At macro level, this chapter will review the overview of BIM implementation, definition, revolution and worldwide BIM adoption. This chapter also present an analysis of the direction of BIM adoption in Malaysia. At micro level, this chapter will define who is a client in construction. Furthermore, discussion on the issues, impact of BIM, BIM uses, business benefits and challenges for BIM implementation also presented.

Chapter Three provide review on the underpinning theory of Diffusion of BIM adoption. In essence, this chapter provides a conceptual framework for the whole research and propose framework for the diffusion of BIM adoption strategy for the private client.

Chapter Four aims to discuss the research design and methodology that are chosen for this study. The justification, relevance and adequateness of the research design and methods are presented in this chapter. This chapter opens with a discussion of the overview of research design and methodology. Following is a section which provides a discussion on the research phases (Stage 1—Conceptual study; Stage 2—Empirical study, and Stage 3—Model development).

Chapter Five aims to outline the results of the descriptive analysis of the final data. The analysis is divided into two major parts. In the first part, a descriptive

analysis of organisation and respondents' demographic is presented. The second part presents the results of the Rasch measurement model and gives an analysis of the open-ended questions.

Chapter Six will triangulate the match and mismatch between the relevant literature, quantitative analysis of the survey, and analysis from the open-ended questions. The presentation of data and discussion of the findings Chapter Six is based on the themes generated according to the research objectives and research questions. For ease of presentation, each of these themes will be allocated a separate sub-section in which the results of data analysis and discussions of the findings to the relevant research questions will be presented in an integrated manner.

Following this, Chapter Seven will provide a summary of previous chapters, present the contributions and implications of this study, propose future research recommendations and will draw conclusions of this research.