AN EMPIRICAL INVESTIGATION THE ADOPTION FACTORS OF BUILDING INFORMATION MODELLING (BIM) FROM THE PERSPECTIVE OF MALAYSIAN CIVIL AND STRUCTURE CONSULTANT FIRMS

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In the name of God, the Merciful praise is to God and prayers and peace on our master and our beloved Muhammad the Messenger of Allah (may Allah bless him and grant him peace) and his honourable companions and those who followed for him.

ABSTRAK

Dalam Revolusi Industri ke-Empat (IR 4.0), industry pembinaan sepatutnya menumpukan terhadap kerja-kerja pembinaan yang berkaitan dengan kemahiran menggunakan teknologi terkini berbanding penggunaan tenaga buruh secara berlebihan. Tetapi industri pembinaan di Malaysia masih lagi menggunakan kaedah tradisional yang mana ianya banyak menggunakan tenaga buruh berbanding menggunakan teknologi terkini. Kesan dari kaedah ini menyebabkan isu pengasingan antara ahli projek dan menyebabkan produktiviti menurun dan tidak efektif. Untuk mengatasi masalah tersebut, Pemodelan Maklumat Bangunan (BIM) boleh dikategorikan sebagai pendekatan inovatif yang menawarkan platform untuk mengintegrasikan antara pihak-pihak yang berkepentingan di dalam sesuatu projek pembinaan. Selain itu BIM juga berupaya meningkatkan produktiviti kerja dan menghasilkan kerja yang sangat efektif. Walaupun banyak faedah boleh diperlolehi oleh industri pembinaan dengan penggunaan BIM dan pelbagai usaha telah dilakukan oleh pihak kerajaan untuk mempromosi BIM seperti pengajuran seminar, bengkel dan insentif namun kadar pengunaan BIM masih lagi rendah jika dibandingkan dengan negara negara asia yang lain. Sehubungan dengan itu, adalah penting untuk mengkaji faktor yang boleh menyebabkan pihak industri menggunakan BIM terutama dari perspektif firma perunding sivil dan struktur (C&S). Banyak kajian sebelum ini telah mengkaji dari perspektif seni bina, pengurusan kemudahan, juru ukur kuantiti dan kontraktor namun sangat sedikit kajian dari sudut perspektif firma perunding C & S. Ini sangat penting kerana firma perunding C & S memainkan peranan penting dalam memastikan rekabentuknya boleh dibina, dikendalikan dan dikekalkan. Oleh itu, tujuan kajian ini adalah untuk mengkaji hubungan antara organisasi, orang dan teknologi dalam membuat keputusan untuk mengunakan BIM dari sudut perspektif firma perunding C&S. Kajian ini menggunakan pendekatan kualitatif dan kuantitatif didalalm usaha untuk memahami keadaan semasa terhadap isu isu yang melibatkan penggunaan BIM. Dan pada masa yang sama dapat meneroka faktor-faktor yang mempengaruhi penggunaan BIM dalam industri pembinaan Malaysia. Ketiadaan garis panduan untuk melaksanakan BIM, kurangnya permintaan dari pelanggan atau kerajaan dan kurang sokongan teknikal dari pakar BIM adalah cabaran yang dihadapi oleh para pengamal BIM selain harga yang mahal dalam membiaya pembelian teknologi BIM. Analisis dari regresi linear berganda mendapati faktor yang mempunyai hubungan yang kuat dalam mempengaruhi organisasi untuk mengamalkan BIM adalah; mempunyai sokongan yang kuat dari pihak pengurusan atasan, paksaan atau tekanan, mempunyai pelan pelaksanaan BIM yang jelas, menawarkan skim latihan, mempunyai pasukan BIM yang kompetent, mempunyai spesifikasi pekerjaan yang jelas, teknologi BIM harus bebas dari isu kebolehoperasian, biaya teknologi tidak membebani organisasi dan teknologi itu harus mempunyai keserasian dengan teknologi terkini. Hasil dari kajian ini menawarkan satu pandangan baru dari perspektif firma perunding C & S dalam mengenal pasti faktor-faktor yang mempengaruhi penggunaan BIM. Pada masa yang sama, ia boleh mengisi jurang dari kajian terdahulu dengan memperluaskan kajian penerimaan BIM dari sudut pandangan firma perunding C & S dan ianya melengkapkan keseluruhannya sudut penerimaan BIM daripada semua pemain industry pembinaan.

ABSTRACT

The construction industry in the Fourth Industrial Revolution (IR 4.0) have to focus on high-technology jobs such as technological skill rather than labour-intensive approach and low-skilled job. But, most of the construction industries in Malaysia are using traditional approach which is labour-intensive approach and it has resulted in fragmentation issue among the project participants resulting less productivity and inefficiency in delivering the project. In order to tackle this issue, Building Information Modelling (BIM) can offer a platform to integrate between different parties in the construction industry. It also offers a lot of benefits to construction industry in term of productivity and efficiency. Even though there are a lot of benefits that can be gained by BIM utilisation and many efforts to increase the adoption of BIM in construction projects such as conducting the seminars, workshops and incentives but, the rate of BIM adoption by the Malaysian construction players is still low compared to other Asians countries. Therefore, there is a need to study the adoption factors within Malaysian construction industry that could facilitate the pace of BIM adoption in Malaysia especially from the perspective of civil and structure (C&S) consultant firms. Several studies had explored the way to increase the pace of BIM adoption from the perspective of architectures, facilities management, quantity surveyor and contractors, and very little effort to identify the adoption factors and its relationship that could facilitate the adoption of BIM especially from the perspective of C&S consultant firms. C&S consultant firm plays a vital role to ensure the design is constructible, operable and maintainable. Thus, the aim of this study is to examine the relationship between organizations, people and technology towards making decisions in adopting BIM from the perspective C&S consultant firm. In this study, qualitative and quantitative approaches have been utilised as research method to develop in-depth understanding of the happening by obtaining the views on the subject studied especially the current application of BIM in the Malaysian construction industry. At the same time, this study is conducted to explore what are the factors that affecting the adoption of BIM in the Malaysian construction industry. Lack of national guideline for implementing BIM, pressure from clients or governments and lacking of technical support from BIM experts are the vital challenges faced by the adopters besides having a higher cost of early investment in BIM technology. Analysis from multiple linear regression revealed the factors that have a strong relationship in influencing organisation to adopt BIM are; having a strong support from the top management, having a coercive pressure, having a clear BIM implementation plan, undergo training, having a BIM competency team, having a clear job specification for new roles, BIM technology must free from interoperability issue, less cost of technology, and the issue of compatibility. This study offers a new insight from the perspective of C&S consultant firms on the adoption of BIM and could improve the rate of BIM adoption. At the same time, it could fill the gap from previous studies by extending the study of BIM adoption by investigating from C&S consultant firm's point of view and it complementing the overall view of BIM adoption from all participants.

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LIST OF ABBREVIATIONS

2D	2 Dimensional
3D	3 Dimensional
4D	4 Dimensional
5D	5 Dimensional
n-D	n Dimensional
AEC	Architectural, Engineering and Construction
AGC	The Associated General Contractors of America
BIM	Building Information Modelling
C&S	Civil and Structure
CAD	Computer Aided Design
CIMP	Construction Industry Master Plan of Malaysia
CIDB	Construction Industry Development Board of Malaysia
CITP	Construction Industry Transformation Plan
CREAM	Construction Research Institute of Malaysia
EPU	Economy Planning Unit of Malaysia
GDP	Gross Domestic Product
IBS	Industrialised Building System
ICT	Information & Communication Technology
IFC	Industry Foundation Classes
IS	Information System
ISO	International Organisation for Standardisation
IT	Information Technology
MEP	Mechanical, Electrical and Plumbing
PWD	Public Work Department of Malaysia
R&D	Research and Development
RAM	Random Access Memory
RICS	Royal Institution of Chartered Surveyor
RM	Ringgit Malaysia
U.S	United States of America
U.K	United Kingdom
VDC	Virtual Design and Construction

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CHAPTER 1

INTRODUCTION

1.1 Introduction

In Malaysia, construction industry makes a significant contribution to the country. Over the past decade, this sector annually accounted for about 3.5% of the Gross Domestic Product (GDP) and provided employment for about 10% of the total labour (Department of Statistic Malaysia, 2014). However, the economic downturn from the mid of 2007 until 2008 due to global financial crisis, construction industry in Malaysia enjoyed an additional budget amounting to RM60 billion under government driven stimulus package to spur the construction activities in Malaysia (Malaysian-German Chamber of Commerce, 2010) and this has resulted the Malaysian economy began to climb up and achieve a slow recovery. Malaysian Engineering Consulting companies as part of Malaysian construction industry play a big role in reviving the Malaysian economy. According to Accenture (2010), the size of economic contribute by Malaysian Engineering Consulting companies was valued around RM1.59 billion to RM2.39 billion from the total of Malaysian construction industry spending which is RM77.3 billion. This figure shows, roles of Civil and Structure (C&S) consultant firm as part of Malaysian Engineering Consulting companies in the economic development of the country are not deniable.

Despite having a strong support from the Malaysian government, in reality, Malaysian construction industry is facing a serious problem although the government via Construction Industry Development Board (CIDB) put many efforts to upgrade the level of knowledge and skills among the construction player such as too depending on unskilled and foreign labour, low productivity and lack of innovation in construction (CIDB, 2011 and Kamal and Flanagan 2012).

Abdul Rahman, Berawi, Berwai, Mohamed, Othman & Yahya (2006), Murali, S. & Soon, Y. W. (2007), Ramanathan (2012) and Hamzah, Khoiry, Arshada, Tawil & Che

Ani (2011) added other problem facing by the government is delay in completing the construction project where about 17.3%, government contract projects in Malaysia were considered sick due to the delay of more than three months or abandoned due to various causes. A study conducted by Hamzah et al. (2011), there are many factors contributed to the delay in completing the construction project such as contractor's lack of experience, poor site monitor, failure and defective during construction, poor supervision, delay during the design stage and inability to estimate project duration. But the main factor that contributed to these issues is failure in providing information to construction site. This is mainly because the construction process in Malaysia is separated between the design phase and construction phase where it has led to the issue of fragmentation (Hamzah et al., 2011, Mohd et al., 2014). These show the problems faced by Malaysian construction industry.

Murali, S. & Soon, Y. W. (2007), Hamzah et al. (2011) and Mohd et al. (2014) believed that these problems arose because of failure to effective communicate among parties in the construction industry due to parties in the construction industry working in their own silo that resulting to inefficiencies. Communication between parties in construction will be difficult because each party has a various background, references and goal. When there is a failure of communication between parties, the consequences are the plans and specifications will not be clearly defined. The contractors must spend their time asking for clarification, changing of plans, and sometimes re-working components that were installed according to the contractor's interpretation of the documents, but not in compliance with the owner's needs. Mohd et al. (2014) identified that poor in transmitting communication and information; coordination and teamwork have been the main causes of most of the performance problems in the construction industry.

To improve collaboration and communication among construction players, having a proper documentation management can be achieved via the implementation of Building Information Modelling (BIM) according to Eastman et al. (2011) and Ding et al. (2014). BIM also improves communication and collaboration among construction players in order to increase efficiency and effectiveness in managing construction projects. BIM implementation in the construction industry has been widely used in the United States of America (USA), Hong Kong (HK), Australia, and Singapore (Eastman et al., 2011; Monteiro & Martin, 2013 and Ahmad Latiffi et al., 2014). However, according to CIDB (2014) the implementation of BIM in the Malaysian construction industry is still new.

The Malaysian government know that, BIM in Malaysia still infant and therefore the Malaysian government has taken many efforts to introduce and increase the adoption of BIM in construction projects that include the involvement of Construction Industry Development Board (CIDB) and Public Works Department (PWD) to encourage construction players to implement BIM such as organized several seminars and preparing BIM roadmap as well as guideline as a way to promote BIM (CIDB, 2014). By having BIM seminars, construction players will be aware of the existence of BIM and the benefits that they could gain by implementing it. Besides having seminars and workshops, several BIM pilot projects have been constructed to test the capabilities of BIM beside to identified any risks and these BIM pilot projects monitored by PWD (Ahmad Latiffi, Mohd, Kasim & Fathi, 2013).

In 2015, CIDB collaborated with PWD launching the Construction Industry Transformation Plan (CITP) 2016 – 2020 to transform Malaysian construction industry. This plan is a continuation from CIMP 2006 – 2015. In CITP 2016 -2020, there are four strategic thrusts namely; Quality, Safety & Professionalism, Environment Sustainability, Productivity and Internationalisation and each thrust have its own initiatives (CITP, 2016). In CITP 2016 – 2020, initiative for BIM is under thrust productivity which rolls out technology advantage a cross project life cycle. Under this initiative, PWD should facilitate BIM adoption in construction via regulation and establish reference centre to support the development and adoption of BIM and modern method and by 2020 CIDB has targeted the adoption by construction industry in Malaysia is about 40% (CIDB, 2015).

This show how serious the government intention to transform current construction practice. But, the recent studies from 2007 – 2015, CIDB found that the percentage of adopting BIM in Malaysia is about 17%. This figure shows the low level of BIM adoption in Malaysia compared to Japan (43%) and South Korea (52%) in 2015 (McGraw Hill, 2014 and CIDB, 2015). Although there are many efforts done by the Malaysian government to increase the adoption of BIM in construction projects, but the rate of BIM adoption is still low.

To increase the rate of BIM adoption in Malaysian context, several studies have explored the issues, benefits, readiness and adoption of BIM. Harris, Che Ani, Haron & Husain (2014) studied the possibilities the implementation of BIM by the contractors, Abdullah, Sulaiman, Latiffi & Baldry (2014) studied the benefit and opportunities by implement BIM from the perspective of Facilities Manager, Ali, Ibrahim & Boon (2013) studied the awareness and readiness from the perspective of Quantity Surveyor and Haron (2013) studied the readiness framework for general design consultants. However, there is not much effort to identify the adoption factors and its relationship that could facilitate the adoption of BIM especially from the perspective of (C&S) consultant firms.

Thus, there is a need to study the adoption factors within Malaysian constructions industry that could facilitate the pace of BIM adoption in Malaysia especially from the perspective of (C&S) consultant firms.

1.2 Problem Statement

Despite Malaysian Engineering Consulting companies recognised as a part of sector that have significant contribution to Malaysian economy, in reality, this sector is facing various problems. Low productivity, lack of innovation, resistance to change and adopt to new technology, delay in completing the design for complex projects are some of issues faces by Malaysian Engineering consulting companies. These issues resulting delay in completing the construction project. To solve these issues, Malaysian government has taken many efforts to introduce and increase the adoption of Building Information Modelling (BIM) in construction projects that include the involvement of Construction Industry Development Board (CIDB) and Public Works Department (PWD) to encourage construction players to implement BIM. But, the adoption rate by the Malaysian construction industry still low. In order to increase the adoption rate, there are several studies have explored the issues, benefits, readiness and adoption of BIM from the context of Malaysia. But there is not much effort to identify the adoption factors and its relationship that could facilitate the adoption of BIM especially from the perspective of Civil and Structure (C&S) consultant firms. Therefore, it is crucial for this study to be conducted in order to understand the factors influencing the adoption of BIM among the

C&S consultant firms. It is important to know from the perspective of C&S consultant firm because C&S consultant firm are one of the key parties in developing BIM projects. The input from C&S consultant firms cannot be neglected as they would help in contributing to BIM transition in the Malaysian construction industry. Thus, this study will attempt to investigate the factors that could facilitate the adoption of BIM from the perspective of &S consultant firm.

1.3 Research Aim and Objectives

The aim of this study is to examine the relationship between organisations, people and technology towards making decisions in adopting of Building Information Modelling (BIM) from the perspective of Civil & Structural (C&S) consultant firms. In order to achieve the aim of this study, a series of research objectives have been developed and the followings are the research objectives for this research.

1. To identify the obstacles and influences factors to the adoption of BIM.
2. To formulate the hypothesis and the conceptual BIM adoption model.
3. To validate and adjustment of the conceptual BIM adoption model.

1.4 Scope of the Study

From Macleamy Curve (2004), it was found that at the early stage of the project life cycle, the decision or information from client is high and many information is gathered from various parties. The implementation of Building Information Modelling (BIM) is suitable to be deployed at the early stage of project life cycle to minimize any error and change. This is because any error or change during this stage will not affect the cost. But if the design changes occur after the design stage is completed, the cost will increase and could hinder the pace of constructing. As part of parties involved in developing BIM, the point of view from Civil and Structure (C&S) consultant firms on how to speed up the adoption of BIM cannot be abandoned. This view could offer an alternative view of BIM adoption. Thus, the scope of this study will focus on the design and development stage and C&S consultant firms as respondents.

In this study, qualitative and quantitative data were used. There are three stages involved in this study.

- Stage 1, to understand the issues faced by the C&S Consultant in delivering projects and at the same time to identify the obstacles and influences factors to the adoption of BIM and current BIM implementation status in Malaysia.
- Stage 2, exploratory interview was used to gather qualitative data to validate the identified obstacles and influences factors to the adoption of BIM by interviewing respondents that have experiences using BIM in their projects. All interviews were audio-recorded and content analysis was conducted to analyse the qualitative data. In this stage formulation of conceptual BIM adoption model and its' hypotheses were developed.
- Stage 3, quantitative data was gathered using a questionnaire survey and analyse using multiple linear regressions. Multiple linear regressions were used to validate the conceptual BIM adoption model and finally make an adjustment of model based on findings from the analysis.

1.5 Structure of the Thesis

This thesis consists of seven chapters which are as follows;

Chapter 1 introduces an overall view of this research. It started with introduction, problem background, problem statement, research aims and objectives, scope of study and outline of the thesis.

Chapter 2 reviews the literature related to Building Information Modelling (BIM). It addresses the basic concept of BIM, the challenges, the benefits and the driven factors in adopting BIM. This chapter also reviewed the background of Malaysian construction industry and the history of BIM adoption in Malaysian construction.

Chapter 3 describes the research approach and research design for this.

Chapter 4 discusses and conclude the qualitative and quantitative data that have been obtained based on the interview sessions from three companies that have experienced adopting Building Information Modelling (BIM) and questionnaires survey. The development of conceptual BIM adoption model and hypotheses also being discussed in this chapter. This chapter ended with the discussion on the findings from correlational relationship between the organisational, people and technological factors towards interest in adopting BIM by examining conceptual BIM adoption model using multiple linear regression.

Chapter 5 conclude the findings for this study, followed by limitation of the research, contribution of the research and end with recommendation for future research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The construction sector is very important as it contributes to the Malaysian economy. In 2013, construction sector contributes about 3.5% Gross Domestic Product (GDP) to the Malaysian economy and this trend has increased since year 2013 (Table 2). Construction industry in Malaysia can be categorised into four types of construction namely, residential buildings, none-residential buildings, civil engineering and the special trade sectors. The residential sector involves the construction of houses and condominiums. The non-residential construction comprises of all building construction other than residential. These include the construction of commercial and industrial buildings. Civil engineering is related to the construction of public infrastructure such as bridges and highways.

Table 2 GDP contribution by sectors
Source: Department of Statistic Malaysia (2014).

Sector	2009	2010	2011	2012	2013
Agriculture	7.9	7.6	7.6	7.3	7.1
Mining and Quarrying	10.5	9.8	8.8	8.4	8.1
Manufacturing	24.2	25.2	25.0	24.8	24.5
Construction	3.1	3.2	3.2	3.5	3.8
Services	53.2	53.2	54.2	54.6	55.2
Plus, import duties	1.1	1.1	1.2	1.3	1.3
GDP at purchasers' prices	100.0	100.0	100.0	100.0	100.0

These figures show how importance the construction industry to Malaysian economy. As part of the parties involved in the construction industry, Malaysian engineering consulting firms also contribute to Malaysian economy by contributing between RM1.59 billion – RM2.39 billion from total construction project of RM78.6 billion in 2010 (Wong, 2012). Beside plays a significant role in contributing to Malaysian economy, most of the construction projects in Malaysia are using conventional method that tend to create problems such as delay, cost overrun, low tech application and labour intensive (Kamal & Flanagan, 2012). In 2018, Unit Penyelaras Perlaksana (ICU), Jabatan Perdana Mentri reported about 61 government projects consider as 'sick project' because of delay during design stage. This happened because design stage can be considered one of the most fragmented stages in the project life cycle because it involves many participants (Alaghbari et al., 2001 and Kamal & Flanagan, 2012).

2.2 Malaysian Engineering Consulting Firm: Current Scenario

Board of Engineer Malaysia (BEM), regulate engineers must register with BEM if they want to practice in Malaysia. This regulation stated in Act 138 – Registration of Engineers Act 1967 (Revised 2002), stated that *"8. (1) Except as otherwise provided under any other written law, no person or body, other than a Professional Engineer who is residing and practising in Malaysia or an Engineering consultancy practice providing professional engineering services in Malaysia, shall be entitled to submit plans, engineering surveys, drawings, schemes, proposals, reports, designs or studies to any person or authority in Malaysia*" (BEM, 2012). From BEM's database, currently about 10,479 registered as Professional Engineers (PE), whereas about 62,626 registered as Graduate Engineers (BEM, 2012).

For practicing engineering consulting firms, BEM also regulate to register as engineering consultancy practices. BEM classified engineering consulting firms into 3 categories which are, as sole company, partnerships company or as body corporates. According to BEM, for sole company, the owner must have registered as PE, while for partnerships, all the partners must have registered as PE. For body corporate, the board of directors must consist of PE, Professional Architects (Ar) or registered Quantity Surveyor (Sr). About 1,928 engineering consulting practices registered with the BEM and consist of 838 sole proprietorships, 185 partnerships and 905 body corporate and about 684 from 1,928 is Civil and Structural consulting firms (BEM, 2012; Kementerian Kewangan Malaysia, 2014).

As part of parties involved in project life cycle, consulting engineering firms have some significant roles to ensure the development of project follow the client's requirements. Some of their responsibilities are given a professional advice to clients related to technical, safety and health aspect. They must professionally fulfil according to the terms of the contract of engagement. A registered engineer shall conduct himself honourably, responsibly, ethically and lawfully so as to enhance the honour, reputation and usefulness of the profession. This stated in Clause 5 Code Professional Conduct for Engineer states that: *"A registered engineer shall conduct himself honourably, responsibly, ethically and lawfully so as to enhance the honour, reputation and usefulness of the profession"* (BEM, 2012). Consulting engineering firms not only involved in the design phase, but they also actively involved in the constructions phase in order to make sure the constructor construct according to design and construction code. They also observe the progress of the project to make sure it can be completed within time frame stipulated in the document contract.

In Malaysia, under 11th Malaysian about RM260 billion is allocate for building of public infrastructure and about 4% is the market for consulting engineering firms (EPU, 2016). This show how important role of consulting engineering firms contribute to Malaysian economy. Despite the huge amount of allocation for local construction industry, delay in public project are very serious and resulting about 89% claimed the cost of project was increase about 10% from actual cost (Hamzah et al., 2012). These problems arose due various reasons. Alaghbari et al. (2001), found that the cause of delay can be categorised into two categories which are internal factors and external factors. For internal factors the delay can be contributed by clients, consultants and contractors, while for external factors the delay can be contributed by suppliers and even the weather. In Malaysian construction industry, Mohammed et al. (2010) revealed that, changes in the design by the consultant are the main causes of variations in building projects in Selangor, Malaysia and Mendelsohn (1997) and Oyewobi et al. (2011), revealed the problems faced on site are 75% came during at the design phase and these design defects are detected during the execution phase of project. Most common problem contribute by the consultant are design discrepancies and changes.

These issues lead to rework and/or design changes are the primary contributor to schedule delays and cost overruns in design and construction projects according to Sun and Meng (2009); Love et al. (2009) and Han, Love and Pena-Mora (2013). Andi and Minato (2003) and Lopez and Love (2012) added resulting from design errors and discrepancies can harmfully project performance and contribute to failures, accidents, and loss of life. These errors occurred because of coordination problem during the design stage (Tenah, 2001 and Tribelsky & Sack, 2010). Currently most drawing crosschecking relies primarily on manual methods and this method been characterized as slow, costly, and ineffective Wang (2000), Kong and Gray (2006) and Grau, Back and Prince (2012). Tenah (2001) and Mohamad et al. (2012) added, by manually checking, the designer sees the design on drawings or on the computer screen appears good but in reality sometime the designer overlook some design element that difficult to build, and modifications is needed during the construction stage and these resulting in rework, changes in quantities, and delays and defects in construction.

Beside these technical drawbacks, Wang (2000), Kong and Gray (2006) and Grau, Back and Prince (2012) indicated design errors and discrepancies could lead to stressful relationship among project participants and resulting disagreement between the contracting parties. Wang (2000) and Mohamad et al. (2012) urged to improve the design management process to eliminate the design errors and discrepancies because most studied revealed, there is significant relationship between improved coordination and saving in project costs and time, as well as better safety and quality performance with positive relationship among construction parties. By eliminate the design errors and discrepancies enable the project management team to complete the project successfully by evaluate the potential causes of discrepancies during the project life-cycle.

These issues arose because, majority of construction players are adopting the traditional method in delivery the project which is resulting the fragmented working process that lead to problem of coordination (D. Bryde, M. Broquetas and J. Volm, 2013; Hamzah, A., Jeffery Boon, H. Y. & Chen Wang, 2017). Resulting from fragmented working process lead to issue of constructability, variation order during construction phase, communication between parties, misinterpretation of actual requirements of a project, etc (D. Bryde, M. Broquetas and J. Volm, 2013; Hamzah, A., Jeffery Boon, H. Y. & Chen Wang, 2017). Therefore, in order to reduce these issues and to increase the productivity of construction sector, there is the needs to change from current method to more innovative method. Therefore, the Malaysian construction industry must step up by adopting new innovative approach. Construction Industry Board (CIDB) has realised over this scenario and in order to minimize the negative impacts to this sector therefore they have developed Malaysian Construction Industry Master Plan (CIMP) 2006 -2015. This plan emphasizes on four main aspects in order to improve the Malaysian construction industry and some of the aspects are modernisation of the industry and application of new technology (CIMP, 2007). With the explosion of BIM and taking the spirit of CIMP, in 2013 CIDB has established BIM Steering Committee to identify how BIM can increase the construction productivity (CIDB, 2014).

First step this steering committee that consists of industries and government sector is forming Malaysian BIM Roadmap 2014 – 2020. In order to develop BIM Malaysian Roadmap, the steering committee has developed six BIM taskforce working groups that consist of Working Group Standard, Working Group Guides and Framework, Working Group Education & Training, Working Group Technology & Tools, Working Group Policies & Incentives and Working Group Business Development (see Figure 2). These BIM Taskforce working group will focus on its own niche area. It will present its findings to the other group to establish collective solutions for any issues arising (Ahmad et al., 2015). Besides that, this steering committee will also organise the BIM awareness program to the Malaysian construction players and develop BIM portal to disseminate the information about BIM.

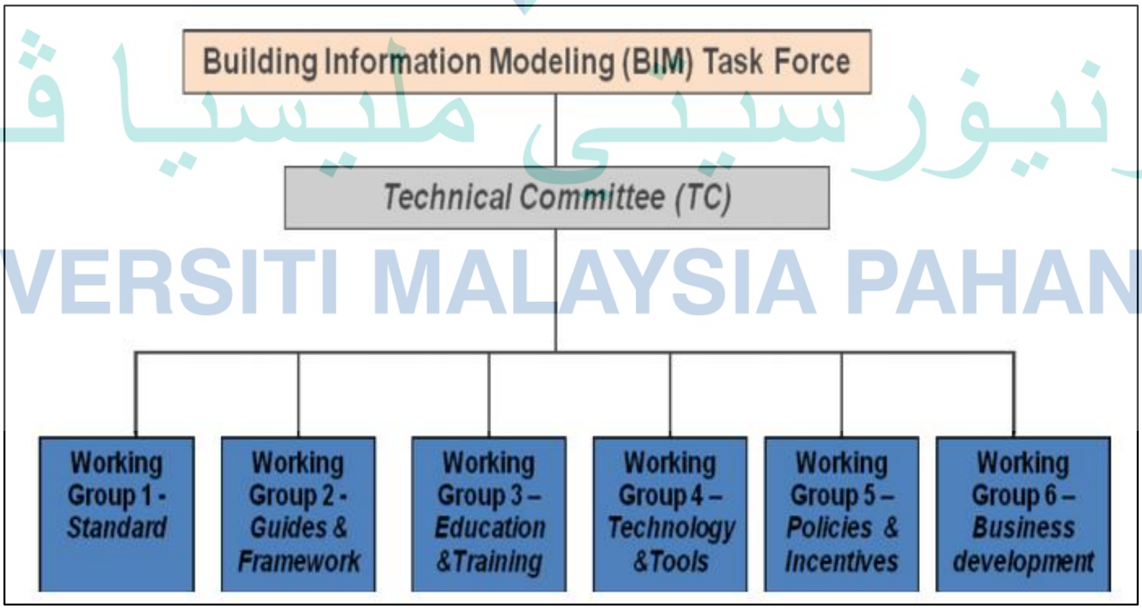

Figure 2 BIM Taskforce working group organisation chart
Source: Ahmad et al. (2015)

In 2016, CIDB collaborated with Public Work Department (PWD) has launched the Construction Industry Transformation Plan (CITP) 2016 – 2020. This plan is a continuation from CIMP 2006 – 2015. In CITP 2016 -2020, there are four strategic thrusts namely; Quality, Safety & Professionalism, Environment Sustainability, Productivity and Internationalisation and each thrust has its own initiatives (CIDB, 2015). In CITP 2016 – 2020, the initiative for BIM is under thrust productivity which rolls out technology advantage a cross project life cycle. Under this initiative PWD should facilitate BIM adoption in construction via regulation and establish reference centre to support the development and adoption of BIM and modern method (CIDB, 2015). This shows how serious the government intends to transform current construction practice.

Under this thrust, CITP has suggested a reference centre to support BIM adoption in Malaysia must be established. This centre will act as one stop information centre that displays benefits of BIM. This centre also offers training and seminar or workshop that could create awareness of BIM among construction participants in Malaysia. CIDB will work together with training provider to train Graduates of Akademi Binaan Malaysia (ABM) and groomed as BIM experts. To show how serious the government implement BIM, the introduction of a certification and accreditation programme for BIM personnel will be developed and implemented. This approach is made to make sure the quality of BIM personnel in construction meets the required standards. Besides that, in order to facilitate the adoption of BIM, a national BIM guide and standard BIM library will be developed (CIDB, 2015).

2.3 Building Information Modelling (BIM): An Overview

BIM can be defined in many ways and interpretations. Eastman et al. (2011), defined *"BIM as a modelling technology and associated set of processes to produce, communicate, and analyse building models"*. Smith (2009) defined BIM as *"a system approach to the design, construction, ownership, management, operation, maintenance, use, and demolition or reuse of buildings"*. BIM SmartMarket Report from McGraw-Hill (2008) defined BIM as *"the process of creating and using digital models for design, construction and/or operations of projects*". The National Institute of Building Sciences (NIBS, 2007) stated that "*BIM stands for new concepts and practices that are so greatly improved by innovative information technologies and business structures that they will* *dramatically reduce the multiple forms of waste and inefficiency in the building industry".* From these definitions, the information, coordination and integration can be considered as key functions in BIM. It can be viewed as a single respiratory system that supplies and receives any information in digital form related to construction projects. Eastman, Teicholz, Sacks & Liston (2011) added, BIM involves more than just implementing new software, as in the process of creating 3D parametric model, it required all parties to shift from the traditional workflow where normally they always work on separate information into a new workflow where all the information will be shared together. Succar (2010) believed that the most important part of BIM is not the software functionality, but collaboration in the design and planning process which speeds the process and clarifies design

In general, BIM can be considered as the process of creating and using 3D parametric computer-aided-design (CAD) technologies for design that allows exchanging information within a construction project team in a digital format (Revit, 2008; Taylor & Bernstein, 2008; Succar, 2010 and Eastman et al., 2011). This model can be passed digitally between construction participants in the construction projects and the more importantly is the model that is created using BIM will produce the intelligent objects of building that can be combined into a single model and checked with clash-detection software to ensure smooth coordination because of free clash (Kymmell, 2008). The building models developed are also consistent and coordinated because of the possibility of redundancy in data entry can be reduced. This approach is not only faster but can reduce the chance of human error into a minimum level. This model can be passed to the contractor for estimating and planning the construction projects. Figure 2.1 shows the vision of BIM sharing the information in integrating the different parties through BIM.

The main component in BIM is the information that lays in the model. As mentioned before, BIM can be viewed as a single respiratory system that supplies and received any information in the digital form related to construction projects to support all parties involved, because all parties have access to the same data. In order to have a common single and coordinated source of structured information, the implementation of BIM is needed to change the traditional process in transmitting the information. The transition from the traditional process into the new process is to ensure all parties in the construction industry have the same information for design. In order to do this, it will require new skills, and these will have to be learned from practice.

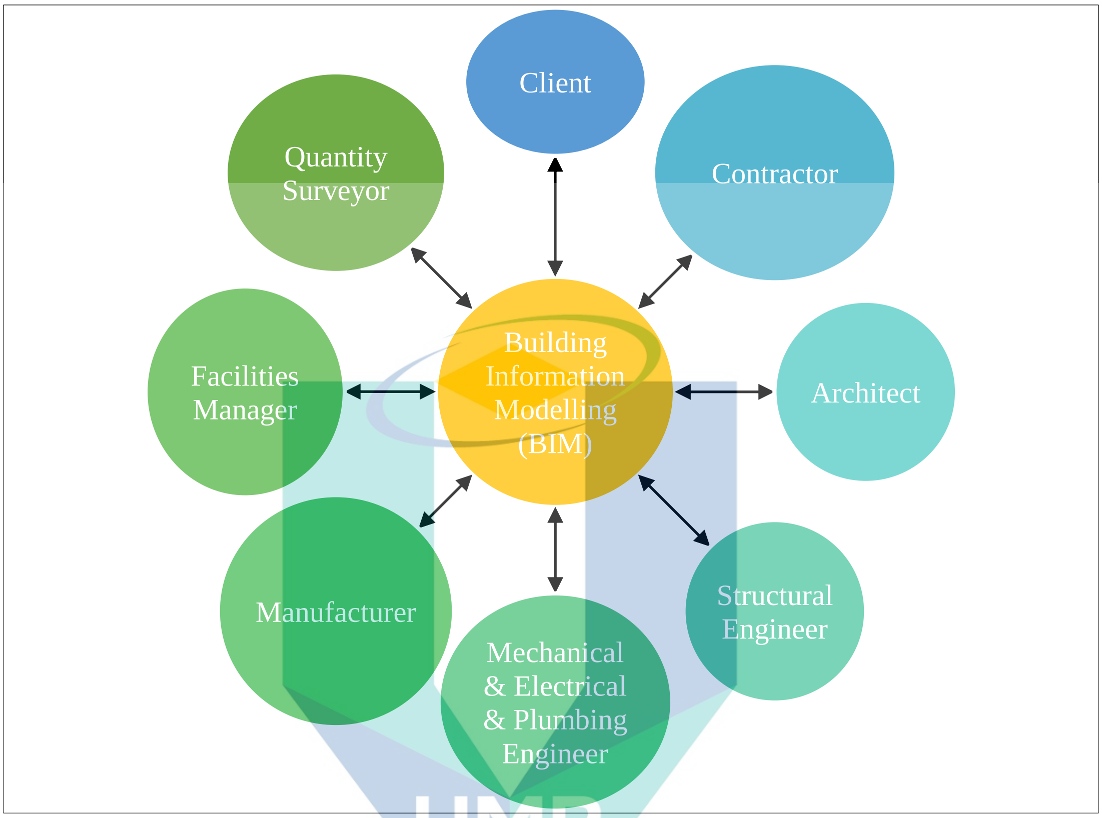

Figure 2.1 The vision of integrating different parties through BIM

2.3.1 The Application of Building Information Modelling (BIM)

The application of Building Information Modelling (BIM) in construction projects can be applied throughout a project life cycle and all parties are able to gain the benefits of BIM. Normally the project life cycle consists of four phases. It starts with plan, design, construct and ends with operate. BIM Project Execution Planning Guide by The Pennsylvania State University revealed that there are twenty-five uses of BIM for consideration as shown in Figure 2.2 (Computer Integrated Construction Research Program, 2011). During the planning and design stage, owners can fully utilise the function of 3D modelling to experience and understand the end product and able to modify it. In these stages, the team which consists of multiple parties will be able to come out with ideas and solution to any problems arise like cost, clash, design, etc. before it become a liability for the construction projects. In order to do this approach, cooperation, collaboration and coordination of the entire project staff is a must. Failing to do so, will make BIM lost its main functions, which are sharing all the information throughout project life cycle and promoting collaboration between different parties in the construction projects. Besides that, the main contractor is able to start making coordination between subcontractors and suppliers in these stages.

During the construction phase, BIM can give constructability, sequencing, value and engineering report to the main contractor. During the operation phase, actual information recorded in BIM can help owners to maintain the building throughout its life cycle. These processes can be achieved if BIM is fully implemented, and all parties in the construction projects collaborate with each other as this is the vision of BIM. But due to some reasons, it is not made practicable. Therefore, according to this guide, it is not appropriate to implement all the applications of BIM. This is due to not everybody knows how to implement BIM in a right way and there are some obstacles to implementing fully BIM in construction industry, especially in Malaysia and they must know why they need BIM technology.

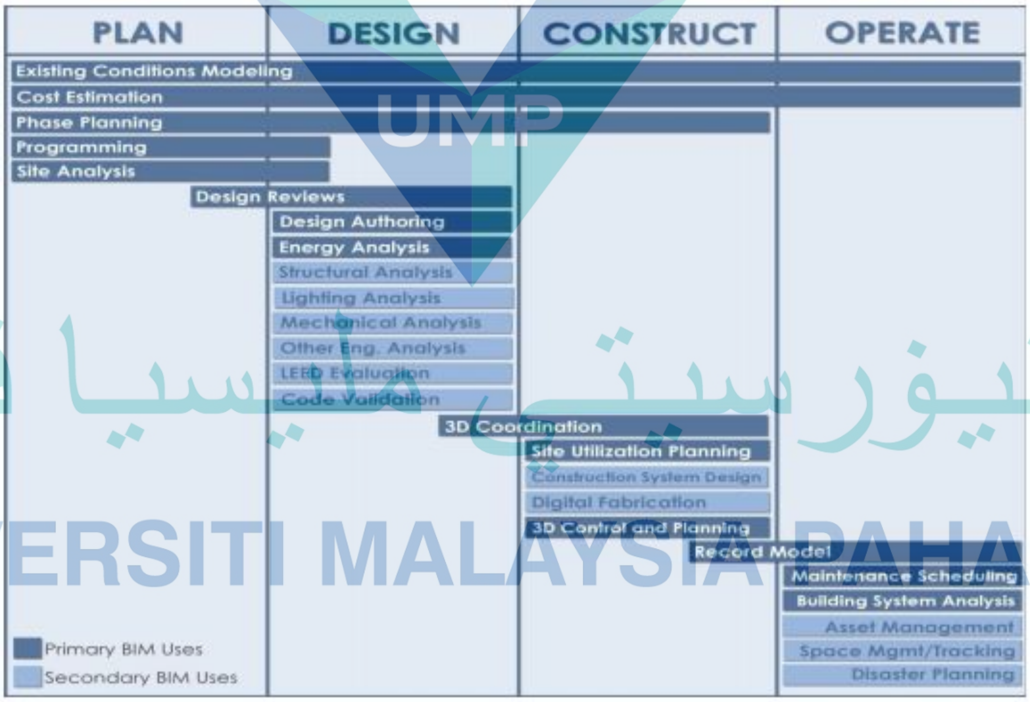

Figure 2.2 BIM application in project's Lifecycle
Source: Computer Integrated Construction Research Program (2011).

2.4 Benefits of Building Information Modelling (BIM)

There are many benefits that can be achieved by implementing BIM, because the application of BIM can be applied throughout project life cycle. These benefits can be categorised into communication, coordination, cost and decision-making benefits.

2.4.1 Communication Benefits

In a typical construction project, a lot of information has to be gathered in many forms including drawings, contracts, reports, charts and worksheets. The project involves numerous parties (owner, architects, engineers, contractors), decisions and data, and a long set of processes starting with the initial idea and followed by a feasibility study, design, construction and operation and maintenance works (Waleed, Lee Wah Peng, Kadir, Mohd. Saleh Jaafar & Mohd. Sapuan Salit, 2003). Communication between members of the construction projects can be difficult because the background, references and goals of each party will be different. These situations contribute to the fragmented environment for the construction industry. In the project life cycle, teams will exchange the information between parties, and CIDB (2009) found that the amount of information decreased from one phase to another phase in the project's life cycle. One of the factors why this situation happened is because of misinterpretation of drawing based on computer aid drafting (CAD) by the parties involved. During the exchanging of technical drawing between consultants, problem of interpretation occurs and some documentation errors have been overlooked such as scaling error, misaligned grid and others (Mahalingam, Kashyap & Mahajan, 2010 and Lu at al., 2014). This will affect the overall success of the project due to lack of accurate information between project teams.

Therefore, Succar (2010); Eastman et al. (2011); Khosrowshahi & Arayici (2012) and Migilinskas, Popov, Juocevicius & Ustinovichius (2013) believed that BIM can be one of the platforms for promoting collaboration and to share knowledge between construction parties and the same ability to enhance the way of communication between parties and the construction industry. In conventional practice, construction drawing normally is generated using normal CAD system, project participants exchange information between each other using normal CAD system and tend losing information because of the use of various type of CAD system by project participants. BIM is able to extract accurate and consistent drawing from 3D model resulting minimizing errors during generating construction drawings compared to generating construction drawing via normal CAD system (Eastman et al., 2011). The use of BIM allows us to interact and communicate effectively between parties in the construction projects and at the same time, it could reduce conflicts and repeated work. These activities show how BIM can be an enabler for collaborative activities in the construction projects. The construction industry can be benefited from the utilisation of BIM and can reduce the issues on fragmented because of sharing and transmitting of information among various parties in the construction industry more reliable and efficient. Thus, Chuang, Lee & Wu (2011) and Migilinskas et al. (2013) believed that most companies adopting BIM because BIM capability to share the information through project life cycle with different parties.

2.4.2 Coordination Benefits

Kymmell (2008) and Taylor and Bernstein (2008) believed that visualisation is one of the benefits that can be gained by the exploitation of BIM. The visualisation could help parties that involved in the construction projects to gain better understanding of what they construct by creating the detailed 3D view. With the utilisation of BIM, the use of 3D visualization as a communication tool has become more accessible because 3D data can be extracted directly from the design authoring tools (Mikael Johansson, MattiasRoupé & PetraBosch-Sijtsema, 2015). Kymmell (2008) added, one of the critical tasks in Mechanical, Electrical and Plumbing (MEP) design is clash detection and without having good visualisation tools, this task will consume time. Traditionally in 2D drawing, to do a clash detection process is by overlaying 2D plan drawings in order to visualize the location of the system components in 3D space. However, by exploiting 3D parametric modelling between architect and structural engineer, this task can be done within short of time and more accurate compare traditional method. As a result, from error free design documentation, it shortened lead times and reduced Requests For Information (RFI), the productivity of the construction project significantly in term of coordination between parties has been increased (Kaner,Sacks, Kassian & Quitt, 2008; Khanzode, Fischer & Reed, 2008 and Staub-French and Fischer, 2001).

Beside coordination for early clash detection to avoid design and documentation error, BIM could facilitate coordination for planning and scheduling. Coordination for planning and scheduling will become more accurate and reliable due to the capabilities of BIM to simulate 3D parametric with time and known as BIM 4D. BIM 4D is able to visualize the stages of construction and show the work progress by simulate with time (Eastman et al., 2011 and Salman Azhar, Malik Khalfan & Tayyab Maqsood, 2012). According to Salman et al. (2012), Eastman et al. (2011) and Bryde, Broquetas & Volm (2013) BIM 4D is able to analyse and identify the optimum time for construction by analysing the sequence of construction activities and resulting project time can be reduced up to 7%. By implementing it, coordination between parties are assisted because BIM 4D is able to visualize the task and the relationship between works and equipment, thus the communication of schedule intent become clearer (Chuang et al., 2011 and Eastman et al., 2011). BIM 4D model is able to show the real time status of construction at any time in the project, which was useful to enhance coordination on equipment and material deliveries (Mikael et al., 2015).

2.4.3 Cost Benefits

A case study studied by Kristen & Kenneth (2012), found that BIM has been recognised having significant cost benefits for the construction project. By implementing BIM, they found that the Request For Information (RFI) has decreased about 50% and the duration has been reduced to 67% based on standard duration and its saved about 2% from overall cost (Kristen & Kenneth, 2012). This happened due to the efficiency of transmitting and collaboration between parties at the early stage of construction where they are able to minimize the document and design errors.

While studies done by Khanzode et al. (2008), for Medical Office Building (MOB) facility and parking garage found that by implementing BIM, for the rework for mechanical, electrical and plumbing works recorded only less than 20% due to effectiveness of BIM clash detection at the early stage of construction. By having a right and accurate information, it can reduce errors during design and construction stage resulting less cost and fewer claims and dispute due to efficiencies in the design, detailing and construction processes.

2.4.4 Decision Making Benefits

Decision making is the complex process where the manager needs to assess the project cost, project performance, project quality and at the same time need to make judgements and adjustments accordingly. The decision made by the managers has an impact to the project performance and cost, Olatunji (2011) and Chuang et al. (2011), recommended that BIM is able to help managers in making decision by resolving the issues related with non-collaborative and isolated operations, poor communication and manual documentation processing that could lead to errors etc. This is supported by Eastman et al. (2011) and Chuang et al. (2011), where BIM is able to extract accurate information and consistent drawing based on 3D model or specified view of project that resulting in reduced time and error during generating construction drawing.

Besides providing an effective communication to assist managers in making a decision, the ability of BIM to provide visualization and simulation of the project is one of the factors that could help the managers in making a decision. According to Chuang et al. (2011) and Mikael et al. (2015), the utilization of visualization and simulation in the early stage allows the managers to identify the errors and come up with the resolutions of any issues in advance of construction resulting reducing reworks and minimizing change orders. In term of safety planning, by having visualization and simulation ability, it could help the managers to minimize construction risks by reviewing complex details or procedures in advance before going onto site by analysing and configuring the right location for machineries, temporary access point and the same time it can identify the safety measurements for the construction projects (Khanzode et al., 2008; Sulankivi, Kähkönen, Mäkelä & Kiviniemi, 2010 and Sulankivi et al., 2013).

In conclusion, the benefits gained from optimization of BIM in term of an effective communication, coordination, cost control and decision support could increase the quality of construction due to better management processes.

2.5 Challenges in Adopting Building Information Modelling (BIM)

Despite the numerous benefits that have been gained from the utilisation of BIM, Malaysian's adoption of new technology especially BIM seems to be stagnant. The construction sector known as a traditional sector that can be characterized as reluctant and even resistant to change due to some factors and Davis & Songer (2008), Hartman & Fischer (2008) and Wu & Issa (2014) found that, in the construction industry, the main reason for this situation is the reluctance or the resistance of people to change from current practice to a new practice. The effect from this resistance causes the failure of organisations to change. They believe that the productivity will suffer when implementing BIM because the technology is difficult to learn, and the established current workflow will be disturbed; designers believe that the owner and contractors will gain the most benefits when implementing BIM and BIM will increase the risk (Revit, 2008 and Kuo-Feng Chien, Zong-Han Wu & Shyh-Chang Huang, 2014). Many organisations believe that the implementation of BIM will affect their established business processes because implementing new Information Technology (IT) will reshape their business processes and during this process, productivity will suffer because the transition process from fragmented to collaborative in nature will put the project outcomes and clients' expectations at risk (Taylor & Levitt, 2007 and Olatunji, 2011a). Ryan & Derek (2014) identified that the main hurdle that the Architect-Engineering-Construction (AEC) industry needs to overcome is the integration of BIM across the different phase because of the involvement of the different participants in a construction project.

Besides facing the resistance from people within the construction industry, the capabilities of the BIM technology are also questioned to provide the stable sharing information platform. Eastman et al., (2011) explained that, in order to fully gain the benefit from implementing BIM, the BIM technology requires interoperability between different BIM applications that are used by project participants. Eastman et al., (2011) refers interoperability is the capability of BIM application passing data between different BIM applications allowing multiple construction team members to contribute their input to the design and construction process. Interoperability is the main issue because many organizations use different software for their scope of work, and to have software that is able to interact with each other, will increase the cost (Palos, 2012). Wu & Hsieh (2012) and Alreshidi, Mourshed & Rezgui (2014) believed that, the effect from the issue of interoperability is data share between parties will be inconsistent resulting sharing of information and communication between parties will not be accurate and effective.

Legal issues also contribute to challenges in adopting BIM. The issue of ownership or intellectual property is one of the factors hindering the adoption of BIM (Olatunji, 2011b). This issue of who may claim ownership of the design documentation and licensing will arise when other stakeholders than the owners and architects contribute data that is integrated into BIM (Azhar, 2011 and Olatunji, 2011b). Addressing these issues could help facilitating the adoption of BIM. Kuo-Feng et al. (2014) argued that, cyber security needs to be resolved before adopting BIM because the concern of online unauthorised access and copyright infringement. This can be happened because the capability of BIM sharing the model information within project participants and could make the data accessible to other team members. Due to this ability of BIM sharing the model within project participants, the issue of who will control the data and who will be responsible for any inaccuracies will still be ambiguous that could lead to liability risk (Eastman et al., 2011 and Ashcraft, 2008). The most prominent question that needs to be answered are; who owns the design and for data entry of the model, who will be responsible for the activities that ensure the data is accurate; and if there is any inaccuracy in the model, who will be taking responsibility for that issue, and to overcome these issues creating a new roles and responsibilities is one of the approach according to Ashcraft, (2008); Salman et al. (2011) and Eastman et al. (2011).

The high cost for initial investment in implementing BIM practices includes the acquisition of BIM based software and hardware is the most common challenges when to migrate from conventional process to BIM (Lee, Yu, Jungho & Jeong, 2013). These include upgrading the current infrastructure that could support BIM based software by the organization. Implementation of BIM is not only related with technical issues such as interoperability, its effects on organizational structure and work processes but this type of change brings organizational issues. Changes of organizational structure and work processes will have financial impact because to implement BIM, they need people that are familiar with BIM environment which is lead to requirement of professional personnel with BIM knowledge and cost of training for existing personnel (Eastman et al., 2011). On top of that Lu & Li (2011) added by implementing BIM, it will change the current process especially in reviewing construction information via BIM data. Therefore, there is a requirement of additional time imputing and reviewing the BIM data, which will create new costs in the design and project administration process.

In conclusion challenges in implementing BIM can be clustered into management obstacles, technology obstacles, legal obstacles and financial obstacles as shown in Figure 2.3.

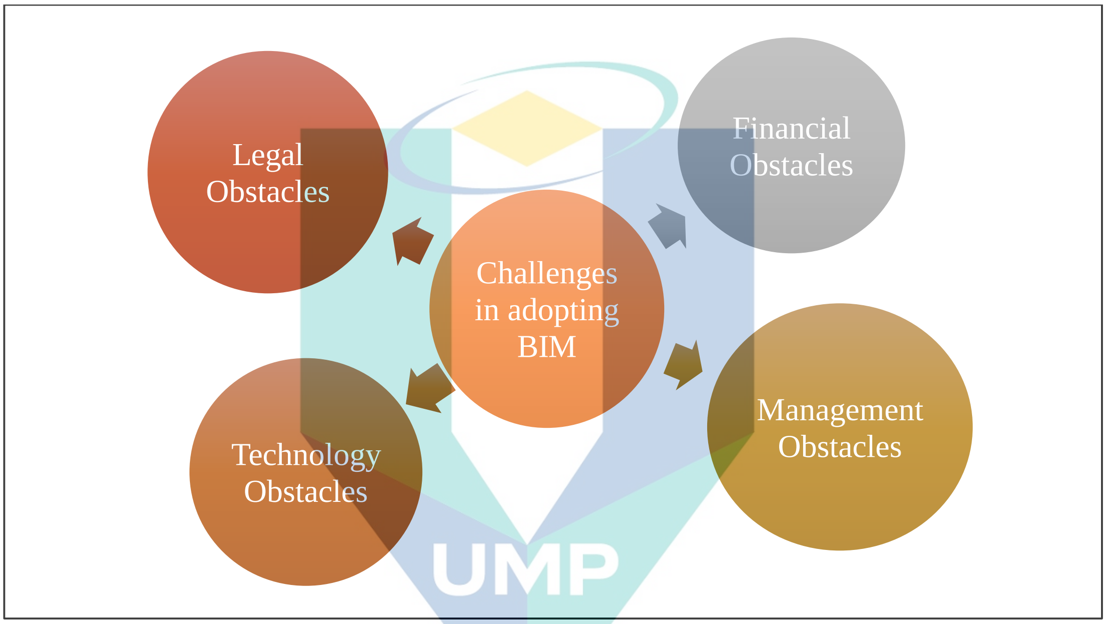

Figure 2.3 Challenges in adopting BIM

2.6 Current Building Information Modelling (BIM) Adoption

BIM has been implemented in many countries since the early of 2000s and the rate of implementing BIM in their project has been significantly increasing. A survey has been conducted in North America found that the contractors who implemented BIM have increased from 28% in 2007 to 71% in 2012 whereas the implementation of BIM in the United Kingdom (UK) also increased from 31% in 2010 to 54% in 2013 (McGraw Hill, 2014). Reports by the same publisher for the same year also stated that the adoption rates in Korea is at 58% while the Middle East stands close to 25% and BIM usage in Western Europe has reached 38%. On the Southern Hemisphere, a 2012 national report by Masterspec states that New Zealand has 34% users of BIM while Australian adoption rate is at 19% (Masterspec, 2013).

The increasing adoption of BIM worldwide clearly shows that; they have gained the benefit by implementing BIM in their project. They also believed that in order to keep up with other competitors, they must upgrade and update their tools and technology in order for them to keep up the competitive edge (McGraw Hill, 2014). Besides that, support from the government also contribute to the increasing of BIM adoption such as in the United States, the General Services Administration (GSA) began requiring the use of BIM in all new projects in 2007 (Fortner et al., 2008). Whereas in Asia, The Hong Kong Housing Authority will require BIM for all new projects from 2014 while the Public Procurement Service of Singapore has made BIM compulsory for all projects over S$50 million and for all public sector projects by 2016 (BuildingSMART, 2012).

2.7 Building Information Modelling (BIM) Adoption in the Malaysian Construction Industry

In Malaysia, most of the construction projects according to Mohd Nasrun Mohd Nawi, Nazim Baluch & Ahmad Yusni Bahauddin (2014), are still using conventional construction process which contribute to the issues of delays, cost increased, reworks due to ineffective communication and coordination among project participants. To overcome these issues, Peslak (2005) believed, in the era of technology, the utilisation of innovation in Information and Communication Technology (ICT) could enhance the process of transmitting communication, collaboration and information management and could increase the construction performance. An innovation is not limited to technology only; it could be a new product or process technology, or administrators such as a new structure or administrative system pertaining to organisational members (Damanpour, 1991). Due to the potential of utilisation of ICT which could address the issues of fragmented and ineffective communication and coordination among project participants Eastman et al. (2011) suggested implementation of BIM could reduce these issues. According to Eastman et al. (2011), BIM is one of the platforms to promote collaborative and integration between the project participants via sharing 3D parametric model and could offers solution to the management and communication problems.

The effects from increasing rate of implementation of BIM worldwide and the benefits they gained found that the existing of BIM gain the attention from Malaysian constructions industry (Bryde, Broquetas & Volm, 2013 and Ahmad Latiffi, Mohd, Kasim & Fathi, 2013). In Malaysia, according to Latiffi, Brahim & Fathi (2016), although The Malaysian Public Work and Department (PWD) has introduced BIM into the construction industry early 2007, the first project that implemented BIM is the construction of National Cancer Institute in 2010. This indicates the pace of adoption and implementation of BIM in Malaysia is still slow. To increase the adoption and implementation of BIM in Malaysia PWD with Construction Development Industry Board (CIDB) have been organising various programmes in order to improve the adoption rate in the construction organisations (Latiffi et al., 2013 and Latiffi et al., 2016). Even though, the implementation of BIM in Malaysian constructions industry is still new and slow pace, but the rate of implementation of BIM is steadily increased (Latiffi et al., 2013). To facilitate the adoption and implementation of BIM, in 2014, CIDB has developed BIM roadmap which focused on seven pillars such as Standard and Accreditation (P1), Collaboration and Incentives (P2), Education and Awareness (P3), National BIM Library (P4), BIM Guidelines and Legal Issues (P5), Special Interest Group (P6) and Research and Development (P7) (CIDB, 2014).

In 2016, CIDB studied the adoption of BIM in Malaysia and at the same time to access the effectiveness of BIM roadmap that has been developed in 2014. From the report, it has been found the percentage of BIM adoption in Malaysia is about 17%. This figure shows the low level of BIM adoption in Malaysia compared to Japan (43%) and South Korea (52%) in 2015 (McGraw Hill, 2014 and CIDB, 2016). Due to this, CIDB has developed Construction Industry Transformation Plan (CITP) 2016 -2020 in 2015 with outlined BIM will be utilised to improve construction productivity and, by 2020 CIDB target the adoption by in Malaysia is about 40% (CIDB, 2016).

Therefore, there is the needs to study the adoption factors within Malaysian constructions industry that could facilitate the pace of BIM adoption in Malaysia. For Malaysian context, several studies have explored the issues, benefits, readiness and adoption of BIM. Harris, Che Ani, Haron & Husain (2014) studied the possibilities the implementation of BIM by the contractors, Abdullah, Sulaiman, Latiffi & Baldry (2014) studied the benefit and opportunities by implement BIM from the perspective of Facilities Manager, Ali, Ibrahim & Boon (2013) studied the awareness and readiness from the perspective of Quantity Surveyor and Haron (2013) studied the readiness framework for design consultants. However, there is not much effort to identify the adoption factors and its relationship that could facilitate the adoption of BIM especially from the perspective of civil and structure (C&S) firms. Therefore, this study is crucial to be conducted in order to understand the factors influencing its adoption within the C&S organisation.

2.8 Driven Factors in Adopting Building Information Modelling (BIM)

Rogers (1995) defined adoption as *"a decision to make full use of an innovation as the best course of action available"* and the outcomes from the decision are either to adopt or to reject. Thus, there is the needs identifying the right driven factors that could facilitating the decision for adopting BIM that could increase the pace of adoption in Malaysia. This research studied how the context of people, organisational and technological as main factors could facilitate the pace of BIM adoption in Malaysia from the perspective of civil and structure (C&S) firms.

Many studies revealed the most barriers to implement new technology in construction industry is facing resistance from people (Davis & Songer, 2008, Hartman & Fischer, 2008 and Wu & Issa, 2014). It is because people when being introduced to a new technology, there are several factors will influence their decisions due to their perception of the new technology (Majid et al., 2011). Some of them are afraid to change their working style or reluctant to learn something new because to implement something new and innovative such as BIM, it requires more efforts and time to implement and this will burden them (Suebsin & Gerdsri, 2009). To minimise the resistance from the people, the organisation itself must be ready to change it including support and commitments of management and personnel with regards to BIM adoption because people are willing to accept a new technology when there is a support from the management (Tsikriktsis, 2004). Song, Migliaccio, Wang & Lu (2017) added by having support from organisation it will bring a significant impact in motivating employees' potential, it could improve work performance and at the same time having a significant mandate in allocating budget.

Howard, Restrepo & Chang (2017) further explained that by improving the strategy policy and promoting incentive within organisation would facilitate the process of BIM adoption because some people are not looking the benefit gained by utilised BIM. While, Khazanchi (2005); Weiner (2009); Xu et al. (2014) and Son et al. (2015) revealed that to ensure the successful of implementing new technology that is related to organisational readiness to change because some of organisation failed to adopt new technology because of they are too rigid and not flexible enough to change their structure. This happened because, they believed that any innovation practice will disrupt existing processes or practices and it also will change their workflows and business process (Hartmann, Fischer & Haymaker, 2009 and Dossick & Neff, 2010).

Beside people factors and organisation, technology also play a vital role in the process of adoption. It is because by introducing new technology, users will assess the benefits they gained and the process of transition before accepting new technology (Khosrowshahi, & Arayici, 2012). They will access in term of the usefulness and ease of use of technology beside Kuo (2013), suggested the organisation should have technology-supported environment in order to facilitate the adoption of new technology. Although some researchers include process and policy as part of adoption factors (Eastman et al., 2011; Succar, 2014 and Enegbuma & Ali, 2011), however in this study policy and process viewed as sub element that can be developed under BIM implementation guideline. This is because every organisation is unique and they have their own policy and process and some policy is not suitable to other organisation and we cannot develop a policy and process that can fit to all.

Therefore, this study will focus on how context of people, organisational and technological as the main factors could facilitate the pace of BIM adoption in Malaysia from the perspective of Civil and Structure (C&S) Firms.

2.8.1 People Context

A survey done by Khemlani (2004) revealed that the resistance to implement new technology is not only limited to operational level but it includes all levels and positions in any organisation. Khemlani (2004) also found that the primary obstacles to implement Building Information Modelling (BIM) are the resistance and challenges from employees who are reluctant to learn something new because of what their belief and complacency with current status. One of the reason is lack of knowledge and skill using the new technology could lead to a hindrance of implementing new technology beside contributing to low self-confidence, therefore a proper training provided by the organisation could reduce the resistance from the people in implementing new technology (O'Brien, 2000; Love, Irahi, Li, Cheng & Tse, 2001; Stewart & Mohamed, 2002 and Thorpe, 2003). McGraw Hill (2014) and Lee & Yu (2016), reported many organisations not achieving satisfactory level of BIM implementation because of lack of training and has affected on decision making in adopting BIM.

Training is one of the factors that could increase the pace in adopting new technology according to Song et al. (2017), but according to Eastman et al. (2011) it is hard to guarantee that each person participates in the organisation has the required technology and skill, therefore the organisation could establish a technical support group or experienced staffs to cater these problems and to solve any problem arise. According to Ralph (1991) technical support plays a vital role in providing the assistance by the knowledgeable people to the technology users whether hardware or software products. By having experienced staff, it would cut the transition time because he or she will be able to deal with new technology such as BIM and able to operate with minimal assistance compared to fresh graduate which is more frequently to feel pressured and frustrated if the outcomes are not up to expectation (Lee et al., 2013 and Son et al., 2015). Therefore, there is the need to have BIM technical support to cater some of this issue.

This technical support group and experienced staffs could disseminate their knowledge among the staffs within an organisation and this activity could spread the spirit of knowledge sharing among them. Implementing BIM, could change the current process and roles especially on deliverable approach from the collaborating teams which are involving with various parties and different phases of the project (Yong et al., 2015 and Lee & Yu, 2016). Yong et al. (2015) revealed that the organisation that has been succeeded in implementing BIM is having a strong support from the technical team especially during the transition period, because at this time the rate of the productivity is slow. By having the strong support from this team, it would minimise the pressure faced by the organisation.

Beside organising the training, this BIM technical team could develop a clear new role and responsibility in BIM environment because Gu & London (2010) and Yong et al. (2015) found that, lack of clearness on roles and responsibilities for staffs in implementing BIM is one of the barriers to adopt BIM. Therefore, the organisation must align the definition of new roles and responsibilities to meet the expectation of the organisation especially related with BIM such as BIM Modeller, BIM Operator, BIM Coordinator, BIM Manager and Head of Change (Smith & Tardif, 2009, Deutsch, 2011 and Lee et al., 2013). By having the clear roles and responsibilities, it easy for organisation to assign their staff to the projects based on their capabilities and roles (Xu, Feng & Li, 2014 and Yong et al., 2015) and it will ease the process of adoption.

2.8.2 Organisational Context

To reduce the resistance from the people to change, support from top management is very crucial (Gilligan & Kunz, 2007) because during the migration to new technology, the role of top management is very important to formulate the strategies and direction of the organisation in adopting new technology. Support from top management is very crucial during the migration from conventional working process to BIM-based working process. Song et al. (2017) defined support from top management included providing the support system such as policy, resource and moral to embrace new system. Beside support in tangible form, support from intangible form is also crucial. It is because studies by O'Brien (2000); Son, Lee & Kim (2015) and Cao, Li, Wang & Huang (2017) revealed that, some people having a low self-confidence especially when related with implementing new technology because of lack of knowledge, therefore motivation by the top management could be one of the factors to build up self-confidence to motivate individuals to use Information Technology (IT) applications. By having support from top management, employee will feel of being trusted and it will make them be more dedicated and try to prove that they can contribute something to achieve the organisational goal (Son et al., 2015 and Cao et al., 2017).

Beside support from top management, the size of the organisation is one of the important criteria to ensure the smooth transition to adopt BIM because according to Arayici et al. (2011) and Byrd et al. (2013), in BIM based environment, new roles and responsibilities have been created to manage a new process especially managing design, construction, cost, schedule and exchange information and it is easy for large organisation to handle it compared to small organisation. Arayici et al. (2011) and Travaglini, Radujković & Mancini (2014) also believed that, consultants are more feasible and easier to adopt BIM compare to contractors because consultants gained more benefits from BIM implementation in term of design process and handling BIM based software.

In order to have smooth transition to BIM-based environment, BIM implementation plan need to be established because migrating from current work process into new work process needs is not easy and can be done overnight. Succar (2010), Eastman et al. (2011) and Yong et al. (2015), found that, organisations having a difficulty make an adjustment from current culture and work processes to BIM based work processes due to lack of clearly assigned responsibilities resulting misconception of BIM. This situation could lead to frustration and disappointment and to make it worse, they abandon their intention to adopt BIM (Yong et al., 2015). According to Eastman et al. (2011) and Howard et al. (2017), the BIM implementation plan should have clear BIM objectives, project goal, processes of collaborative coordination, roles and responsibilities. By having BIM implementation plan, the organisations will have a clear road map on how to implement BIM and could expedite their BIM implementation.

A study done by Eadie, Browne, Odeyinka, Mckeown & Mcniff, (2013) and Smith (2014), indicated why adoption rate is very high in United States (US), United Kingdom (UK) and Singapore is because a push from the government to implement BIM in any government projects and this indicate that insistence from the authorities is one of the primary factors influencing BIM adoption. According to Lee et al. (2013), in mandatory system, enforcement or push form authorities had a significant impact at the early stage of adopting new technology and it will lessen over time once the early adopters get used with that technology. The effect can be seen in US, UK and Singapore.

According to CIBER (2012), the US General Services Administration (GSA) started the mandate to implement BIM in their project in 2007 to push the rate of BIM adoption by their construction players. While, in the UK, the government has introduced a BIM implementation strategy in 2011 and targeted all government project should implement BIM by year 2016 and achieving a 20% saving in procurement cost (Cabinet Office, 2011). According to McGraw Hill (2014), this strategy had an impact on the UK construction industry where the rate of adopting BIM increased from 28% in 2012 to 66% in 2015. In Singapore, Granholm (2011) reported that The Singapore Building and Construction Authority (BSA) mandated all project should use BIM by year 2015. To achieve the objective of BSA, a Construction Productivity and Capability Fund (CPCF) amounted S$250 million has be establish with intention to promote the application of BIM in construction projects (Smith, 2014).

Any changes in any organisations drastically and without planning could face the resistance because of some reasons such as afraid of unknown, complacent with current practice etc. therefore, by creating the supportive environment in the organisation could cut down the resistance and negative stresses support (Smith, 2014). Eastman et al. (2011), viewed by having supportive environment surrounding the organisation during the migration to BIM based environment could ease the process of adoption. This can be achieved through communication, knowledge sharing via training the trainer where experienced users can give strong support by assisting novices to get used of BIM, open discussion and providing an adequate facilities and infrastructure (Eastman et al., 2011 and Deutsch, 2011).

2.8.3 Technological Context

BIM technology is seemly new and there is a lot of factors why issues of technology could hinder the adoption of BIM and initial cost investing the software and hardware is one of it. High cost of BIM software, license and associated applications is the decision the organisation had made whether to adopt or not to adopt (Eastman et al., 2011, Khosrowshahi & Arayici. 2012 and Rodgers et al., 2015). Many early adopters are concern about return of investment (ROI) when they invest in BIM tools because there is no tangible figure indicates that by implementing BIM could reduce the overall construction cost (Eastman et al., 2011). Salman et al. (2012) agreed that higher initial cost could influence organisation to adopt BIM but this cost can be offset by the efficiency of BIM such as reducing errors during construction stage because at the early stage of project any anomaly of design will be identified. Based on report from McGraw Hill (2014) almost 23% respondents agreed that by implementing BIM construction, the cost can be reduced due to reduction of reworks and errors. Some of the organisations have failed to achieve targeted ROI and cost reduction when implementing BIM because they have chosen wrong software and hardware due to having a wrong advice by unexperienced staffs. On top of that, having unskilled workers and lack of knowledge in operating BIM tools is one of the reasons why they cannot gain the expected result in term of cost reduction due to not fully achieved optimal performance of BIM tools.

BIM technology is not fully matured, so there is some hiccup that could hinder in achieving optimal performance of BIM tools such as collaborative coordination between project participants in exchanging and sharing information. Issues of interoperability and compatibility have been a concern from the adopters. Interoperability is the ability to exchange data between applications to facilitate automation and avoidance of data re-entry (Eastman et al., 2011). Information exchange is crucial in promotion integrated process between project participants. According to Smith & Tardif (2009), the most prominent concern in issues of interoperability is data inconsistency whereas data compatibility for sharing or exchange is the second most common. Some of problems arise such as objects not appearing correctly or missing when imported and geometry does not export accurately. This is supported in studies by Son et al. (2015) and Kim, Chin, Han & Choi (2017), revealed that beside factor of the complexity of BIM work process that hinder the pace of BIM adoption, issues of software operation such as compatibility and interoperability was identified as one of the prominent obstacle to BIM adoption.

To solve the issues of interoperability and compatibility, Industry Foundation Classes (IFC) and XML Schemas have been developed to solve interoperability issues stage by stage (Smith & Tardif, 2009). The study done by Robert, Henry, Clare & Sean (2015) found that about 71% of respondents agreed that the existence of IFC and XML Schemas helped increased interoperability to an acceptable level. Beside that the introduction of National BIM Guideline and Standard is the major steps to assists the BIM adopters to identify the right data format and type and exchanging protocols to reduce the issues of interoperability. However recent study conducted by Redmond, Hore, Alshawi & West (2012) revealed that most construction professionals have never used most of the exchange protocols due to none existence of National BIM Guideline and Standard at the certain countries and some of them preferred to use their own guideline for exchanging protocols.

Ease of use or user friendly of BIM tools is another concerns by the BIM adopters. The less complexity of BIM tools will increase the pace of adoption because they can reduce time in design process and it is easy to exchange the information among project participants (Yaxin, Xiaolong and Yan, 2013 and Osman, Mazlina, Khuzzan & Sapian, 2015). By having the user-friendly BIM tools, people are easy to accept and used because it easy for them to train and adopt because they are easy to be familiar with (Won, Lee, Dossick & Messner, 2013 and Yeliz & Julide, 2015). On top of that, the time required for training can be reduced and, it is easy for people to accept and use new technology if they are familiar with it. In addition, ease of use can motivate older generation of professionals and managers to adopt and at the same time they might think that by adopting BIM could improve their productivity and performance.

As a summary the driven factors that could increase the adoption of BIM in Malaysia shown in Table 2.1.

Table 2.1 Summary of driven factors in adopting BIM

Context	Reference	Influence Factor	Conclusion
Organisational Context	Gilligan & Kunz (2007); O'Brien (2000); Son et al., (2015); Song et al. (2017) and Cao et al., (2017)	Support form top management	Strong ***support from top management*** within organisation has a significant and positive impact toward BIM adoption.
	Arayici et al. (2011) and Byrd et al. (2013)	Conducive working environment	Having ***conducive working environment*** that promote knowledge sharing among staff and able to open to accept any suggestion from staffs. This attribute possibly facilitates in adopting process.
	Smith (2014); McGraw Hill (2014) and Granholm (2011); Eadie et al. (2013) and Lee et al. (2013)	Coercive pressure	***Internal and External pressure*** or could force the adopting pace.
	Eastman et al. (2011); McGraw Hill (2014); Yong et al. (2015) and Howard et al. (2017)	BIM implementation plan	Having a ***BIM implementation plan*** with a clear roadmap toward implementing BIM could ease the adoption process.

Table 2.1 Continued

Context	Reference	Influence Factor	Conclusion
Organisational Context	Arayici et al. (2011); Byrd et al. (2013) and Travaglini et al. (2014)	Type of organisation	***Type of organisation*** play a significant role in adopting process. Such as consulting firms are easy to adopt compare general contractors
People Context	Love at al. (2001); Stewart & Mohamed (2002); Thorpe (2003); McGraw Hill (2014); Lee & Yu (2016) and Song et al. (2017)	Training and Education	***Training and Education*** in term of provide adequate training internally or externally could ease the adoption process.
	Eastman et al. (2011); McGraw Hill (2014); Jung & Kang (2007); Lee et al. (2013) and Son et al. (2015)	Experienced staff	***Experienced staff*** can disseminate their knowledge among the unexperienced staffs within an organisation and can smooth the adoption process.

Table 2.1 Continued

Context	Reference	Influence Factor	Conclusion
People Context	Eastman et al. (2011); McGraw Hill (2014); Hartman & Fischer (2008); Ralph (1991); Lee et al. (2013); Son et al. (2014); Yong et al. (2015) and Lee & Yu (2016)	BIM competency team	Forming ***BIM competency team*** internally or externally as a BIM technical support team could increase the confident level of unexperienced staffs in adopting BIM.
	Gu & London (2010); Eastman et al. (2011); Deutsch (2011); Yong et al. (2015), Lee et al. (2013) and Xu et al. (2014)	New roles and responsibilities	Having a clearly defined ***new roles and responsibilities*** such as BIM manager, BIM modeller etc. could ease the adoption process.

Table 2.1 Continued

Context	Reference	Influence Factor	Conclusion
	Smith & Tardif (2009); Eastman et al. (2011); Redmond et al. (2012); Son et al. (2015) and Kim et al. (2017)	Compatibility	Higher ***compatibility*** between BIM tools could ease in making decision to adopt.
Technological Context	Yaxin et al. (2013); Osman et al. (2015); Yeliz & Julide (2015); Won et al. (2013) and Kim et al. (2017)	Complexity	Less of ***complexity*** or ease of use of BIM tools contribute to decision to adopt.
	Smith & Tardif (2009); Eastman et al. (2011); Redmond et al. (2012); Son et al. (2015) and Kim et al. (2017)	Interoperability	Less issues of ***interoperability*** between BIM tools could ease in making decision to adopt.
	Eastman et al. (2011); Khosrowshahi & Arayici (2012), Azhar et al. (2012) and Rodgers et al. (2015)	Cost	Having lower ***cost*** in purchasing hardware and software of BIM tools could speed up the process of adoption.

2.9 Summary

This chapter citing literature related to concept Building Information Modelling (BIM) and of challenges, benefits and driven factors when adopting BIM. This chapter also citing literature related to the background of Malaysian construction industry and the history of BIM adoption in Malaysian construction. At the same time preliminary of BIM adoption factors also identified.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the research design and method used to achieve the objectives of this study. In this study qualitative and quantitative research methods were used. This chapter also discusses the research approach, research design and process, research instrument and method of analysis that will be used to achieve the objectives of this study.

3.2 Research Approach

Research approach can be categorised as exploratory, descriptive, and explanatory (Sekaran, 2009 and Saunders, Lewis & Thornhill, 2007). Selection of the appropriate approach defends by the research purpose and type of data that is needed to answer the research questions (Sekaran, 2009). Saunder et al. (2007) viewed an exploratory study as approaches to understand, clarify, search for a new insight and assess the problem arise, and at the same time to know what is happening. Since the aim of this study to examine the relationship between organisations, people and technology towards making decisions in adopting of Building Information Modelling (BIM) and at the same time to identify the BIM status and issues in Malaysian construction industry therefore this study was conducted as an exploratory and descriptive study by utilised qualitative and quantitative data.

The exploration needs to be carried out because the implementation of BIM in the Malaysian construction industry still new and using exploration approach would help the researcher to identify what is BIM status in Malaysia and what is the main issue in implementing BIM and what are the driven factors that can influence the adoption of BIM. While, descriptive approach was used to determine the influence and strong influential factors toward BIM adoption. Yin (2009), emphasised that by combining research methods such as qualitative and quantitative, it could compensate for each other's weaknesses and enhance one another's strengths and could lead the thoroughness of a study.

3.3 Research Design

Research design is the strategy or plan how the researcher collects and analyses data that should answer the objectives (Saunders et al., 2007). The research design for this study consists of both qualitative and quantitative data and consists of three stages (as shown in Figure 3). According to Strauss & Corbin (1990) qualitative research is a form of social inquiry that focuses on the way people interpret and make sense of their experiences and the world in which they live. Therefore, to explore what is Building Information Modelling (BIM) status in Malaysia, what is the main issue in implementing BIM and to validate the driven factors that influencing the adoption of BIM; qualitative inquiry is the best approach because it could capture unique individual experience and knowledge by interviewing the practitioners. In addition, from qualitative, inquiry could lead further exploration of other potential influences (Mertens, 2010).

Quantitative data were to obtain the statistical relationship between adoption factors and the most contributing factor towards BIM adoption through inferential statistics. Multiple linear regression was used determine the influence and strong influential factors toward BIM adoption by assessing the conceptual of BIM adoption model as shown in Figure 3.1.

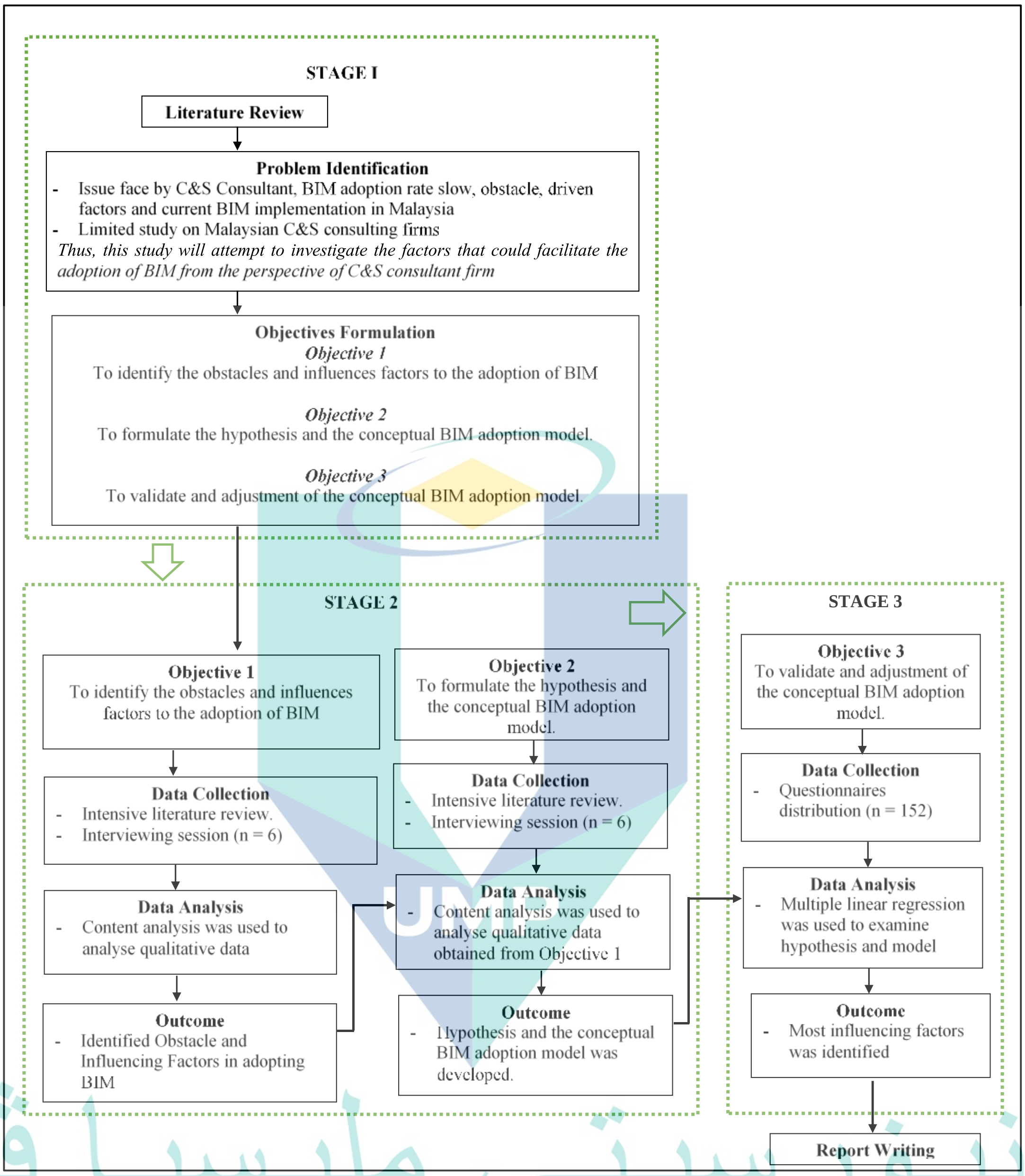

Figure 3 Framework of Research Design

3.3.1 Research Design: Stage 1

In stage 1, From Figure 3, extensive literature review was conducted to develop knowledge of the current issues in the construction industry and to understand the issues faced by the C&S Consultant in delivering projects and at the same time to identify the obstacles and influences factors to the adoption of BIM and current BIM implementation status in Malaysia. Beside the obstacle and influencing adoption factors being identified, findings from this phase were used to guide the researcher to explore the area of study and develop structured interview to explore about BIM adoption status in Malaysian construction industry.

The questions were developed based on identified adoption factors gathered from the previous literature and focusing on the themes generated by the previous literature namely; Organisation, People and Technology and these questions were presented in Appendix A. The questions started with general background of the company, how they start adopting BIM, issues facing, current status and after that, the questions moved into more details which are related to interviewee's experience in adopting BIM and their opinion on the identified obstacle and influencing adoption factors gathered from the previous literature.

3.3.2 Research Design: Stage 2

In the stage 2, exploratory interview was used to gather qualitative data to validate the identified obstacles and influences factors to the adoption of Building Information Modelling (BIM) by interviewing respondents that have experienced using BIM in their projects. All interviews were audio-recorded and content analysis was conducted to analyse the qualitative data. In this stage formulation of conceptual BIM adoption model and its' hypotheses were developed.

Interviews were chosen as part of research instrument in this study because the researcher is attempting to explore and understand current BIM practice and application. According to Fontana & Frey (2000), *"one of the most and powerful ways in which we try to understand our fellow human being is interviewing them"*. In addition, Cohen et al. (2007) said that during the interviewing session, the participants able to express or revealed their own point of view related with their experience and working live. Therefore, interviews approach was used because, it is relevant to the study because by interviewing the practitioners, researcher is able to gather the current BIM practice and the issues related with BIM adoption.

Since the adoption of BIM in Malaysia is still infant and there is no formal or accurate statistical data that revealed the numbers of organisation used BIM, therefore the researcher has contacted Construction Research Institute of Malaysia (CREAM) and Construction Industry Development Board of Malaysia (CIDB) to identify the organisations that were already implemented BIM in their projects. Five companies were identified and only three companies were willing to participate in the interviews session after application for conducting the interview was sent out to them. The criteria for selecting the interviewees are must at least 1 year experienced using BIM tools, involved with project that implemented BIM and have a good knowledge about BIM.

The interviews were conducted in English and Bahasa Melayu. Yin (2009) suggested researcher should be flexible during the interview session to ensure the interviewees felt comfortable by doing this it could help to produce a good interview which able to document interviewee's experience and knowledge more accurate. Therefore, before conducting the interview session, the participants were informed earlier their right and the purpose of this study via cover letter explaining the objectives of the interview and assured respondents of anonymity (in Appendix A). This form was emailed together with interview questions to the participants before they agreed to be interviewed. Appointment with the participants has been made once they agreed with the term and condition stated in the consent form. To analyse the qualitative data, content analysis being used as per suggested by Miles & Huberman (1994), Strauss & Corbin (1990) and Patton (1990), which found that content analysis as one of the methods to analyse qualitative data by identifying the quotes, coding the quotes, and categorising the code and lastly mapping approach being used to find the relationship between the different categories.

The formulation of conceptual BIM adoption model and hypotheses for this model were developed based on validation process via interview. In principal there are 12 factors in this conceptual BIM adoption model after go through validation process. These factors are Top Management Support, BIM Implementation Plan, Coercive Pressure, Working Environment, Training and Education, Experienced Staff, BIM Competency Team, New Roles and Responsibilities, Compatibility, Complexity, Interoperability and Cost. These factors then were clustered into appropriate constructs. These constructs are Organisational Context, People Context and Technological Context. These constructs then were used to formulate the conceptual BIM adoption model as shown in Figure 3.1. In order to examine the which factors having a strong relationship toward the adoption of BIM, series of hypotheses were developed. These hypotheses were developed based on the factors and supported by pervious literatures. The process of developing the conceptual BIM adoption model hypotheses was discussed lengthy in Chapter 4 section 4.4.

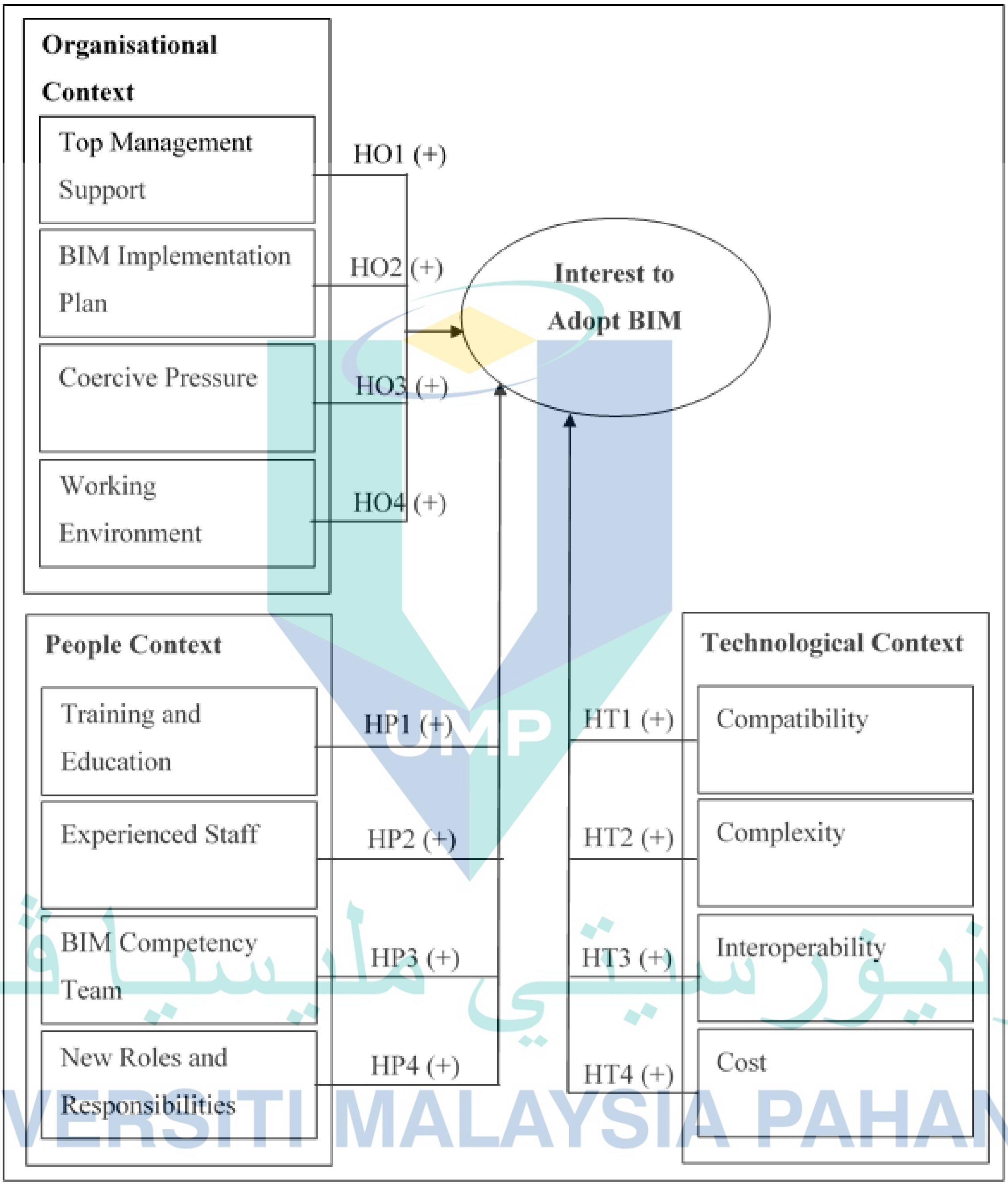

Figure 3.1 The Conceptual of BIM adoption model

3.3.3 Research Design: Stage 3

In Stage 3, quantitative data was used to validate and adjustment of the conceptual Building Information Modelling (BIM) adoption model. Multiple linear regression was used to examine the conceptual of BIM adoption model. As mentioned by Sekaran (2009), multiple regression analysis is used to *"examine the simultaneous effects of several independent variables on a dependent variable"*. Besides that, multiple linear regression was used due to a correlation study has been widely used in similar study such as Ross (2010) studied the relationship between the cloud computing adoption and factors included cost and security. Chebrolu (2010) used the same methodology to examine the relationship between cloud adoption by Information Technology (IT) organizations and their IT effectiveness in relation with the strategic alignment with business and Zorn's (2011) study of assessing institutional pressures alongside organisational and environmental influences on non-profit organizations to adopt the use of information and communication technologies.

In this study multiple linear regression was used to examine the direct relationship between independent variables and dependent variables via questionnaire survey. Before conducting the assessment of the conceptual of BIM adoption model using multiple linear regression, pilot survey was conducted before conducting primary questionnaire survey. The purpose of this pilot study to assess reliability and validity of research instrument, testing wording of questionnaire and testing procedures of testing (Straub, 1989 and Ticehurst & Veal, 2000).

In this study, there are three multiples linear regression models to be accessed. The first multiple linear regression model is to examine the Organisational independent variables which are Support from Top Management (O1), BIM Implementation Plan (O2), Coercive Pressure (O3) and Working Environment (O4) toward interest to adopt BIM as dependent variable. The multiple linear regression model can be described as follows;

Interest to Adopt BIM = $\alpha + \beta_1$ O1 + β_2 O2 + β_3 O3 + β_4 O4, where; α is the Y intercept (the value of Y when all the X values are zero and $\beta_1 - \beta_4$ is coefficients measuring relationship strength.

The second multiple linear regression model is to examine the Peoples independent variables which are Support from Training and Education (P1), Experienced Staff (P2), BIM Competency Team (P3) and New Roles and Responsibilities (P4) toward interest to adopt BIM as dependent variable. The multiple linear regression model can be described as follows;

Interest to Adopt BIM = $\alpha + \beta_1$ P1 + β_2 P2 + β_3 P3 + β_4 P4, where; α is the Y intercept (the value of Y when all the X values are zero and $\beta_1 - \beta_4$ is coefficients measuring relationship strength.

The third multiple linear regression model is to examine the Technological independent variables which are Compatibility (T1), Complexity (T2), BIM Interoperability (T3) and Cost (T4) toward interest to adopt BIM as dependent variable. The multiple linear regression model can be described as follows;

Interest to Adopt BIM = $\alpha + \beta_1$ T1 + β_2 T2 + β_3 T3 + β_4 T4, where; α is the Y intercept (the value of Y when all the X values are zero and $\beta_1 - \beta_4$ is coefficients measuring relationship strength.

Once the influence and strong influenced factors toward BIM adoption being identified, then the conceptual model for BIM adoption from the perspective of C&S consultant firms will be refined and finalised.

3.3.4 Design of Survey Instrument

In this study, most questions were developed based on previous literature to generate questionnaire items and by adopting questionnaires by previous similar study such as studies by William (2009), Said (2009) and Din S. Z. Cox (2013), as these studies had demonstrated reliability and constructs validity. However, some questions were modified and new items have been formulated because the previous validated instrument was not being used in the context of Building Information Modelling (BIM). In this study, there are 12 factors or Independent Variables (IV) were identified from the literature review and interview session. The factors or IV that were identified that could influence the decision in adopting BIM are; Top Management Support, BIM Implementation Plan, Coercive Pressure, Working Environment, Training and Education, Experience Staff, BIM Competency Team, New Roles and Responsibilities, Compatibility, Complexity, Interoperability and Cost.

These factors or IV then were clustered into appropriate constructs namely Organisational Context, People Context and Technological Context. Organisational Context was measured by the factors or IV of Top Management Support, BIM Implementation Plan, Coercive Pressure and Working Environment. People Context was measured by the factors or IV of Training and Education, Experience, BIM Competency Team and New Roles and Responsibilities. Technological Context was measured by the factors IV of Compatibility, Complexity, Interoperability and Cost. While the dependent variable (DV) is Interest to Adopt BIM.

To ensure that the instrument is suitable to be used in this study, some modification has been done and pilot testing has been carried out to ensure its reliability.

The questionnaire consists of two parts with a total of 48 items (see Appendix B). In Part A, there is only one section which is section A and was designed to understand the respondent's profile and information as shown in Table 3. In Part B there are four sections namely, section B, C, D and E. Section B, C and D were designed to examine and identify the relationship between factors or IV for Organisational Context, People Context, Technological Context towards BIM adoption, while section E is for dependent variables (DV) which is Organisation Interest in Adopting BIM. In section B, C, D and E a five-scale point measurement (1- Strongly Disagree to 5- Strongly Agree) was used for respondents to rate their statement (see Appendix B for full questionnaire questions).

Table 3 Section description in the questionnaire

Section	Description	Items
Part A (Respondent Profile)	Current Position	1
	Working Experience	1
	Knowledgeable about BIM	1
	Involved with the project using BIM	1
Part B (Respondent Statement)	Section B – Organisational Context	13
	Section C – People Context	13
	Section D – Technological Context	12
	Section E – Interest to Adopt BIM	6

3.3.5 Sampling Procedure

Sampling is a process of obtaining a sufficient number of units such as people, organisations etc. from a population of interest, so by studying the sample, the researcher is able to generalise the findings (Sekaran, 2009). Therefore, it is important to ensure the sample was used in this study is correct to ensure the data was reliable and valid. Since this study is to examine the factors that could influence the decision in adopting Building Information Modelling (BIM) from the perspective of Civil and Structure (C&S) consultant firms, therefore C&S consultant firms that are registered with Ministry of Finance were selected as targeted participants.

Malaysia consists of 13 states and three federal territories and due to time constraints and cost, this study had to be limited by focusing in Peninsular Malaysia. Table 3.1 shows the number of populations for C&S consultant firms which registered with Ministry of Finance. From Table 3.1 the total number of populations for C&S consultant firms are 683 and due to lack of actual data that revealed the number of C&S consultant firms who implemented BIM in their projects and after taking out 30 sample for pilot study, therefore, the sample size for this study is 653.

Table 3.1 Number of C&S consultant firm registered with Ministry of Finance Source: Bahagian Perunding, Kem. Kewangan Malaysia (2014).

State	**Number of C&S consultant firms**
Johor	59
Melaka	14
Negeri Sembilan	14
Selangor	290
Wilayah Persekutuan Kuala Lumpur	150
Wilayah Persekutuan Putrajaya	3
Perak	35
Kedah	32
Perlis	6
Kelantan	25
Terengganu	30
Pahang	25
TOTAL	**683**

3.3.6 Data Collection

Data collection was divided into two stages; the first stage is for pilot testing and the second stage is the primary data collection. The purpose of conducting pilot testing is to examine the reliability of the research instrument i.e.; survey questionnaires. Anderson (1998) suggested the numbers of respondent for pilot testing between 6 to 12 respondents, while Cooper & Schindler (2006) suggested the numbers of respondent for pilot testing may ranging between 25 - 100 respondents.

In this study, 30 respondents were participated in the pilot testing. The researcher used convenience sampling method to select the respondents. The questionnaire was delivered in an online electronic survey format (via Google Online Survey) and hardcopy format. For online electronic format, the researcher emailed to the targeted respondents and for hardcopy format, personal visits were used. 3 respondents were manually answered the questionnaire as face validation. From the observation, it was found that an average time for the respondents to answer the questions is about 20-25 minutes. The respondents also gave comments and suggestion to enhance the quality of the questions and these feedbacks have been taken into the account before collecting primary data.

For second stage of data collecting which is collecting primary data, online electronic survey format (via Google Online Survey) and hardcopy format was used. For online electronic survey format, the researcher emailed to the targeted respondents and all emails contained a link to the online survey. The email contained cover letter explaining the objectives of the survey and assured respondents of anonymity (see Appendix B). For hardcopy format, the mail contained cover letter explaining the objectives of the survey and assured respondents of anonymity, postage-paid return envelope and a questionnaire. To increase the participants, there are two rounds of reminder and telephone reminder were conducted.

3.3.7 Reliability of Survey Instrument

To test the reliability of research instruments, Cronbach's alpha was being used. According to Sekaran (2009) Cronbach's alpha referred to *"a reliability coefficient that indicated how well the items in a set were positively correlated to one another. It was computed in terms of the average interrelations among the items measuring the concept"*. In other word, reliability test is concerned with the stability and consistency of measurement. For reliability test, a value closer to 1 showed higher internal consistency reliability. Hair, Black, Babib, Anderson & Tatham (2006) suggested any construct that score value more than 0.70 is acceptable, while Malhorta (2004), suggested a value that score more than 0.60 is acceptable. In this study Cronbach's alpha value more than 0.60 is consider as reliable.

3.3.8 Construct Validity of Survey Instrument

Validity tests are to show *"how well an instrument that is developed measures a particular concept it is intended to measure"* (Sekaran, 2009). Thus, validity test is concerned with whether the right concept is measured. In this study, construct validity was assessed by using two different validities; convergent validity and discriminate validity (Sekaran, 2009). For convergent validity, this study used Average Varian Extracted (AVE) (Fornell & Larcker, 1981 and Chin, 1998). To ensure the validity of the construct the AVE score must above cut point 0.50 and this cut point is widely accepted procedure (Fornell & Larcker, 1981).

To discriminate validity, assessing the value of Variance Inflation Factor (VIF) has been conducted to check the multicollinearity and Tabachnick & Fidell (2007) and Pallant (2005) suggested the value of VIF must lower than 10 to ensure there is no multicollinearity issue.

3.3.9 Assumption of Multiple Linear Regression

According to Tabachnick & Fidell (2007), before analysing the significance of the independent variables in relationship with the dependent variable using Multiple Regression being conducted, the data must fulfil the assumption of;

a) Multicollinearity.
b) Outliers.
c) Linearity.
d) Homoscedasticity.

Therefore, before assessing the model, the quantitative data must fulfil the requirement of assumption of multiple linear regression.

3.4 Summary

This chapter presented the research methodology and design that was used in the study. Qualitative and quantitative data were used in this study to achieve the objectives of the study. It describes the criteria for selecting study respondents, administration of questionnaire survey and data analysis techniques that were used.

CHAPTER 4

BUILDING INFORMATION MODELLING (BIM) ADOPTION MODEL ANALYSIS

4.1 Introduction

This chapter analyse and discusses the qualitative and quantitative data. Qualitative data was being obtained based on the interview sessions from three companies that have experienced adopting Building Information Modelling (BIM), while for quantitative data is from questionnaires survey. The purpose of this interviewing is to explore current BIM implementation status in Malaysia and to validate identified driven factors that could influence the adoption of BIM. At the same time the formulation of conceptual model and hypotheses formulation for the conceptual of BIM adoption model was developed based on identified BIM adoption factors. This chapter also analyse and discusses the findings from correlational relationship between the organisational, people and technological factors towards interest in adopting BIM by examining BIM adoption model using Multiple Linear Regression which is gathered from questionnaires survey.

4.2 Building Information Modelling (BIM) Adoption Status in Malaysian Construction Industry

This section discusses qualitative data that have been obtained based on the interview sessions from three companies that have experienced adopting Building Information Modelling (BIM). Other criteria to select the interviewees are must have at least a 1-year experience using BIM tools, involved with project that implemented BIM and have a good knowledge about BIM. The purpose of this interviewing is to explore current BIM implementation status in Malaysia and to validate identified driven factors that could influence the adoption of BIM. To achieve these objectives, it started with discussing on the background of the company and explore the current BIM practice by them. Then, followed by validated identified driven factors that could influence the adoption of BIM by cross analysis between interviewing session and identified adoption factors. The interview session guided by identified driven adoption factors as follows;

a) Organisational Context.
   i. Support from top management.
   ii. Working environment.
   iii. Coercive pressure.
   iv. BIM implementation plan.
   v. Type of organisation.
b) People Context.
   i. Training and education.
   ii. Experienced staff.
   iii. BIM competency team.
   iv. New roles and responsibilities.
c) Technological Context.
   i. Compatibility
   ii. Complexity
   iii. Interoperability
   iv. Cost

In this study, interview was used to develop the understanding of real world situation by gathering the information from individual to understand current issues of BIM implementation status in Malaysia. In qualitative method, issue of sample size still under debating (Mark, 2010). To overcome this issue, some researchers come up with general guideline, because qualitative research can be time consuming if analysing large sample. Mostly for qualitative studies the sample size normally much smaller than those used in quantitative studies, because qualitative research is focused with meaning and not making generalised hypothesis statements (Ritchie, Lewis & Elam, 2003 and Crouch & Mckenzie, 2006). In general, sample size for qualitative study based on the type of qualitative approach used, for ethnography study, Morse (1994) suggested 30-50 interviews, for grounded theory Creswell (2003) suggested 20-30 interviews while Morse (1994) suggested 30-50 interviews and for phenomenology/exploratory study Creswell (2003) suggested 5 – 25 interview while Morse (1994) suggested at least 6 interviews.

This study is to explore the current BIM implementation status and issues faced in Malaysian construction industry and at the same time to validate the identified theoretical adoption factors. Thus, exploratory interview was used to gather qualitative data. These activities required to understand the interviewee as social actors and at the same time able to grasp their knowledge based on their experience. Three companies are willing to participate in the interviews session after application for conducting the interview has been sent out to them with total number for interviewees are 6 which has fulfilled the requirement suggested by Creswell (2003) and Morse (1994) for exploratory study.

4.2.1 Respondents Background

Through database from Construction Industry Development Board (CIDB) and Construction Research Institute of Malaysia (CREAM), the researchers have identified five companies that have experienced implement BIM in their construction projects. Letter of invitation was sent to the five companies to participate in this study, and only three out five companies replied agreed to participate in this study. They gave consent for taping the conversation during the interview session.

These three companies are identifying as Company A (COA), Company B (COB) and Company C (COC). Table 4, shows the general background of these companies. COA is a Project Management Consultant and had implement Building Information Modelling (BIM) since 2008, while COB is a developer and started using BIM since 2010 and their first project using BIM is design oil and gas project platform. COC is a developer company and started using BIM almost 3-5 years.

Table 4 Summarises general information of interviewed organisations

Company	Type of Company	BIM Experience
COA	Project Management Consultant	Since 2008
COB	Developer	Since 2010
COC	Developer	Since 2010

In order to keep the confidentiality, Chell, 2004 urged that all the respondents' profile must be omitted during report writing and each respondent was assigned a code e.g.: INTCA1. Respondents for the interview in this study were from the middle level and top level management because Smith & Tardif (2007) viewed, these levels of management have a mandate to implement BIM or not in their organisations. Table 4.1 shows, the respondents' profile.

Table 4.1 Respondents Profile

Respondents		Years of Experience	Position
Company A	INTCOA1	15	Top Management
	INTCOA2	7	Middle Management
Company B	INTCOB1	18	Top Management
	INTCOB2	9	Middle Management
Company C	INTCOC1	11	Top Management
	INTCOC2	6	Middle Management

4.2.2 Current Building Information Modelling (BIM) Practice

Implementation of BIM in Malaysia is still new. From the interview session with Company A (COA), Company B (COB) and Company C (COC), it was found that COA and COB have started to implement BIM in year 2008 and 2010 while COC started in 2009. COA started implementing BIM by designing an oil and gas platform while COB started with in-house pilot project. In the early implementation of BIM, both companies have different BIM objective to achieve, COA focus more on exploiting the implementation of BIM to improve the process of planning and scheduling while, COB focus on reducing designing time frame. COB claimed that by implementing BIM, the duration during the design stage can be reduced up to 30%. This achievement gives a morale boost for COB to extend the implementation of BIM by mandating the implementation of BIM in their projects to any external consultants that worked with them. This shows that, the implementation of BIM has a place in the Malaysian construction industry. While COC started with show room building as their BIM pilot project. Compare to COA and COB, COC implement BIM to increase their productivity by using innovative approach after getting advice from their Research and Development (R&D) department.

In early stage of BIM implementation, COA, COB and COC faced a lot of challenges that hinder the pace of BIM adoption. Resistance from people to change is one of the challenges. This occurs because of fear factors such as uncertainty of their job in the future, complacency with current working conditions, afraid to compete with junior staff etc. To deal with these resistances; motivation, provide training, provide promotion etc. are some of the approaches taken by COA, COB and COC. Changing from established working process to new working process is very stressful and tiredness, without proper plan or guideline can lead the implementation of BIM to wrong direction. This is because there is no national BIM guideline, COA, COB and COC have to develop the BIM implementation from the scratch and modify the BIM implementation plan from abroad to suit their needs and business strategy.

To do this, COA, COB and COC appointed external BIM expert team to assist them. This is because in Malaysia, the number of people with BIM competency is very limited therefore they have to outsource the BIM experts. Figure 4 show the general BIM competency team structure developed by COA, COB and COC. With assistance from external BIM expert team, they started to develop BIM implementation plan that includes the process of hiring staff, develop training and education module, creating new roles and responsibilities such as BIM manager, BIM modeller, BIM technologist, BIM coordinator etc., develop a clear job scope and responsibilities for these new posts and assessing the BIM technology before purchasing it. COA, COB and COC agreed that the relevant authorities should come up with national standard BIM guideline, as this it would help new adopter to adopt BIM in a proper way and at the same time it can minimise the duration of developing a new BIM implementation plan.

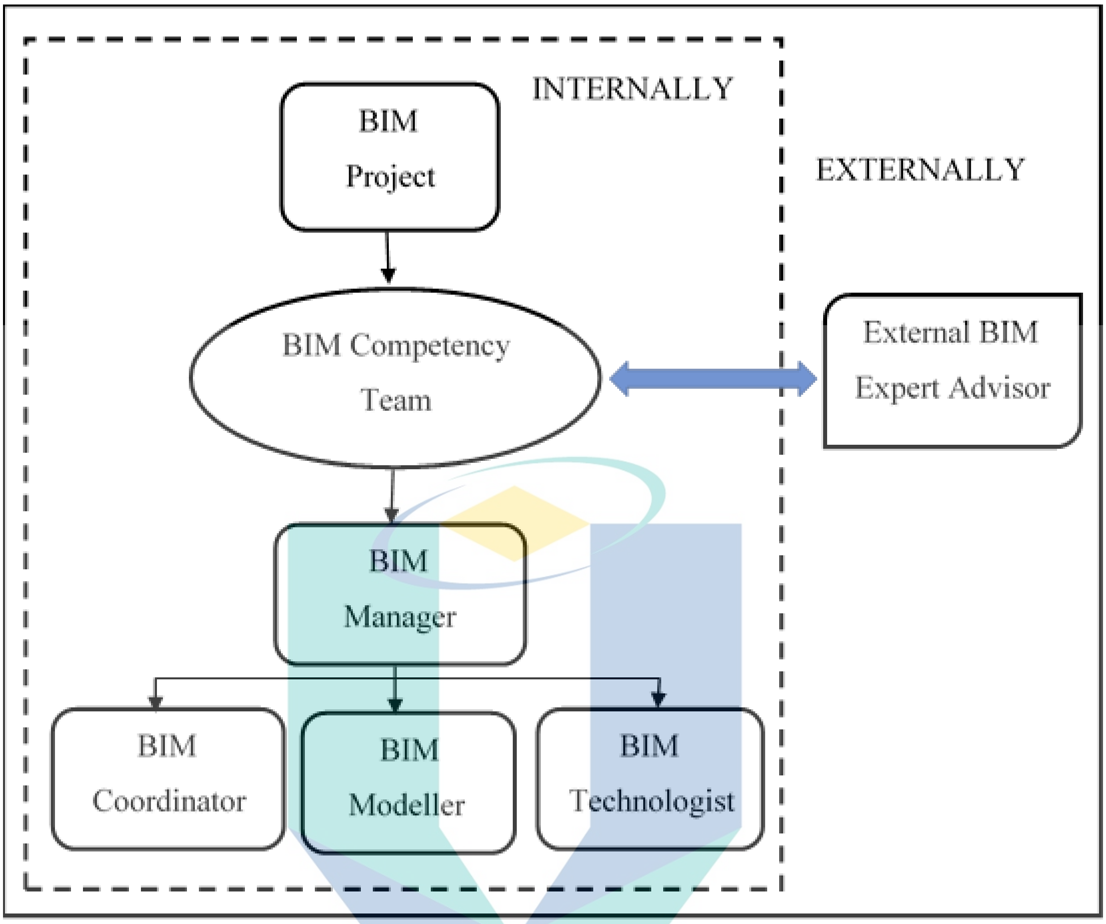

Figure 4 Example BIM competency team structure for COA, COB and COC

Issue of compatibility, complexity and interoperability are some of the challenges facing by COA, COB and COC. Some BIM technologies are very complex to understand and operate, some have issue of compatibility and interoperability between BIM technologies. To reduce these issues, COA, COB and COC mandate their BIM competency team to review the BIM technology in term of compatibility, complexity and interoperability before purchase. To minimize the risk of compatibility and interoperability, they have come up with standard exchanging information protocol such as project participants must submit all the information in the agreed format, i.e. *.RVT as shown in Figure 4.1. Beside technical issues, the higher initial cost in investing the BIM technology could hinder the pace of BIM adoption in Malaysia. This cost includes the cost of upgrading the hardware and the software. Therefore, the BIM competency team play a significant role to ensure they invest in the right technology to avoid unnecessary cost. But COA, COB and COC agreed that, to increase the number of BIM adoption in Malaysia these issues need to address accordingly.

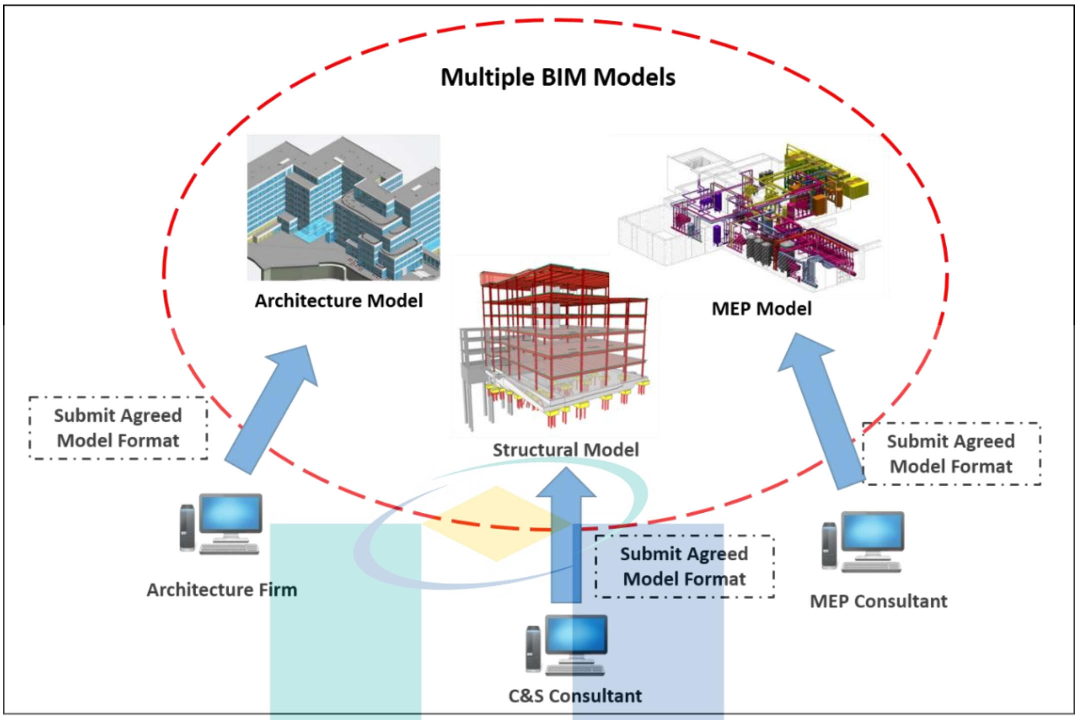

Figure 4.1 Submission of agreed model format done by COA, COB and COC

Other approach that could increase the number of BIM adoption in Malaysia, is a push or pressure from the client. For instance, to increase the use of Industrial Building System (IBS) in Malaysia, government has regulated that all government project must use certain percentage of IBS components. Same goes to the implementation of BIM in Malaysia. The government or client have to enforce the usage of BIM in their project and this could increase the number of BIM adoption in Malaysia. Top down approach is more effective according to COA, COB and COC but support from industry players also plays a significant role to increase the adoption of BIM in Malaysia. COA, COB and COC agreed that, besides the element of push or pressure or mandate from government, there is the need of the pull element in which the construction parties should pull themselves to shift from practicing traditional approach to more innovative approach. Using a small scale project as their pilot project in implementing BIM is a proper way to minimise the risk and they can learn from this pilot project and at the same time it could build up their confidence level in implementing BIM in near future.

The ultimate BIM goal is to have a single shared model that can be used by construction parties but to achieve this goal by Malaysian construction industry, it cannot be done overnight. Based on the classification by Richards and Brew (2008), level of

BIM can be classified based on level of maturity. There are 4 levels of BIM maturity as shown in Figure 4.2. It can be concluded that, the level of BIM maturity for COA, COB and COC is at level 1 where they are trying to manage the transition from 2D ACAD environment into 3D BIM working environment. Since COA and COB are still new in implementing BIM, the achievement by both companies is encouraging and inspiring. Both companies have targeted to achieve BIM level 2 in year 2015 and 2016 while COC did not mentioned when they will achieve BIM level 2. Currently, these companies are trying to increase the number of BIM competent staff.

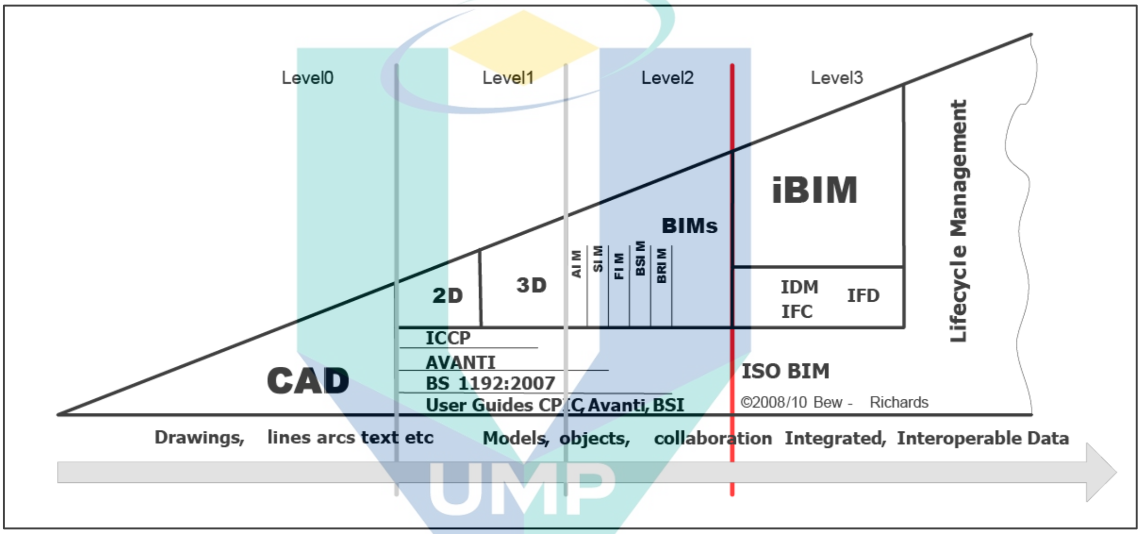

Figure 4.2 Level of BIM
Source: Richards and Brew (2008).

The classified of BIM levels are as follows;

i. *BIM Level 0:* Usually in 2D environment with unmanaged CAD coordination, most formats are papers and electronic e.g. Pdf file. These formats are treated as the main data exchange mechanism.

ii. *BIM Level 1*: Managed CAD in 2D or 3D format with a collaboration tool (extranet) providing a common data environment, possibly using some standard data structures and formats.

iii. *BIM Level 2:* Managed 3D environment held in separate discipline 'BIM' models and tools with attached data. Data exchange is mainly on the basis of proprietary of exchange formats. This approach may include 4D programme data and 5D cost data.

iv. *BIM Level 3*: Fully-open process with a single project model and data integration and exchange using IFC standards; the process is managed by a collaborative model server.

(Richards and Brew, 2008)

4.2.3 Validation outcomes of Building Information Modelling (BIM) Adoption Factors

1. Organisational Context

From the interview session, for organisational context, majority of respondents, agreed strong support from top management, provide a conducive working environment, having a coercive pressure and developing and having a BIM implementation plan could ease the process of adoption and influence the decision in adopting BIM. Majority of respondents said, they enjoy having a strong support from their top management to change; therefore, they found it is easy for them to do an innovation in their approach. Having a strong support from top management has become a turning point for any company to implement BIM, because to change an established work process into a new work process it required bold steps. And it is related with the cultures that support the innovation culture within organisations.

Since BIM is new to them, majority of respondents urges there is the needs to provide the conducive working environment that can foster the process of exchanging idea and knowledge sharing. Some of them provide a dedicated discussion room for the process of exchanging idea and disseminate knowledge among staff. A dedicated room called as 'BIM room' was created to do a brainstorming among staff of BIM units. In this room everybody is free to voice their opinions and problems encounter and the mentors will jot down and give some solution to any problems arose. This approach could help to cater the stress and uncertainty environment during the early stage of BIM implementation by having a sharing knowledge session and mentoring system.

To move forward, there is the need to put some pressure. One of the examples why to adopt BIM needs a pressure from external. For example, the use of Industrial Building System (IBS) where enforcing any government projects must at least have used some percentages of IBS components. Without enforcing the law, construction participants will just ignore and for BIM there is a need to have a pressure from the government or client for instance. To cater the internal resistance, one of the methods is pressure by the top management such as regulated all project must BIM compliance, giving reward and promotion. Explain to them why we need implement BIM for our future otherwise we have to losing out job. Without having a coercive pressure, the pace of BIM adoption will slow and lag behind.

Besides that, having BIM implementation plan is a must, because it's a roadmap for any organisation to achieve BIM goal. Without BIM implementation plan the possibilities of any organisation go to wrong direction inevitable. Since there is no BIM guideline in Malaysia, majority of respondents have to use BIM guideline from other country and amended it to suit to their needs. It's the best way to develop BIM implementation plan phase by phase, because to achieve the full potential of BIM cannot be done in one night. Although adopting from international standard is not a right way to develop BIM implementation plan, but due to the absence of Malaysia BIM standard, adjusting the international standard to meet local requirement is the best option they have at that time. Besides that, by exploring and studying international standard they could found the main important requirement in implementing BIM. Therefore, having and understand about BIM implementation plan is a must before implementing BIM and it could influence the adoption of BIM.

Majority of respondents did not agree only the consultant firms gained benefit from utilisation of BIM in construction project. BIM application can be applied across project life cycle. Application of BIM can be benefited by contractors through 4D BIM for planning and scheduling. By using 4D BIM, the contractor will be able to control and monitor progress of the work via simulation. The ability of BIM to extract the quantity of material from model could speed up the process of taking off done by quantity surveyor. Contractor also have gained benefit from this beside BIM is able to simulate the construction process in 3D and able to track any abnormity of sequence of work. Therefore, the statement said that only certain types of organisation are suitable using BIM is not true and the type of organisation is not the factor that could influence in adoption of BIM

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2. People Context

People play a major part in implementing Building Information Modelling (BIM). To ensure the success of BIM implementation the people within the organisation should equip with BIM knowledge. Training and education is one of the strategies to equip people with skill and knowledge. This support by Dewan at al. (2004), where resistances culture in the organisation especially came from staff cannot be eliminated; however, these resistances could be managed by developing education and training to increase individual knowledge. However, education and training alone cannot overcome this issue, because some of the personnel went to undergo training just because they have been forced by the management to attend the training programme. To this issue, creating new posts by giving a clear job scope is one of the approach. By having a clear roles and responsibilities of their job scope, they have a clear picture what they will do after completing the training and will motivate them to undergo training and the same time it will make them understand why they needed to undergo the training. Therefore, to influence the implementation of BIM among Malaysian construction players, having proper training and education and clear roles and responsibilities are one of the vital factor.

To speed up the process of learning, recruit new employees with minimum experience in handling and creating 3D models in any 3D software, i.e; ArchiCAD is one of the strategy. By having this strategy, they felt, they could encourage the knowledge sharing attitude among themselves and the same time able to reduce the cost of training. This approach also supports by Eastman et al. (2011) where to create a BIM environment and at the same time to speed up the adoption of BIM, the management should check the process of recruitments by reviewing the application's qualification, experience and skills in handling BIM technology. This experienced staff will form a BIM team as this team will access the risk, software selection, develop BIM implementation plan, conduct training and plan the training syllabus. This team in future will resolve and give technical support to any BIM issue occurs. This approach also could minimise the risk when the process of migration to BIM working process. This show the importance to have BIM competency team with experienced staff to ease the process of adopting BIM.

3. Technological Context.

Without technology, implementation of Building Information Modelling (BIM) will not success because, technology will be a complement for organisations and people who are ready in implementing BIM. Majority of respondents conduct comprehensive study before selecting BIM software and upgraded the hardware and infrastructure. For them this study is very critical to ensure the software they purchased can meet and fulfil their BIM objectives. O'Brien (2000) revealed that, by selecting the wrong technology it not only affects the investment, but at the same time it affects the performance of the organisation. Therefore, comprehensive study must be carried out especially the level of complexity of software because; according to Kunz & Fischer (2007) and Giligan & Kunz (2007) the complexity of BIM software is one of the factors that hinder the widespread of BIM. Therefore, technology with less complex is more favourable and easy to adopt by the staff.

Beside study the complexity of the technology, most of the respondents also look the issue of interoperability and compatibility of the technology. Issue of compatibility and interoperability will slow down their authoring process because some of the file cannot 'communicate' with each other, and to solve this problem they have to use third party software to force 'them' to communicate but sometime some of the components will lost (Eastman et al., 2011). It will be a time and cost consuming if the third party software is used. Issues of interoperability and compatibility are not easy to overcome due to various BIM software available from various companies but interoperability is very important in term of exchanging information and data between project participants. In order to obtain full performance of BIM an ability of interoperability between BIM software is a must. To avoid the issue of compatibility they set the file protocol such as file format and size at early stage of project and it include in their BIM implementation plan. Majority of respondent believed that the ability of interoperability and compatibility between BIM software contribute to decision in adopting BIM.

In order to migrate to BIM working environment, upgrading current hardware, software and infrastructure is a compulsory for any organisations to implement BIM in their construction projects. They must thoroughly study before purchasing or upgrading because it's involved the cost of updating the software and licence, some of the software need renewing licence yearly before can updating to new version. Although it would increase the operational cost but with thorough study in selection of hardware, software and infrastructure the cost could be minimised. They believed that higher cost of investing in BIM technology could influence the decision in adopting BIM.

From the three interview sessions from three companies, it revealed that, there are 12 factors that could influence the adoption of BIM namely, support from top management, working environment, coercive pressure, BIM implementation plan for organisational context. For people context, the factors are training and education, experienced staff, BIM competency team, new roles and responsibilities, while for technological context, the factors are compatibility, complexity, interoperability and cost. It was found that the current BIM implementation level in Malaysia is still at level 1 where three two companies is in the process to fully migrate from 2D environment to 3D BIM environment. Besides that, to start using BIM, it is advisable to implement it through small scale or pilot project because it can minimise the risk during the transition period.

Table 4.2 shows the summary of identified BIM adoption factor for Organisational Context, People Context and Technological Context.

Table 4.2 Summary of identified BIM adoption factor

	Organisational Context			
Factors	***Description***	***Company A***	***Company B***	***Company C***
1. Top Management Support	During the migration to BIM environment, support from top management such as motivation, provide adequate training, give a moral support and promotion could ease the transition and unpleasant feeling from staff.	Accept	Accept	Accept
2. Working Environment	To minimize the resistance from staff to change, having conducive working environment that promote the knowledge sharing, support the innovative or creative idea and support the exchanging idea able to ease the process of adoption.	Accept	Accept	Accept
3. Coercive Pressure	Having an internal or external pressure whether from government or client or top management is one of the factors could influence the pace of adoption.	Accept	Accept	Accept
4. BIM Implementation plan	To deal with uncertainty, having a BIM implementation plan that consist of clear working process, business strategy and roadmap could influence the process of adoption.	Accept	Accept	Accept

Table 4.2 Continued

Organisational Context				
Factors	***Description***	***Company A***	***Company B***	***Company C***
5. *Type of Organisation*	*Only consultants gain the benefits from adoption of BIM compared to other project participants*	*Reject*	*Reject*	*Reject*
People Context				
Factors	***Description***	***Company A***	***Company B***	***Company C***
1. Training and Education	Having adequate training and education whether internally or externally, on job training or attending seminar could ease the resistance from the staff that could speed up the process of adoption.	Accept	Accept	Accept
2. Experienced Staff	Having minimal working experiences such as site, design and ability to operate CAD system could ease the process of adoption.	Accept	Accept	Accept
3. BIM Competency Team	To ease the adoption of BIM, support from BIM technical team whether the team internally or externally is a must.	Accept	Accept	Accept

Table 4.2 Continued

People Context				
Factors	***Description***	***Company A***	***Company B***	***Company C***
4. New Roles and Responsibilities	Working process for BIM is different from conventional working process, therefore creating new roles such as BIM manager, modeller etc. is required to meet the needs of BIM working process. These roles need to clearly define to ease the process of adoption.	Accept	Accept	Accept

Technological Context				
Factors	***Description***	***Company A***	***Company B***	***Company C***
1. Compatibility	The success of BIM adoption is depending on how critical the issues of compatibility between hardware, BIM software and working process happened.	Accept	Accept	Accept
2. Complexity	Having a complexity of BIM software could jeopardise the process of BIM adoption due to resistance from staff and consume time to learn.	Accept	Accept	Accept

Table 4.2 Continued

Technological Context				
Factors	***Description***	***Company A***	***Company B***	***Company C***
3. Interoperability	The success of BIM adoption is depending on how critical the issues of interoperability between BIM software and working process occurs.	Accept	Accept	Accept
4. Cost	High cost in investing hardware, software and infrastructure to support BIM technology could hinder the process of adoption.	Accept	Accept	Accept

4.3 Conceptual Model for Adoption of Building Information Modelling (BIM)

Process of validation BIM adoption factors through interviewing three companies had been conducted. By cross examining the findings from interview session and the literature, the BIM adoption factors identified are as shown in Table 4.3. The conceptual of BIM adoption model for this study was developed based on these factors as shown in Figure 4.3. Figure 4.3 shows the path of the conceptual of BIM adoption model for this study. The conceptual model for BIM adoption consists of three constructs which are Organisational Context, People Context and Technological Context. Each construct was measured by the factors or independent variables (IV) that could speed up the adoption of BIM. These factors or IV were gathered from previous literature review and validation through exploratory interview. The factors or IV that were identified that could speed up the pace of BIM adoption are; Top Management Support, BIM Implementation Plan, Coercive Pressure, Working Environment, Training and Education, Experience Staff, BIM Competency Team, New Roles and Responsibilities, Compatibility, Complexity, Interoperability and Cost.

These factors or IV then were clustered into appropriate construct. The Organisational Context was measured by the factors or IV of Top Management Support, BIM Implementation Plan, Coercive Pressure and Working Environment. The People Context was measured by the factors or IV of Training and Education, Experience, BIM Competency Team and New Roles and Responsibilities. The Technological Context was measured by the factors IV of Compatibility, Complexity, Interoperability and Cost.

This model then will be examined to identify which factors from organisational, people and technological that have significant influenced and strong influence toward the adoption of BIM.

Table 4.3 Identified BIM adoption factors after the validation

Construct	*Factors / IV*
Organisational Context.	1. Support from top management. 2. BIM implementation plan. 3. Coercive pressure. 4. Working environment.
People Context.	1. Training and education. 2. Experienced staff. 3. BIM competency team. 4. New roles and responsibilities.
Technological Context.	1. Compatibility. 2. Complexity. 3. Interoperability. 4. Cost.

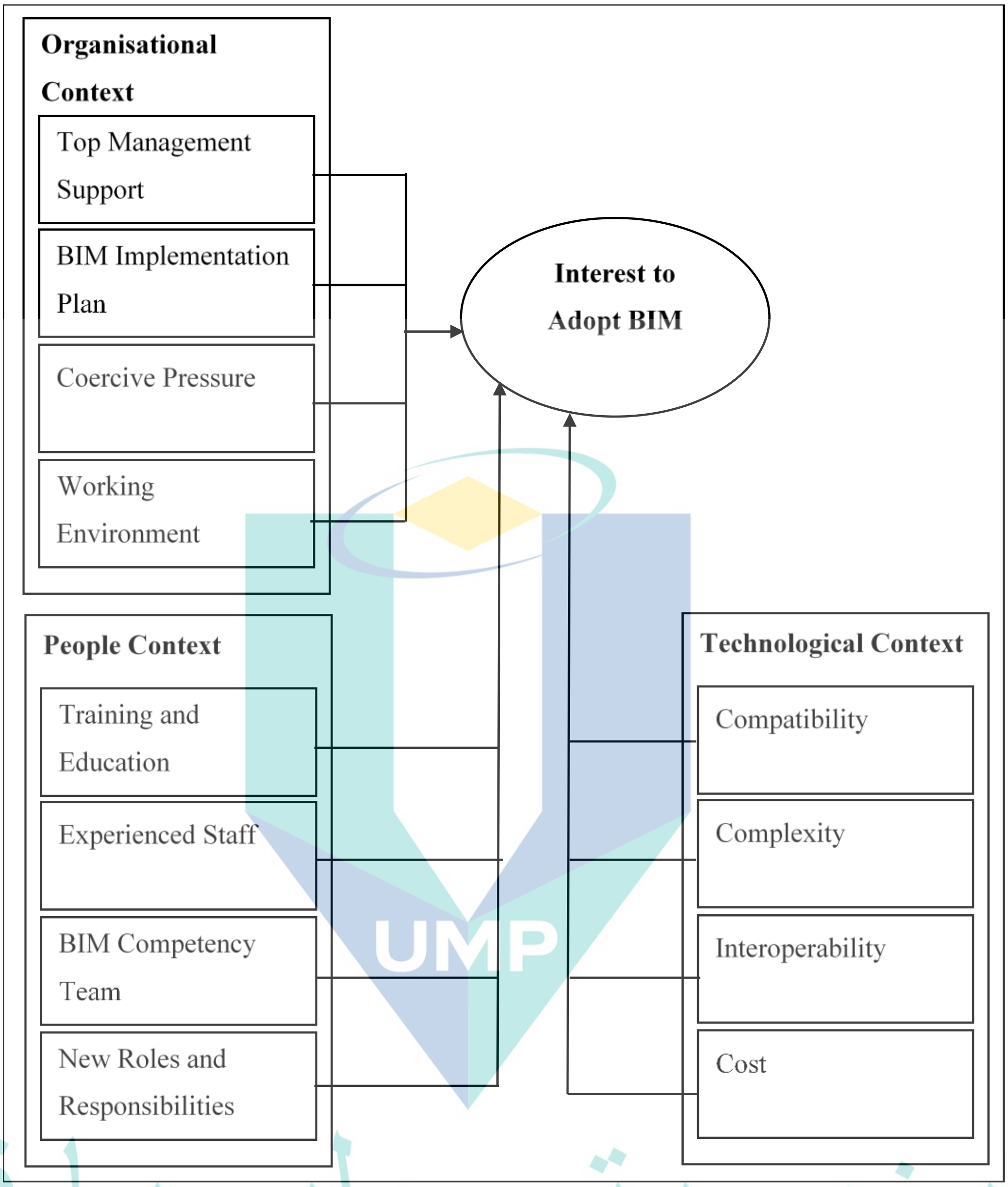

Figure 4.3 The Conceptual of BIM adoption model

4.4 Hypotheses Formulation for the Conceptual of Building Information Modelling (BIM) Adoption Model.

In order to examine which factors from organisational, people and technological that have significant influence and strong influence toward the adoption of BIM, the following hypotheses were developed.

4.4.1 Organisational Context

In Building Information Modelling (BIM), organisation plays a critical role to ensure the success of BIM adoption for construction projects (Kymmell, 2008), because in order to implement BIM, there is a transition working flow from traditional approach into more integrated and it cannot be done individually. A study conducted by Autodesk revealed that about 82% of the respondents said that in order to implement BIM, they have to reconsider their existing ways of working (Khemlani, 2004) and this could affect their organisation working process. Taylor & Levitt (2007), believed that by changing their current ways of working will jeopardise their organisation's productivity. While studies conducted by Thompson, Higgins & Howell (1991) and Newman & Sabherwal (1996) revealed that most of Information Technology (IT) project failed is due to lack of organisational commitment. Therefore, organisation is one of the criteria that could influence the decision in adopting BIM. To examine and measure the role of organisation towards BIM adoption, four factors that will be measured namely; Top Management Support, BIM Implementation Plan, Coercive Pressure and Working Environment.

4.4.1.1 Support from Top Management

According to Jung & Gibson (1999) and Jung & Kang (2007), implementing Building Information Modelling (BIM) has a huge impact to the organisation's operation, especially on their business goal, vision and mission. In order to implement BIM, some of the organisation has to ensure their BIM objectives are aligned with their business goal, vision and mission. In order to do this, involvement from top management cannot be avoided because they have authority to set the organisation's strategy and the direction to implement new technology. Having support from top management could ease the migration process because according to Cascio, Mariadoss, & Mouri (2010) and Kim & Lee (2008), because involvement from top management in adopting new technology clearly shows the commitment to adopt it and influence from top manager could ensure adequate resources in the process of adoption BIM. This includes that the top management will provide a clear vision and mission to achieve BIM goal and how they are going to change the current working process and how those changes will improve the current practice.

Meanwhile, Gilligan & Kunz (2007), Deutsch (2011), added by having support from top management, it could manage the resistance from the people to change their current working process into a new working process. It can be done through motivation or promotions and rewards as one of the approaches to reduce the resistance from the people because it could build up the self-confidence to motivate individuals to use new technology (O'Brien, 2000). In order to make BIM adoption success, support from top management is inevitable, as the involvement from top management shows the commitment of the organisation in adopting new technology and it will motivate their workers to implement new technology. Thus, to this, it can be hypothesised as;

HO1: Strong support from top management within organisation has a significant and positive impact toward BIM adoption.

4.4.1.2 BIM Implementation Plan

In construction industry, to migrate from traditional approach to more innovative approach such as implementation of Building Information Modelling (BIM) required changing current working process or procedure. In BIM environment, the usage of paper-based two-dimensional (2D) computer-aided design (CAD) can be minimised and paper-based drafting will be shifted into more model-based which is three-dimensional (3D) CAD parametric (Taylor & Levitt, 2007). These evolutions have caused an impact towards redistribution of scope of works, skill requirements, new department, equipment and roles (Taylor & Levitt, 2007). This is because, in a construction project, it involves many parties, therefore by changing the current process, it also involves inter-organisation scope of works and responsibilities (Smith & Tardif, 2009), therefore Succar (2010) and Eastman, Teicholz, Sacks & Liston (2011) suggested, organisation needs right strategic implementation plan to ensure that organisation gained from utilisation of BIM because the implementation of BIM required the collaboration between project participants, a clear roles and responsibilities must be address for inter and intra organisation collaboration. Some of the processes in developing BIM implementation plan such as changing process in a small or incremental step, identifying which construction phase will be using BIM, what action plan in the process of adopting BIM and etc. Hardin (2009) advised to develop BIM implementation plan should be done step by step, the owner must involve in the initial stage of discussion to draw the clear goal, vision and mission and to decide the decision on investments in software, hardware and staff. Once the fundamental is clear then it's easy to draw the plan when involved the technical part. Thus, to this; it can be hypothesised as;

HO2: Organisation that have BIM implementation plan has a significant, positive impact toward BIM adoption.

4.4.1.3 Coercive Pressure

DiMaggio & Powell (1983) defined coercive pressures as *"formal and informal pressures exerted on organisations by other organisations upon which they are dependent and by cultural expectations in the society within which organisations function"*. Pressure from both sides either from external parties such as government agencies or clients which are enforced to use Building Information Modelling (BIM) technology in their projects and push from internal such as from boards of directors, partners, and parent companies to use BIM technology to ensure their competitiveness could increase the pace of BIM adoption. Others countries such as Unites State of America, United Kingdom, Singapore and Hong Kong, their government enforce to implement BIM in their project (BuildingSMART, 2011 and Mc Graw Hill, 2014). From the interview session, Company B and C also enforce their external consultant to submit their plan in agreed format in any of their project. Then, a study conducted by Hu, Hart & Cooke (2006) in implementing security technology and a study conducted by Zang & Dhaliwal (2009) in adopting e-commerce technologies, found that coercive pressures was a dominant force in influencing top management's decision to adopt new technology. These studies indicated that the potential adopters of BIM by the organisation are being subject to coercive pressures, and for this reason, it can be hypothesised as;

HO3: High level of coercive pressure received by the organisation has a significant, positive impact toward BIM adoption.

4.4.1.4 Working Environment

Implementing Building Information Modelling (BIM) is one of the opportunities for organisation to change from traditional approach into more collaborative approach; however, these changes will have an impact on the operations of the organisations. In order to handle the process of changes, the organisations need commitment from all the staffs starting from top level of management to operational level through supportive working environment. According to Deutsch (2011); Kaner, Sacks, Kassian & Quitt (2008) and Alshawi (2007) some example of characteristics of supportive working environment are commitment, learning and knowledge sharing and open discussion. Eastman et al. (2011) believed that commitment from individual and top management is a must to ensure the process of BIM adoption is success because, individual commitment will focus on how to use BIM technology, while commitment from top management is to support their staffs to use BIM technology and at the same time they will be committed to support and allocate adequate resources for technology investment.

Besides having a commitment from everybody within organisation, to increase the pace of BIM adoption, there is a need of having learning and knowledge sharing environment (Olatunji, 2011). In any organisations, each staff will have their own knowledge and know how to execute their job and it's important to capture and document their knowledge. Based on interview session Companies A and B agreed that to capture and documented tacit knowledge having an environment that support exchanging idea and innovation idea is a must, therefore, there is a dedicated room was designed to foster the spirit of sharing knowledge between staff. Having learning and knowledge sharing environment will motivate the staffs to do more and could minimise the lack of self-confidence and at the same time it could increase the spirit of team working because according to Grantham & Nichols (1993), *"organisational learning occurs when people in an organisation collaborate to share their different visions, knowledge, experiences, and skills"*. The keyword here is "collaborate" which everybody within organisation will work together to achieve the organisation's business goal, and for this reason, it can be hypothesised as;

HO4: Having a supportive working environment within organisation has a significant and positive impact toward BIM adoption.

4.4.2 People Context

The resistance of people to change is one of the main barriers for any organisation to adopt Building Information Modelling (BIM) in their construction projects (Khemlani, 2004). There are a lot of factors on why people reluctant to change from establish working procedure into new working procedure especially when related with new technology. Therefore, to examine the role of people on the adoption of BIM, there are four factors will be examined namely; Training and Education, Experienced Staff, BIM Competency Team and New Roles and Responsibilities.

4.4.2.1 Training and Education

Many researchers highlighted that training and education is part of approach to ensure the successful in implementing Building Information Modelling (BIM) (Arayici et al., 2011 and Eastman et al., 2011). Due to lack of knowledge and skill, it could contribute to have a low self-confidence for the staff to adopt new technology and this is one of the factors that could impede the pace of adoption new technology. According to O'Brien (2000); this attitude is one of the factors why people resist adopting new technology. It means that everybody needs to adjust themselves into new unknown working process and involve technical skill, therefore, the training is required to equip the staff with technical skill (Arayici et al., 2011). To manage this resistance Stewart & Mohamed (2002) and Thorpe (2003), suggested a proper training provided by the organisation could reduce the resistance from the people in implementing new technology especially when come to adopt BIM because without a proper training scheme, most of the users will take time to learn and only able to utilise some of capabilities of the technology.

To ensure that the staffs are able to gain the skill and the knowledge through training and education program, Fox & Hietanen (2007) recommended training and education program should be based on the needs of the organisation or individuals within an organisation wheatear it done internally, externally or on job training. This is because to avoid dissatisfaction and expenditure loss due to ineffective training and education. Company A, B and C agreed that for training and education they develop their own syllabus to meet their business strategy and at the same time could reduce the training cost. In order to ease and manage the resistance from the people proper training and education program is one of the factors and may motivate them to adopt BIM and it can be hypothesised as;

HP1: Participate in Training and Education program by the people has a significant, positive impact on people's interest to adopt BIM.

4.4.2.2 Experienced Staff

Having a skilled and experienced employee in organisation could increase the ability of the organisation to adopt and make use of new technology. According to Jung & Kang (2007), some organisations are reluctant to adopt new technology because of they do not have much experienced staff especially when it comes to Building Information Modelling (BIM) and they may not want to take a risk to adopt it. Eastman et al. (2011), suggest to implement BIM, the process of staff recruitment must include certain level of experienced or knowledge especially related with CAD and it is possible all the staff that undergo the training program able to gain the desired skills therefore, having an experienced staff is a must and could minimize the risk. From the interview session, it was found that, Company A, B and C added, they put the staff into BIM team with some basic knowledge in 2D drafting or 3D drafting and site experience but still not enough to operate BIM technology alone without training and outsourcing the specialist in BIM to assist them. Therefore, to increase the adoption of BIM, appropriate staffing is required to have the experience especially in the construction industry and able to operate basic 3D model technology. This support by Kuan & Chau (2001) where they found that having an experienced staff could influence the adoption of new technologies because, it could motivate others to learn from them and it could speed up the pace of BIM adoption. Organisations that have higher experienced staffs in operating 3D model technology are more likely to adapt BIM technology. Hence, it is anticipated that the firms that have higher expertise on the use of object-based technology are more likely to adapt BIM technology and it can be hypothesised as;

HP2: Having higher experienced staffs has a significant, positive impact on people's interest to adopt BIM.

4.4.2.3 Building Information Modelling (BIM) Competency Team

Eastman et al. (2011) suggested the organisation for the first time to implement BIM should establish a technical support group that dedicated to solve any problem related to BIM. Arayici et al. (2011) found, that it is critical any organisation to have technical support when using Information Technology (IT)/Information and Communication Technology (ICT) application specifically to provide technical support when problems occurs. Due to lack of internal capabilities within organisation, this support team could be external parties which expert in BIM technology because, although the staff undergo training to be equipped with technical skill but, it is difficult to ensure that everyone participating in the project has the required technology and skill set and having uneven capabilities among team members could jeopardise the adoption of BIM (Smith & Tardif, 2009, Deutsch, 2011 and Eastman et al., 2011).

Companies A and B also appoint external BIM expert team to assist their BIM team to implement BIM, by doing that their BIM team could learn through real case scenario and the level of competency could increase. The team may consist of BIM Manager, BIM Coordinator, BIM Technologist and BIM Modeller and all the post was filled by experienced staff that could handle or have the knowledge about 3D software (Olantunji, 2011). However, having the technical support team also depends on managerial support. This technical support group could disseminate their knowledge among the staffs within an organisation and this activity could spread the spirit of knowledge sharing among them and the same time able to increase the organisations' capabilities. Therefore, it can be hypothesised as;

HP3: Strong support from BIM Competency Team has a significant, positive impact on people's interest to adopt BIM.

4.4.2.4 New Roles and Responsibilities

Vankatesh & Davis (2000) defined job relevance as *"an individual's perception regarding the degree to which the target technology applies to their job. It can also be considered as a function of the importance within one's job of the set of tasks the system is capable of supporting"*. From this definition, it clearly shows that, in order to adopt the new technology every staff needs to know their new roles and responsibilities because according to Khanzode, Fischer & Reed (2008) and Kiviniemi & Fischer (2009), implementing Building Information Modelling (BIM), could change the current process and roles especially on deliverable approach from the collaborating teams which are involving with various parties and different phases of the project. Due to this each roles and responsibilities have to specifically distinguish. In addition, Gu & London (2010) found that, lack of clearness on roles and responsibilities for staff in implementing BIM is one of the barriers to adopt BIM. Therefore, the organisation must define the definition of new roles and responsibilities to meet the expectation of the organisation especially related with BIM such as BIM Modeller, BIM Operator, BIM Coordinator, BIM Manager and Head of Change (Smith & Tardif, 2009 and Deutsch, 2011).

Besides giving a clearly defined for job scope, the management should authorise them to make a decision when related to BIM such as during the selection of staff, purchasing BIM technology, undergo training and education etc. (Gu & London, 2010, Deutch, 2011 and Eastman et al., 2011). In addition, some researchers have empirically shown the relationship between user acceptance and job relevance have a significantly affect the adoption of new technology (Vankatesh & Davis, 2000). Therefore, it can be hypothesised as;

HP4: Clearer new roles and responsibilities for staff have a significant, positive impact on people's interest to adopt BIM.

4.4.3 Technological Context

In order to implement Building Information Modelling (BIM), utilisation of technology cannot be denied. But in Malaysia, BIM technology seems new and there is a lot of factors why the issues of technology could hinder the adoption of BIM. Some of organisation reluctant to invest in BIM technology because issue of compatibility, interoperability, complexity and cost (Meadati & Irizarry, 2010; Howard & Bjork, 2008 and Giligan & Kunz, 2007). Therefore, to examine the role of technology on the adoption of BIM, there are four factors that will be examined namely; Compatibility, Interoperability, Complexity and Cost.

4.4.3.1 Compatibility

Adopting Building Information Modelling (BIM) technology for any organisation will involve in changing of current process including how to deliver design and construction planning process and using new technology and software, it also involved in changing organisation hierarchies and all these changes could cause resistance to change (Ashcraft, 2008; Atkin, 1999; Eastman et al., 2008 and Fox & Hietanen, 2007). Beside resistance from people, issue of compatibility of BIM technology could worsen the current situation, because, according to Meadati & Irizarry, (2010), BIM technology is very highly structured tools and issue of compatible with existing technology may be arose. It happened because the software vendor frequently updated the software and did not aware the latest software with updated version have a difference from the previous and resulting to the incompatibility issues with the software (Meadati & Irizarry, 2010 and Gu & London, 2010). Incompatibility between BIM software could lead to data and information loss during the exchanging process and BIM cannot fully utilised and resulting frustrated among participants (Lee & Ahn, 2010 and Slyke, Johnson, Hightower & Elgarah, 2008). This issue clearly shown that compatibility had a direct effect on adoption of new technologies. Therefore, the issues of compatibility with different existing technology and software application play a significant role to ensure the pace of BIM adoption increase and will be an important factor and for similar reasons, it can be hypothesised as follows;

HT1: High level of compatibility of BIM technology may have a significant, positive impact toward the adoption of BIM.

4.4.3.2 Complexity

Complexity according to Rogers (2003) is *"the degree to which the innovation is perceived as relatively difficult to understand and use"* and in general complexity can be viewed as the perception of the difficulty to use and understand the new things from the users. Studied done by Kunz & Fischer (2007) and Giligan & Kunz (2007) revealed that the complexity of Building Information Modelling (BIM) software is one of the factors hinder the widespread of BIM adoption because the organisation viewed that the complexity of BIM software will increase the cost and time for training. Besides that, Eastman et al. (2011) and Osman, Mazlina, Khuzzan & Sapian (2015), revealed that, the more complex of the BIM technology could increase the rate of rejection from staff because most of the staff especially senior staff found it difficult to learn and they need some time to master it. They prefer the interface of BIM software similar with current software they operate.

Issue of complexity also hinder the adoption others new technology such as Computer Aided Software Engineering (CASE). Premkumar & Robert (1999), found that lack of adoption of CASE because of majority of the users found that CASE is too complex and difficult to use and at the same time it consumes time to learn it. Complexity of BIM software also could lead to uncertainty and could increase the risk factors not to adopt BIM because Ku & Taiebat (2011) and Osman et al. (2015) viewed the complexity of new technology will require the organisation to prolong learning and training process and it could increase the training cost and resulting the organisation have to reconsider their plans to adopting new technology. Thus, the complexity of new technology can be viewed as a barrier to adoption of new technology. Therefore, it can be hypothesised as follows;

HT2: Low level of complexity of BIM technology may have a significant, positive impact toward the adoption of BIM.

4.4.3.3 Interoperability

Building Information Modelling (BIM) that promotes collaborative approach without interoperability will make this vision cannot be achieved and poor interoperability will hinder the pace for collaborative approach due to the organisation have to figure out the solution to enable the BIM software to communicate with each other. Eastman et al. (2011) viewed interoperability as *"an ability of BIM application exchange data seamlessly between different BIM applications"*. Howard & Bjork (2008) agreed that the issue of interoperability between BIM software is one of the challenges faced by the early adaptors because they faced the difficulty to communicate with other parties through sharing model. Some reason the issue of interoperability arose because of some of the BIM software relatively new in the market and some manufacturer develop their own software which can communicate with the software which developed by the same manufacturer (Smith & Tardif, 2009).

According to Gallaher, O'Connor, Dettbarn & Gilday (2004), in United States survey done by the National Institute of Standards and Technology revealed that poor interoperability of technology in the Architect Engineering and Construction (AEC) industry will cause a major problem in the construction projects and the cost related with poor interoperability approximately about USD 15.8 billion annually. This clearly shows that the important of having high level of interoperability in BIM software and Smith & Tardif (2009), Kumar & Cheng (2010) and Cemesova, Hopfe & McLeod (2015) suggested to have seamless information exchange in the construction industry there is the need to have interoperability between brands and product. Therefore, for these reasons, it can be hypothesised as follows;

HT3: High level of interoperability of BIM technology may have a significant, positive toward the adoption of BIM.

4.4.3.4 Cost

By implementing Building Information Modelling (BIM), most of current work practice needed to change because BIM more towards collaborative approach. In traditional approach most of communication and information between parties through 2D drawing but in BIM environment, these approaches have been changed by creating model-based. In order to creating model-based information, hardware and software needed to be upgraded with a proper hardware and software (Olantuji, 2011b). But the initial cost for upgrading hardware and software is relatively high and considered as barriers to adopt BIM especially for small-medium enterprises (SMEs) (Aranda-Mena, Crawford, Chevez & Froese, 2009 and Paine, 2013).

The survey conducted by McGraw Hill in 2012 shows that cost of investment in hardware and software is the factor that contributes the slow pace of adoption. The survey revealed that in 2009, where 41% respondents agreed that the cost of software and 33% respondents agreed that the cost of hardware are the factors why they did not adopt BIM and in 2012 the survey revealed that the percentage of respondents responded that cost of hardware and software is still the factor why they did not adopt BIM increased to 57% and 47% respectively (McGraw Hill, 2012). This show that with lower cost of investment of hardware and software is one of factors that could speed up the adoption of BIM, thus it can be hypothesised as follows;

HT4: Lower cost of BIM technology may have a significant, positive impact toward the adoption of BIM.

4.4.4 Hypotheses Outcome of Building Information Model (BIM) Adoption Model

Table 4.4 shows the hypotheses outcome of BIM adoption model for each factors / independent variables (IV) that has been developed.

Table 4.4 Hypotheses outcome of BIM adoption model

Construct	Factor / IV	Hypothesis
1. Organisational Context	1. Support form top management.	*HO1: Strong support from top management within organisation has a significant and positive impact toward BIM adoption.*
	2. BIM Implementation Plan.	*HO2: Organisation that have BIM implementation plan has a significant, positive impact toward BIM adoption.*
	3. Coercive Pressure.	*HO3: High level of coercive pressure received by the organisation has a significant, positive impact toward BIM adoption.*
	4. Working Environment.	*HO4: Having a supportive working environment within organisation has a significant and positive impact toward BIM adoption.*
2. People Context	1. Training and Education.	*HP1: Participate in Training and Education program by the people has a significant, positive impact on people's interest to adopt BIM.*
	2. Experienced Staff	*HP2: Having higher experienced staff has a significant, positive impact on people's interest to adopt BIM.*
	3. BIM Competency Team	*HP3: Strong support from BIM Competency Team has a significant, positive impact on people's interest to adopt BIM.*
	4. New Roles and Responsibilities	*HP4: Clearer new roles and responsibilities for staff have a significant, positive impact on people's interest to adopt BIM.*

Table 4.4 Continued

Construct	Factor / IV	Hypothesis
3. Technological Context	1. Compatibility.	*HT1: High level of compatibility of BIM technology may have a significant, positive impact toward the adoption of BIM.*
	2. Complexity.	*HT2: Low level of complexity of BIM technology may have a significant, positive impact toward the adoption of BIM.*
	3. Interoperability.	*HT3: High level of interoperability of BIM technology may have a significant, positive impact toward the adoption of BIM.*
	4. Cost.	*HT4: Lower cost of BIM technology may have a significant, positive impact toward the adoption of BIM.*

4.5 Accessing the Conceptual of Building Information Modelling (BIM) Adoption Model

This section discusses the statistical analysis to examine the relationship between the organisational, people and technological factors towards interest in adopting BIM. Multiple Linear Regression was used to analyse the correlation relationship between;

a. Organisational factors which consist of a) support form top management, b) BIM implementation plan, c) coercive pressure and d) working environment as independent variables and interest to adopt BIM (as dependent variable).

b. People factors which consist of a) training & education, b) experienced staff, c) BIM competency team and d) new roles and responsibilities as independent variables and interest to adopt BIM (as depended variable).

c. Technological factors which consist of a) compatibility, b) complexity, c) interoperability and d) cost as independent variables and interest to adopt BIM (as depended variable).

This section started with discussion of the findings from pilot survey analysis and Exploratory Data Analysis (EDA) before discuss the finding from hypotheses testing of BIM adoption model using Multiple Linear Regression.

4.5.1 Pilot Survey

In this study, a pilot survey was conducted. The purpose of this pilot study to assess reliability and validity of research instrument, testing wording of questionnaire and testing procedures of testing (Straub, 1989 and Ticehurst & Veal, 2000). Besides that, according to Sproull (1995), the advantages of conducting a pilot test were as follows:

i. Helped determine the appropriateness of research questions and hypothesis.
ii. Enabled is checked of data collection method.
iii. Information gathered enabled procedures modification prior to the real test.
iv. Checking the appropriateness of statistical tests.
v. Enhanced researcher’s reputation for thoroughness.

Anderson (1998) suggested the numbers of respondents for pilot testing is between 6 – 12 respondents, and for this study there are 30 respondents participated and distributed randomly. The pilot test was distributed via Google Online Survey. Apart of 30 respondents, 3 respondents manually answered the questionnaires and it purposed as face validation. From the observation, it was found that an average time for the respondents answered the questions is about 20-25 minutes. The respondents also giving the comments and suggestion to enhance the quality of the questionnaire and these feedbacks has been taken into the account before launching real online survey.

4.5.2 Reliability Test for Pilot Testing

According to Ticerhurst & Veal (2000), reliability refers to *"the extent to which research findings would be the same if the research were to be repeated at a later date, or with a different sample of subjects"*. In other words, the reliability is indicating that the instrument offers consistent measurement across time and across the various items in the instrument (Kripanont, 2007). To test the reliability of research instruments, Cronbach's alpha being used. According to Sekaran (2009) Cronbach's alpha referred to *"a reliability coefficient that indicated how well the items in a set were positively correlated to one another. It was computed in terms of the average interrelations among the items measuring the concept"*. A value closer to 1 showed higher internal consistency reliability. Hair, Black, Babib, Anderson & Tatham (2006) suggested any construct that score value more than 0.70 is acceptable, while Malhorta (2004), suggested value that score more than 0.60 is acceptable. Table 4.5 shows the score of Cronbach's alpha for each construct and found that the reliability of this research instrument is acceptable and fit to undergo actual survey (Appendix C). Although there are two variables namely T2 Complexity and Interest to Adopt BIM score 0.649 and 0.695 respectively but because the score is above 0.60 then it accepted and some modification being done based on feedback from respondents to increase its reliability.

Table 4.5 Cronbach's Alpha value for pilot testing

Construct	Variables	No. of Items	Cronbach's alpha value
Organisational Context	O1. Top Management Support.	4	0.816
	O2. BIM Implementation Plan.	3	0.804
	O3. Coercive Pressures.	3	0.834
	O4. Working Environment.	3	0.900
People Context	P1. Training and Education.	3	0.837
	P2. Experienced Staff.	3	0.843
	P3. BIM Competency Team	4	0.858
	P4. New Roles and Responsibilities.	3	0.766
Technological Context	T1. Compatibility.	3	0.794
	T2. Complexity.	3	0.649
	T3. Interoperability.	3	0.808
	T4. Cost.	3	0.769
INTEREST TO ADOPT			0.695

4.5.3 Exploratory Data Analysis (EDA)

EDA was conducted to ensure the data gathered free from violation of Multiple Linear Regression assumption before further analysing the model. The analysis included normality test, reliability test, construct validity, multicollinearity, outliers, normality, linearity and homoscedasticity.

4.5.3.1 Normality Test

A normality test was conducted as the preliminary examination of data to ensure that data was from normally distributed population. Descriptive statistics (skewness and kurtosis) were used in testing the data. Various opinions can be found concerning the acceptable level of skewness (distribution's symmetry) and kurtosis (the clustering of scores toward the centre of a distribution) for a particular variable. Following the rule of thumb that both skewness and kurtosis should fall below ±1.0 (Hisham, 2008; and Miles & Shevlin, 2001). Some researchers suggested cut-off absolute values of below ±3 and below ±10 for skewness and kurtosis respectively (Almanza & Ismail, 2009; Budruk, 2010; Chakrabarty, Whitten & Green, 2007; Hussein, 2010 and Tu, Lin & Chang, 2011). As shown in Table 4.6, the value of skewness and kurtosis of each variable did not exceed the cut-off point and its show that all data was normally distributed (Appendix D). Further investigation through normal Q-Q plot shows data were distributed in a linear fashion along the regression line, fairly straight diagonal suggests no major departures from normality seen Figure 4.4, and so, the assumption was met. Investigation for outlier by inspecting the boxplot and found that there is no outlier found as shown in Figure 4.5. Therefore, the data gathered can be considered normally distributed.

Table 4.6 Descriptive Statistic: Skewness and Kurtosis

Construct / Variables		Mean	Skewness	Std. Error	Kurtosis	Std. Error
Organisational Context	O1. Top Management Support	4.3289	-.580	.197	-.066	.391
	O2. BIM Implementation Plan	4.2741	-.034	.197	-.742	.391
	O3. Coercive Pressures	4.6145	-.296	.197	-.484	.391
	O4. Working Environment	4.1908	-.177	.197	-.723	.391
People Context	P1. Training and Education	4.2259	-.214	.197	-.184	.391
	P2. Experienced staff	4.1996	.140	.197	-.717	.391
	P3. BIM Competency Team	4.1509	-.538	.197	-.410	.391
	P4. New Roles and Responsibilities	4.1140	.098	.197	-.560	.391
Technological Context	T1. Compatibility	4.2325	-.060	.197	-.929	.391
	T2. Complexity	4.0833	-.035	.197	-.358	.391
	T3. Interoperability	4.0080	-.034	.197	-.376	.391
	T4. Cost	4.1711	-.267	.197	-.142	.391
INTEREST TO ADOPT		4.0526	-.215	.197	-.465	.391

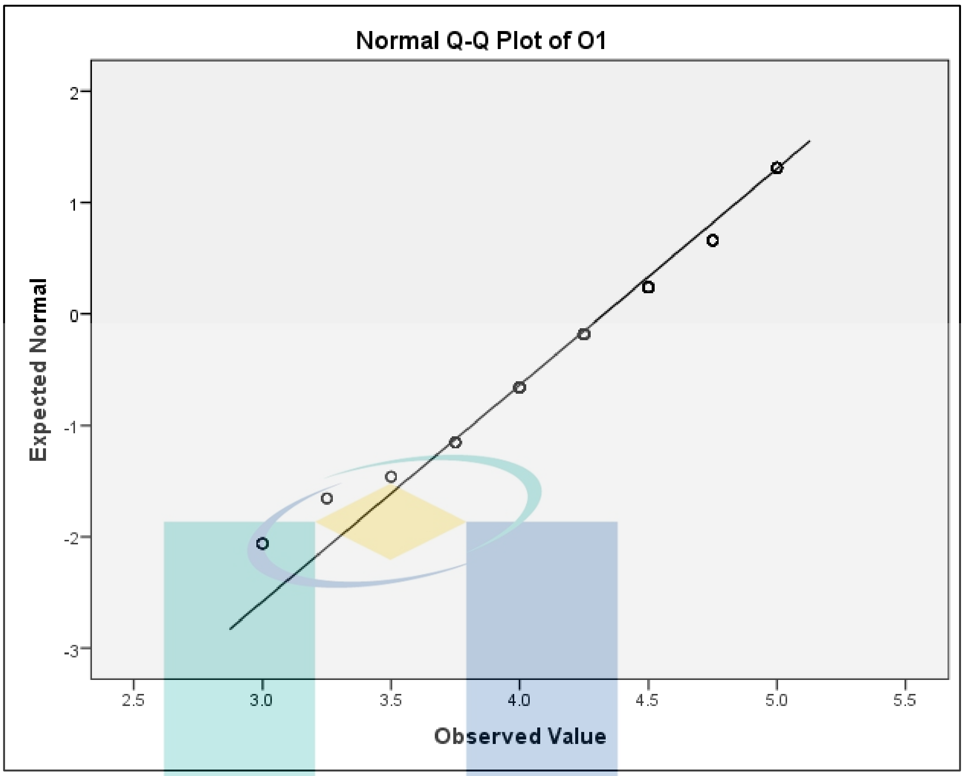

Figure 4.4	Normal Q-Q plot for O1

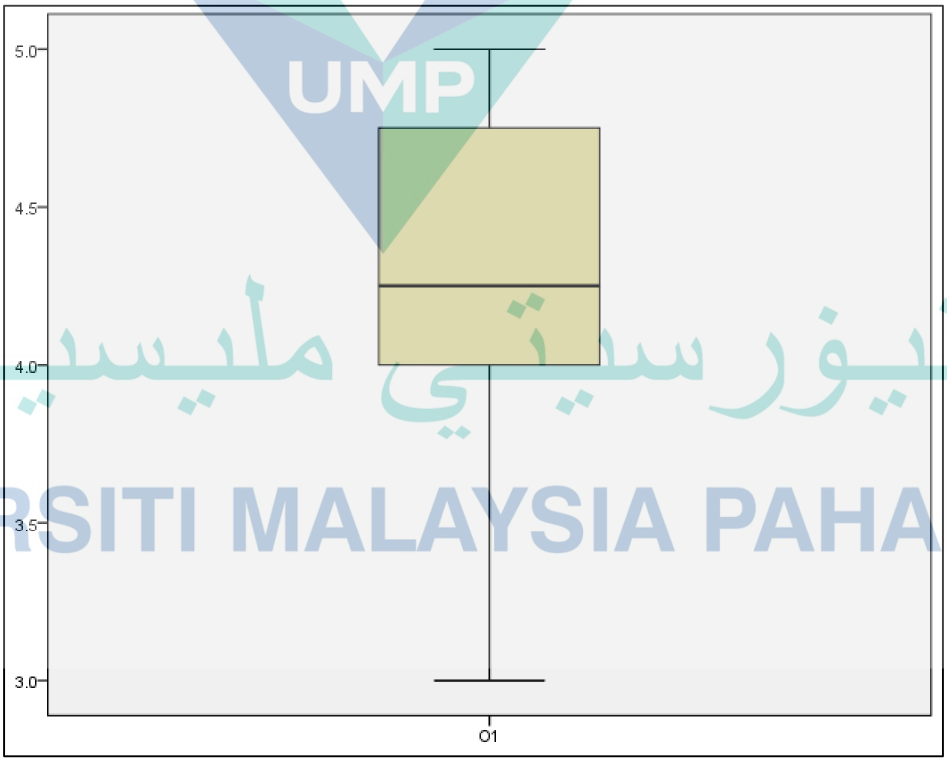

Figure 4.5	Normal Q-Q box plot for O1

4.5.3.2 Reliability and Construct Validity

It was necessary to ensure that the research instrument has a satisfactory level of reliability and validity before testing for a significant relationship (Ifinedo, 2006). In this study, the reliability of each variable was assessed using Cronbach's alpha measurements. While, construct validity was assessed using convergent validity (Sekaran, 2009). For convergent validity, this study used Average Varian Extracted (AVE) (Fornell & Larcker, 1981 and Chin, 1998).

Reliability is to test the consistency of measurement instrument. In this study Cronbach's alpha was used to identify the internal consistency of instrument. In this study the cut-off Cronbach's alpha value is 0.60. Table 4.7 shows the score of Cronbach's alpha for each variable and found that the research instrument is considered internally consistent and reliable because all the variables score more than 0.60 (Appendix E).

Table 4.7 Comparison Cronbach's Alpha value between Pilot Test and Actual Survey

Construct	Variables	No. of Items	Pilot Test	Actual Survey
Organisational Context	O1. Top Management Support.	4	0.816	0.734
	O2. BIM Implementation Plan.	3	0.804	0.767
	O3. Coercive Pressure.	3	0.834	0.798
	O4. Working Environment.	3	0.900	0.795
People Context	P1. Training and Education.	3	0.837	0.714
	P2. Experienced Staff.	3	0.843	0.706
	P3. BIM Competency Team.	4	0.858	0.751
	P4. New Roles and Responsibilities.	3	0.766	0.758
Technological Context	T1. Compatibility.	3	0.794	0.753
	T2. Complexity.	3	0.649	0.706
	T3. Interoperability.	3	0.808	0.723
	T4. Cost.	3	0.769	0.730
INTEREST TO ADOPT		6	0.695	0.717

Construct validity was being conducted to testify *"how well results obtained from the use of the measure fit the theories around which the test is designed"* (Sekaran, 2009). Convergent validity is one of the method to test the validity of construct (Sekaran, 2009). Convergent validity is the extent to which the survey items for a given construct converge (i.e. strongly correlate) compared to survey items measuring different constructs (Urbach & Ahlemann, 2010). To assess the convergent validity of the reflective constructs in the research model, the average variance extracted (AVE) was calculated for each construct as shown in Table 4.8 The loading for each variable was gathered from Principal Component Analysis (PCA) (Appendix F). The AVE was computed by squaring the sum of the factor loading divided by number of factors of the underlying construct (Fornell & Larcker, 1981, Chin, 1998 and Chen, Chen & Tung, 2010). According to the widely accepted procedure proposed by Fornell & Larcker (1981), the AVE value for each construct must be at least 0.50 in order to demonstrate sufficient convergent validity of the constructs. As shown in Table 4.8, all the constructs meet the cut point 0.50 and the result suggest this instrument full fill the convergent validity assumption.

Table 4.8 Loading and AVE value for each construct

Construct	Variables	Loading	Cronbach's Alpha	AVE
Organisational Context	O1. Top Management Support.	0.910	0.734	0.828
	O2. BIM Implementation Plan.	0.915	0.767	0.837
	O3. Coercive Pressure.	0.909	0.798	0.826
	O4. Working Environment.	0.949	0.795	0.900
People Context	P1. Training and Education.	0.862	0.714	0.743
	P2. Experienced Staff.	0.913	0.706	0.833
	P3. BIM Competency Team.	0.945	0.751	0.893
	P4. New Roles and Responsibilities.	0.917	0.758	0.841
Technological Context	T1. Compatibility.	0.952	0.753	0.906
	T2. Complexity.	0.953	0.706	0.908
	T3. Interoperability.	0.956	0.723	0.914
	T4. Cost.	0.958	0.730	0.918

**Note.* *All Bartlett's Tests were significant at* $p < .01$

Results from Crobanch's Alpha and Average Variance Extracted (AVE), suggested that the instrument used in this study measured the constructs of interest with adequate reliability and validity.

4.5.3.3 Assumption of Multiple Linear Regression

According to Tabachnick & Fidell (2007), before analysing significance of the independent variables in relationship with the dependent variable using Multiple Regression being conducted, the data must full fill the assumption of;

a) Multicollinearity.
b) Outliers.
c) Linearity.
d) Homoscedasticity.

To ensure the data meet the requirement data screening at the early stages of data analysis is very important to ensure the reliability of the findings (Vogt, 2007).

a) Multicollinearity

In data analysis, it was assumed that no correlation existed among independent variables. The violation of the assumption resulted in the existence of multicollinearity (when two or more independent variables were very much correlated) (Cohen et al., 2003). For that reason, at least one independent variable is needed to be removed from the equation. To ensure there are no issue of multicollinearity, Tabachnick & Fidell (2007) and Pallant (2005) suggested using the value of Variance Inflation Factor (VIF) as an indicator the presence of multicollinearity. Tabachnick & Fidell (2007) and Pallant (2005) suggested the value of VIF must less than 10 and the value of tolerance must greater than 0.10 to ensure there are no multicollinearity issue, if the value of tolerance lower than 0.10 and values of VIF greater than 10, then it indicated that there is multiple correlation with other variable is higher and possibility of multicollinearity (Mendenhall & Sincich, 1998). Besides examining the value of tolerance ad VIF, there are the needs to assess the value of correlation between variables. Tabachnick & Fidell (2007) suggested to omit the variables with a bivariate correlation of 0.70 or higher, while Cohen et al. (2003) stated that if two variables have a correlation coefficient of 0.90 or above, one of the variables must be eliminated from the equation.

From Table 4.9 and Appendix G, revealed that the values of VIF are lower than 10, while for tolerance there is no value less than 0.10. These indicators shown there is no multicollinearity issue in this data (Tabachnick & Fidell, 2007 and Pallant, 2005). Further investigation was carried out to access the value of correlation between variables, whether it meet the cut-off point suggested by Tabachnick & Fidell (2007) and Hair et al. (2006) which is must less than 0.70. By examined Table 4.10 and Appendix G revealed that none of variables having a bivariate correlation of 0.70 or higher and its can be concluding that this data is free from multicollinearity issue.

Table 4.9 Collinearity Statistic

Construct	Variables	No. of Items	Tolerance	VIF
Organisational Context	O1. Top Management Support.	4	0.566	1.766
	O2. BIM Implementation Plan.	3	0.577	1.734
	O3. Coercive Pressure.	3	0.559	1.789
	O4. Working Environment.	3	0.716	1.397
People Context	P1. Training and Education.	3	0.426	2.349
	P2. Experienced Staff.	3	0.501	1.998
	P3. BIM Competency Team.	4	0.664	1.505
	P4. New Roles and Responsibilities.	3	0.586	1.707
Technological Context	T1. Compatibility.	3	0.732	1.366
	T2. Complexity.	3	0.737	1.357
	T3. Interoperability.	3	0.752	1.330
	T4. Cost.	3	0.762	1.313

**Dependent Variable: INT_TO_ADOPT*

b) *Outliers*

The present of outliers could affect the result of multiple regression analysis due to its very sensitive to the outliers. It is important to check the presence of outliers for all variables. Figure 4.6 shows the scatter-plot of standardized residuals and Tabachnick & Fidell (2007) suggested the outliers can be identified by visually examine the scatter-plot by looking at residual point that not more than 3.3 or less than -3.3. By examine Figure 4.6 clearly indicated that there are no outliers for dependent variables. Appendix G show the boxplot for all independent variables and no outliers were found and it can be concluded that this data is free from outliers' issues.

Table 4.10 Correlation Matrix

	VARIABLES	ITA	O1	O2	O3	O4
ORGANISATIONAL CONTEXT	INTEREST TO ADOPT (ITA)	**1.000**	0.556	0.517	0.528	0.427
	O1: Top Management Support	0.556	**1.000**	0.556	0.568	0.471
	O2: BIM Implementation Plan	0.517	0.556	**1.000**	0.579	0.426
	O3: Coercive Pressure	0.528	0.568	0.579	**1.000**	0.447
	O4: BIM Imp. Plan	0.427	0.471	0.426	0.447	**1.000**
	VARIABLES	**ITA**	**P1**	**P2**	**P3**	**P4**
PEOPLE CONTEXT	INTEREST TO ADOPT (ITA)	**1.000**	0.520	0.435	0.472	0.495
	P1: Training & Education	0.520	**1.000**	0.688	0.513	0.565
	P2: Experienced Staff	0.435	0.688	**1.000**	0.361	0.517
	P3: BIM Competency Team	0.472	0.513	0.361	**1.000**	0.508
	P4: New Roles & Responsibilities	0.495	0.565	0.517	0.508	**1.000**
	VARIABLES	**ITA**	**T1**	**T2**	**T3**	**T4**
TECHNOLOGICAL CONTEXT	INTEREST TO ADOPT (ITA)	**1.000**	0.515	0.389	0.541	0.530
	T1: Compatibility	0.515	**1.000**	0.400	0.384	0.402
	T2: Complexity	0.389	0.400	**1.000**	0.407	0.369
	T3: Interoperability	0.541	0.384	0.407	**1.000**	0.356
	T4: Cost	0.530	0.402	0.369	0.356	**1.000**

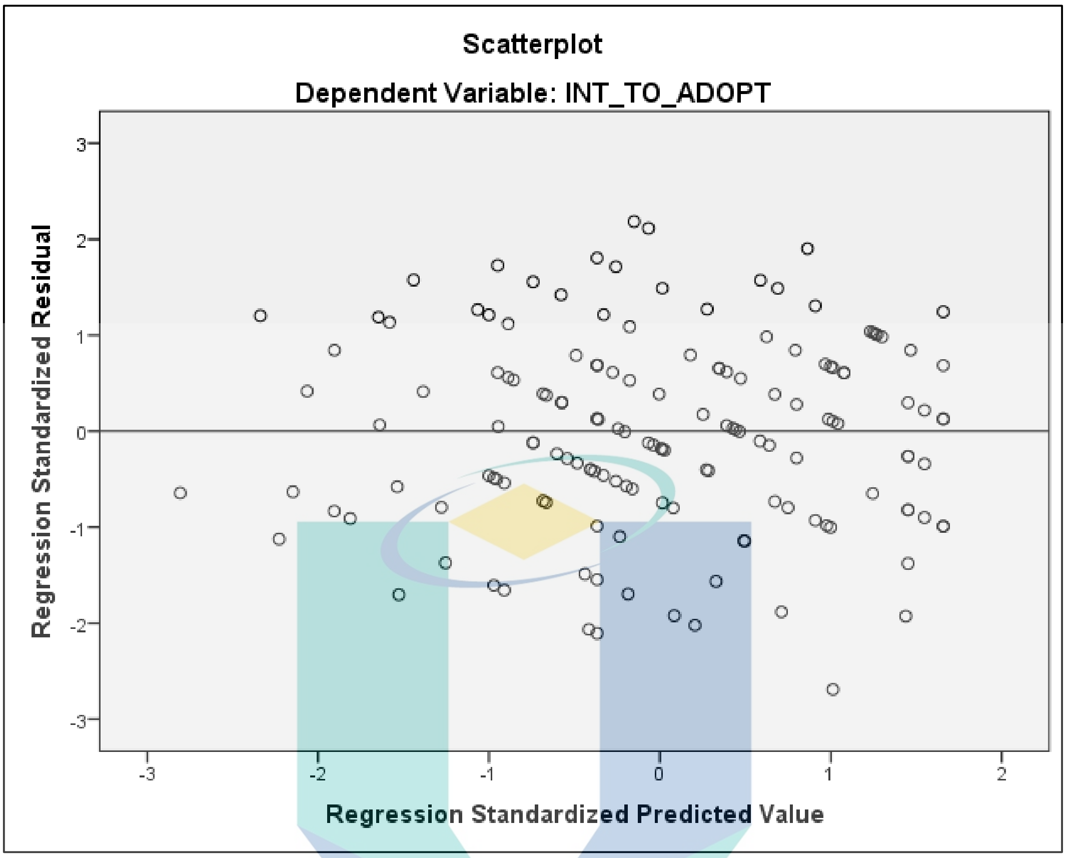

Figure 4.6 Scatter-plot of standardized residuals

c) *Linearity*

Standard multiple regression can only be estimated accurately from the relationship between dependent and independent variables if the relationships are linear in nature (Tabachnick & Fidell, 2007). Therefore, it is important to ensure the data are not violating the multiple regression assumptions, and one of the preferable approaches to examine the linearity is through residual plot (Osborn & Walter, 2002). To ensure the data are not violating the assumption, the scatter-plot should not be curved instead of rectangular, as shown in Figure 4.7 (a) and this pattern called as Curvilinear. If the data is linear, the pattern of the scatter-plot should be in oval shape as shown in Figure 4.7 (b).

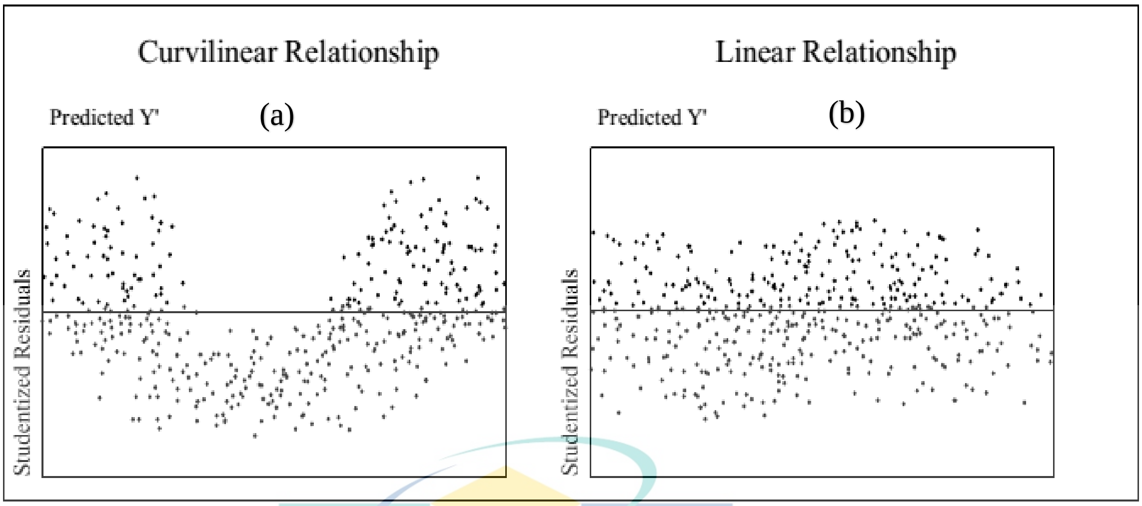

Figure 4.7 Curvilinear and linear relationships with standardized residuals by standardized predicted values

Source: Osborn & Walter (2002).

By examine visually all the scatter-plot of standardized residuals by standardized predicted values for this study in Figure 4.8 and Appendix G, clearly shows that the data for this study is linear and not violate the linearity assumption as shown in Figure 4.8.

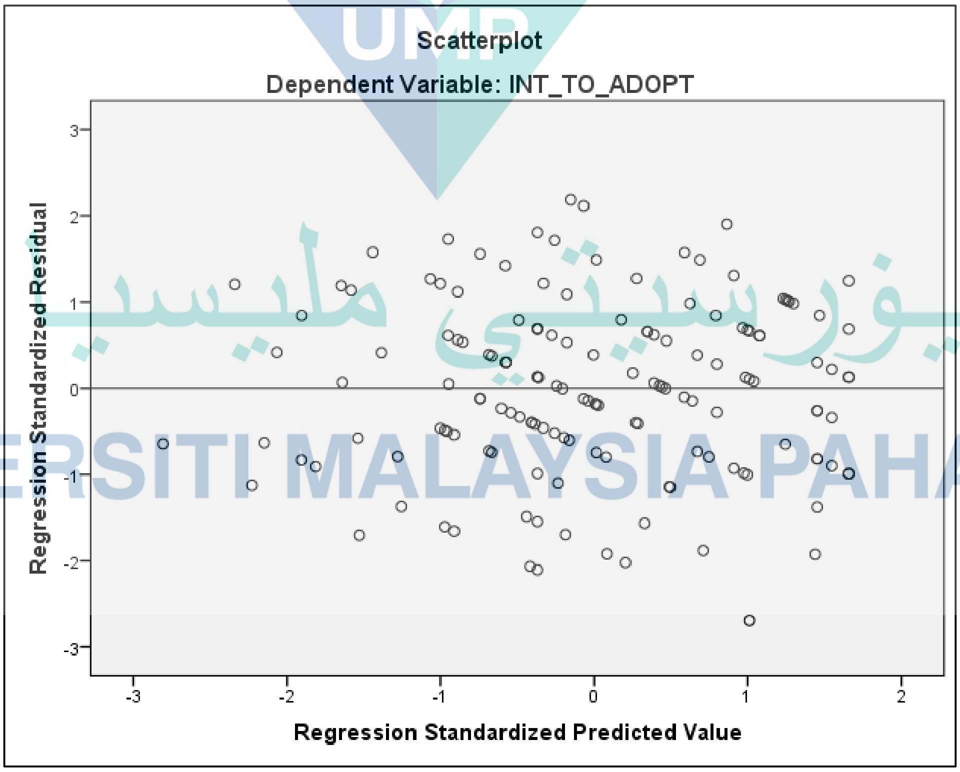

Figure 4.8 Scatter-plot of standardized residuals by standardized predicted values

d) *Homoscedasticity*

According to Tabachnick & Fidell (2007), homoscedasticity presents when the variance of errors is the same across all levels of the Independent Variables (IV), but if the variance of errors is not the same across all levels of the then heteroscedasticity will appear. Figure 4.9 shows the pattern of homoscedasticity and heteroscedasticity in the scatter-plot.

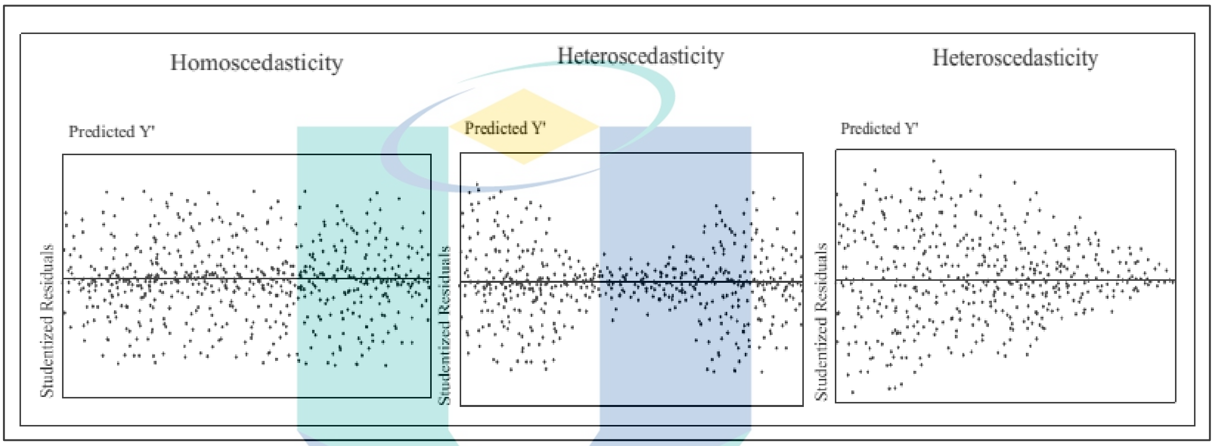

Figure 4.9 The pattern of Homoscedasticity and Heteroscedasticity
Source: Osborn & Walter (2002)

Although Tabachnick & Fidell (2007) said that the presence of slight heteroscedasticity has a little effect on the significance test, however, Osborn & Walter (2002) stressed that the present of heteroscedasticity could lead to serious distortion of findings and seriously weaken the analysis thus increasing the possibility of a Type I error. Therefore, to avoid the possibility of a Type I error, the data of this study will be examined by visualising checked the scatter-plot of standardized residuals from the regression standardized predicted value. As shown in Figure 4.8 and Appendix G, clearly shows that the pattern of scatter-plot generated from the data for this study more likely towards homoscedasticity instead of heteroscedasticity and therefore the data of this study are free from issue of heteroscedasticity.

From the Exploratory Data Analysis (EDA), found that the data of this study are fit to undergo multiple regression analysis because it has fulfilled all the statistical assumptions. Table 4.11 shows the summary of findings from EDA.

Table 4.11 Summary of Exploratory Data Analysis (EDA)

Type of Test		Observation
1. Normality Test	-	The value of skewness and kurtosis of each variable did not exceed the cut-off point of ±3 and ±10, visual examine through normal Q-Q plot shows data were distributed in a linear fashion along the regression line, fairly the straight diagonal suggests no major departures from the straight line and by examining the boxplot, found that there are no data having an extremely high and low scores that contribute to the outliers. From these observations, it can be concluded that the data was normally distributed.
2. Reliability Test	-	Values from alpha's Cronbach are above 0.60 and shows the instrument is reliable.
3. Construct Validity	-	All constructs meet the cut-off point 0.50 in AVE, this result suggested that the instrument used in this study measured the constructs of interest with adequate reliability and validity.
4. Multicollinearity	-	The problem of multicollinearity did not exist; because the values of VIF for each variable are lower than 10, while the value of tolerances is greater than 0.10. And for bivariate correlation, no variables having a bivariate correlation of 0.70 or higher.
5. Outliers	-	By visually examining the boxplot, it was found that there is no data of having an extremely high and low scores that contribute to the outliers.

Table 4.11 Continued

Type of Test		Observation
6. Linearity	-	By visually examining the scatter-plot of standardized residuals by standardized predicted values for this study, found that the scatter-plot is not curved but almost forming a rectangular shape. This pattern shows that the data is linear in nature.
7. Homoscedasticity	-	By visually examining the pattern of scatter-plot; the pattern is likely towards homoscedasticity instead of heteroscedasticity because the scatter-plot almost forming a rectangular shape and therefore the data of this study are free from issue of heteroscedasticity.

4.5.4 Testing Hypotheses of Building Information Model (BIM) Adoption Model

Figure 4.10 shows the path of the Building Information Modelling (BIM) adoption model. This model consists of four constructs that will be hypothesised which are Organisational Context, People Context and Technological Context while, Interest to Adopt BIM is dependent variable (DV). Each construct will be measured by independent variables (IV). The Organisational Context will be measured by IV namely; Top Management Support coded as O1, BIM Implementation Plan coded as O2, Coercive Pressure coded as O3 and Working Environment coded as O4. The People Context will be measured by the IV namely; Training and Education coded as P1, Experienced Staff coded as P2, BIM Competency Team coded as P3, and New Roles and Responsibilities coded as P4. The Technological Context will be measured by the IV namely; Compatibility coded as T1, Complexity coded as T2, Interoperability coded as T3 and Cost coded as T4. This model will be hypothesised by analysing the contributions and significance of the independent variables in relationship with the dependent variable. Table 4.12 shows the restatement of hypotheses of BIM adoption model.

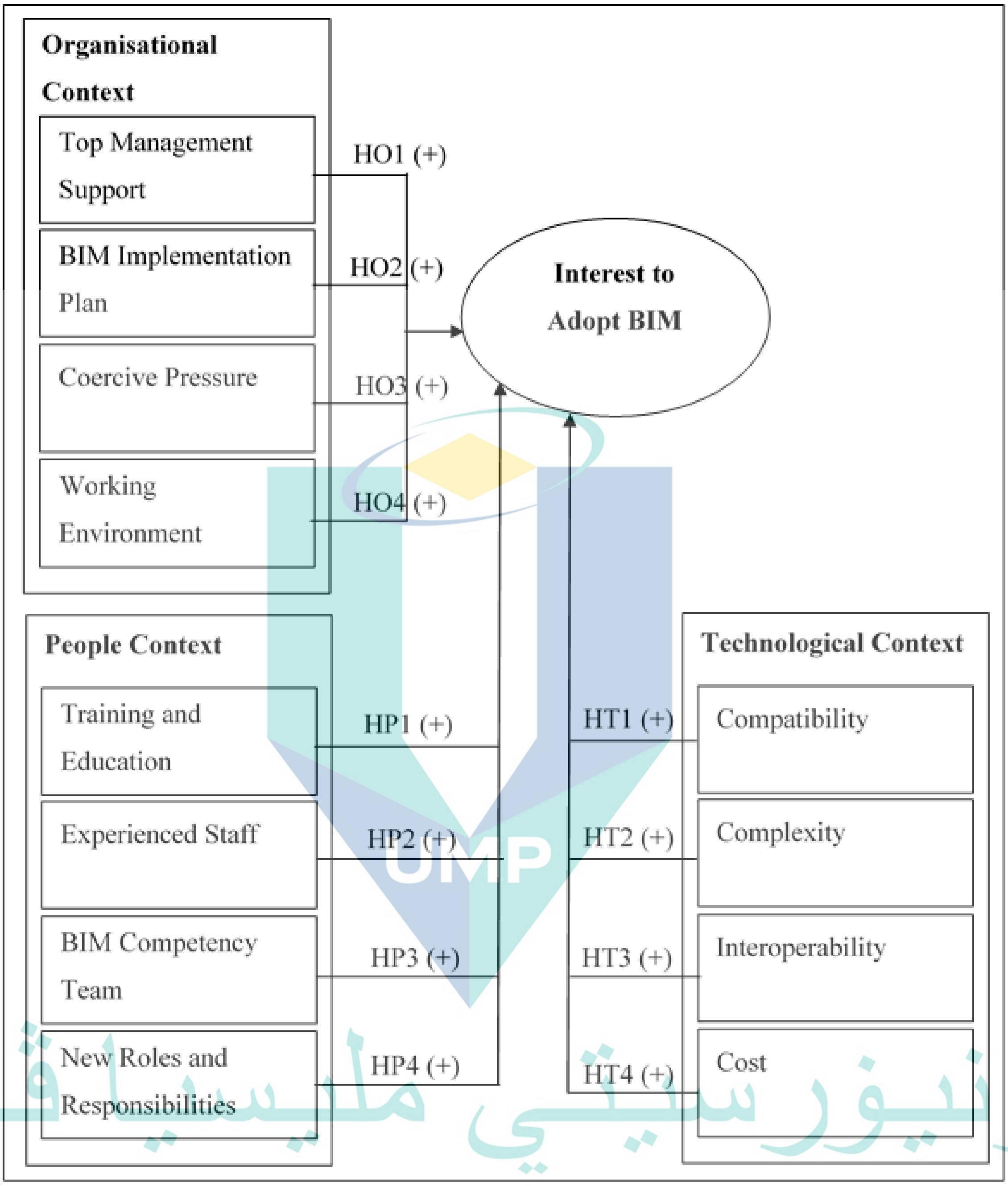

Figure 4.10 The Conceptual of BIM adoption model

Table 4.12 Restatement of hypotheses of BIM Adoption Model

Construct	Factor / IV	Hypothesis
1. Organisational Context	1. Support form top management.	*HO1: Strong support from top management within organisation has a significant and positive impact toward BIM adoption.*
	2. BIM Implementation Plan.	*HO2: Organisations that have BIM implementation plan has a significant, positive impact toward BIM adoption.*
	3. Coercive Pressure.	*HO3: High level of coercive pressure received by the organisation has a significant, positive impact toward BIM adoption.*
	4. Working Environment.	*HO4: Having a supportive working environment within organisation has a significant and positive impact toward BIM adoption.*
2. People Context	1. Training and Education.	*HP1: Participate in Training and Education program by the people has a significant, positive impact on people's interest to adopt BIM.*
	2. Experienced Staff	*HP2: Having higher experienced staff has a significant, positive impact on people's interest to adopt BIM.*
	3. BIM Competency Team	*HP3: Strong support from BIM Competency Team has a significant, positive impact on people's interest to adopt BIM.*
	4. New Roles and Responsibilities	*HP4: Clearer new roles and responsibilities for staff have a significant, positive impact on people's interest to adopt BIM.*

Table 4.12 Continued

Construct	Factor / IV	Hypothesis
3. Technological Context	1. Compatibility.	*HT1: High level of compatibility of BIM technology may have a significant, positive impact toward the adoption of BIM.*
	2. Complexity.	*HT2: Low level of complexity of BIM technology may have a significant, positive impact toward the adoption of BIM.*
	3. Interoperability.	*HT3: High level of interoperability of BIM technology may have a significant, positive impact toward the adoption of BIM.*
	4. Cost.	*HT4: Lower cost of BIM technology may have a significant, positive impact toward the adoption of BIM.*

4.5.4.1 Respondents Profile

The total population registered as civil and structure (C&S) consultant firms with Ministry of Finance in Peninsular Malaysia are 683 (eprunding, 2014). A total of 653 questionnaires was distributed via email and postal and returned surveys are 164. Only 152 completed surveys with no missing values represented the final response rate of 23.27% as shown in Table 4.13 and retained for analysis. Zikmund (2003), stressed that, sufficient number of respondents is very crucial specially to generalise the research findings. According to Hair et al. (2006) and Hulland, Chow & Lam (1996) sample size can be considered small if the size is 100 and below, while sample size between 100 and 200 can be considered as medium and sample size will be considered as large when the size is more than 200. But for multivariate test such as multiple regression analysis Kline (2005) suggested the sample size should have at least 10 times or more the number of independent and dependent variables to be assessed in the model. In this study, there are 12 independent and 1 dependent variable and total up as 13 variables and the numbers of respondents are 152 and more than 130, therefore, the sample size of 152 is suitable for multiple linear regression analysis.

Table 4.13 Response Rate

Questionnaire distributed	Responses returned	Percentage of responses
653	152	23.27%

Figure 4.11 shows the background of respondents that shows about 8% of the participants are principals of the firm, about 36% hold as senior engineer, 55% hold as an engineer and 1% hold other position.

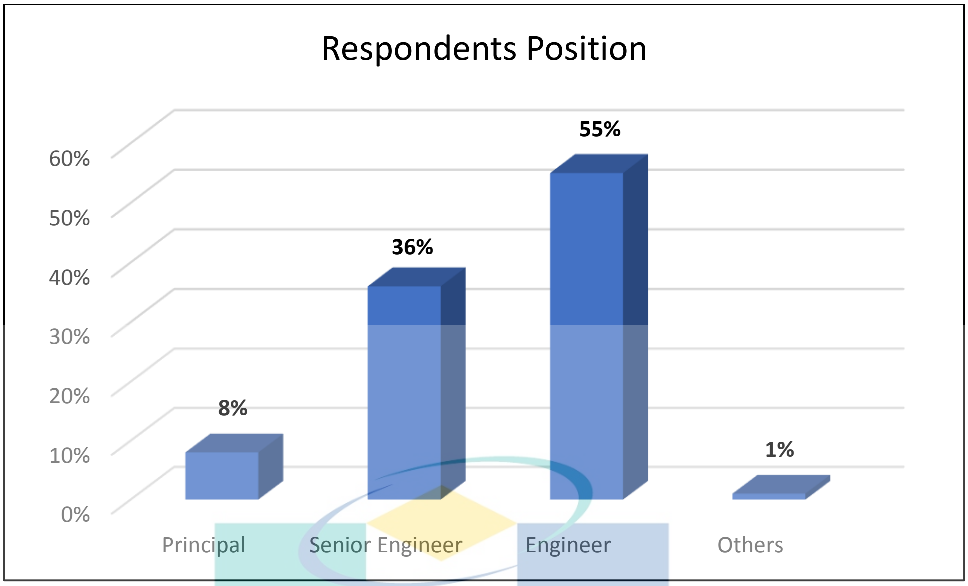

Figure 4.11 Position of participants

Figure 4.12 shows the participants' experiences which is about 12% of the participants had more than 10 years of experience, about 35% had 5 to 10 years of experience and about 53% of the participants had less than 5 years of experience.

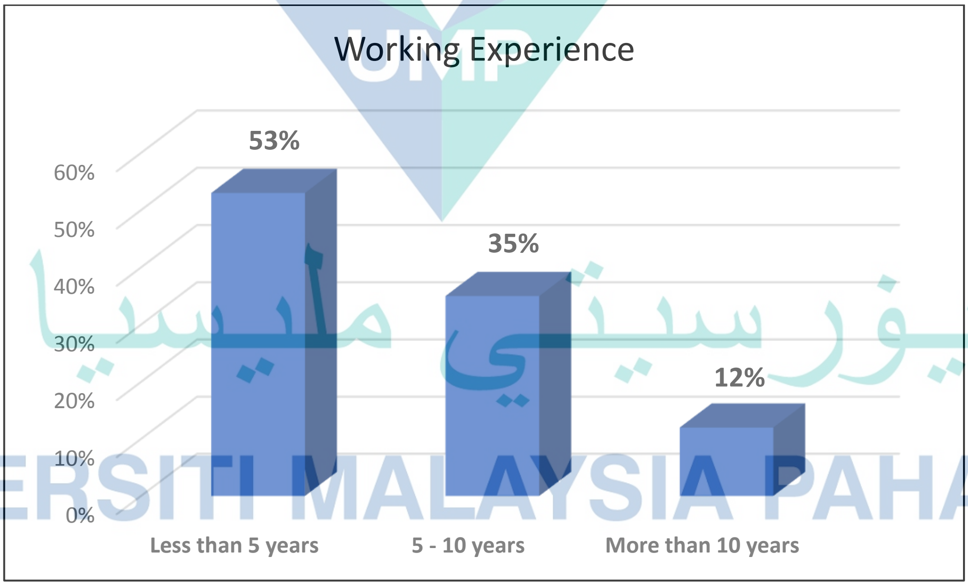

Figure 4.12 Participants working experience

For participants who had BIM knowledge, Figure 4.13 revealed about 48% of the participants know or having some knowledge about BIM.

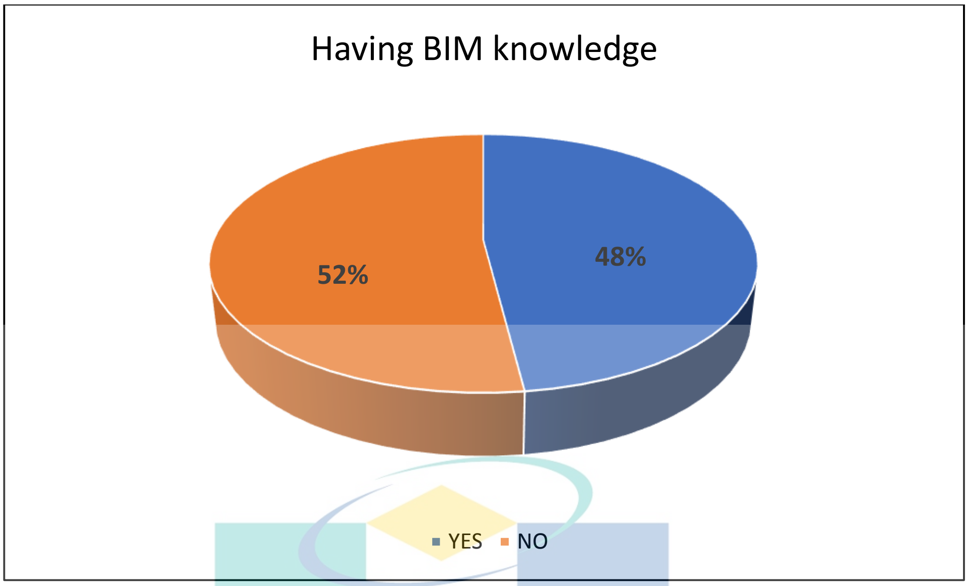

Figure 4.13 Percentage of respondents that have knowledge of BIM

For participants who have involvement of project using BIM Figure 4.14 shows about 6% of the participants having an experience using BIM.

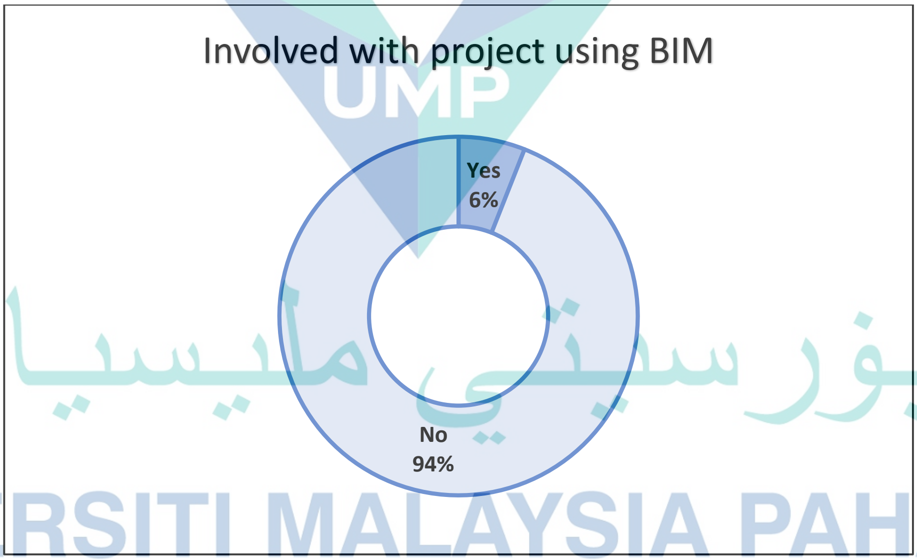

Figure 4.14 Percentage of respondents that have experience using BIM

4.5.4.2 The Role of Organisational Context toward Interest to Adopt Building Information Modelling (BIM)

Poston & Grabski (2001) found that, issue of organisational is one of the factors to the success of implementing the new Information System (IS) in any organisation. In Building Information Modelling (BIM), organisational plays a critical role to ensure the success of BIM adoption for construction projects (Kymmell, 2008). Thus, there are four observed variables, namely; Support from Top Management, BIM Implementation Plan, Coercive Pressure and Working Environment that being investigated the relationship and effect on Interest to Adopt BIM by organisation. In order to investigate the relationship between these variables towards BIM adoption, the following hypotheses were developed and tested;

HO1: Strong support from top management within organisation has a significant and positive impact toward BIM adoption.
HO2: Organisation that have BIM implementation plan has a significant, positive impact toward BIM adoption.
HO3: High level of coercive pressure received by the organisation has a significant, positive impact toward BIM adoption.
HO4: Having a supportive working environment within organisation has a significant and positive impact toward BIM adoption.

The first multiple regression models will investigate the effect of organisations which consist of Support from Top Management (O1), BIM Implementation Plan (O2), Coercive Pressure (O3) and Working Environment (O4) on Interest to Adopt BIM. The multiple linear regression models are described as follows:

Interest to Adopt BIM = $\alpha + \beta1\ (O1) + \beta2\ (O2) + \beta3\ (O3) + \beta4\ (O4)$;

* Where;
- α = is the Y intercept (the value of Y when all the X values are zero)
- βn = coefficients measuring relationship strength

Table 4.14 and Appendix G shows the result from multiple regression analysis for organisational context.

Table 4.14 Result from Multiple Regression Analysis for Organisational Context (N = 152)

Model		Unstandardized Coefficient B	Unstandardized Coefficient Std. Error	Standardised Coefficient β	t	Sig.	Collinearity Statistic VIF
Coefficient [a]							
1	(Constant)	1.704	.239		7.131	.000	
	O1: Top Management Support.	.204	.063	.274	3.260	.001	1.766
	O2: BIM Implementation Plan	.142	.061	.193	2.317	.022	1.734
	O3: Coercive Pressure	.125	.051	.206	2.437	.016	1.789
	O4: Working Environment	.081	.049	.124	1.655	.098	1.397

**Model Summary: R = .643[a], R^2= .414, Adjust R^2= .398, F (4,147) =25.912, p <. 05, Durbin-Watson = 1.684*

**Note: a. Predictors: (Constant) O1, O2, O3, O4; Dependent Variable: Interest to Adopt*

From Table 4.14, it was found that the regression analysis F test ((4, 147) = 25.912, p < .05) indicates that the model is statistically significant in predicting the dependent variable which is Interest to Adopt. Besides that, the value of Durban-Watson of 1.684 falls between the acceptable range (1.5 to 2.5) indicating no autocorrelation problem in the data (Chong, Ooi, Lin & Raman, 2009). In addition, the VIF values are less than 10 that satisfying the assumption of the absence of multicollinearity (Tabachnick & Fidell, 2007 and Pallant, 2005). From Table 4.14, it shows that three predictor variables that have significant effect towards BIM adoption are Top Management Support (β =.274, p <.05), BIM Implementation Plan (β =.193, p <.05) and Coercive Pressure (β =.206, p <.05) with only about 41.4% of the variability in the

Interest to Adopt BIM can be explained by the predictor variables. While, the factor of working environment did not have a significant effect towards to BIM adoption and indicated that the survey respondents acknowledged that, having a conducive working environment is not a critical factor in adopting BIM.

This result also revealed that Top Management Support which have β =.274 is the strongest contribution that can speed up the process of BIM adoption compared to Coercive Pressure (β =.206) and BIM Implementation Plan (β =.193). These results indicated that the survey respondents acknowledged the importance of top management support in enhancing the adoption of BIM. The survey respondents saw that there is a need for top management to express their commitment in adopting BIM by providing the strategic vision and directions of the organisation besides providing enough allocation of budget to adopt BIM.

The result also revealed that the hypothesis HO4 was rejected. Figure 4.15 shows the relationship between organisational factors and interest to adopt BIM.

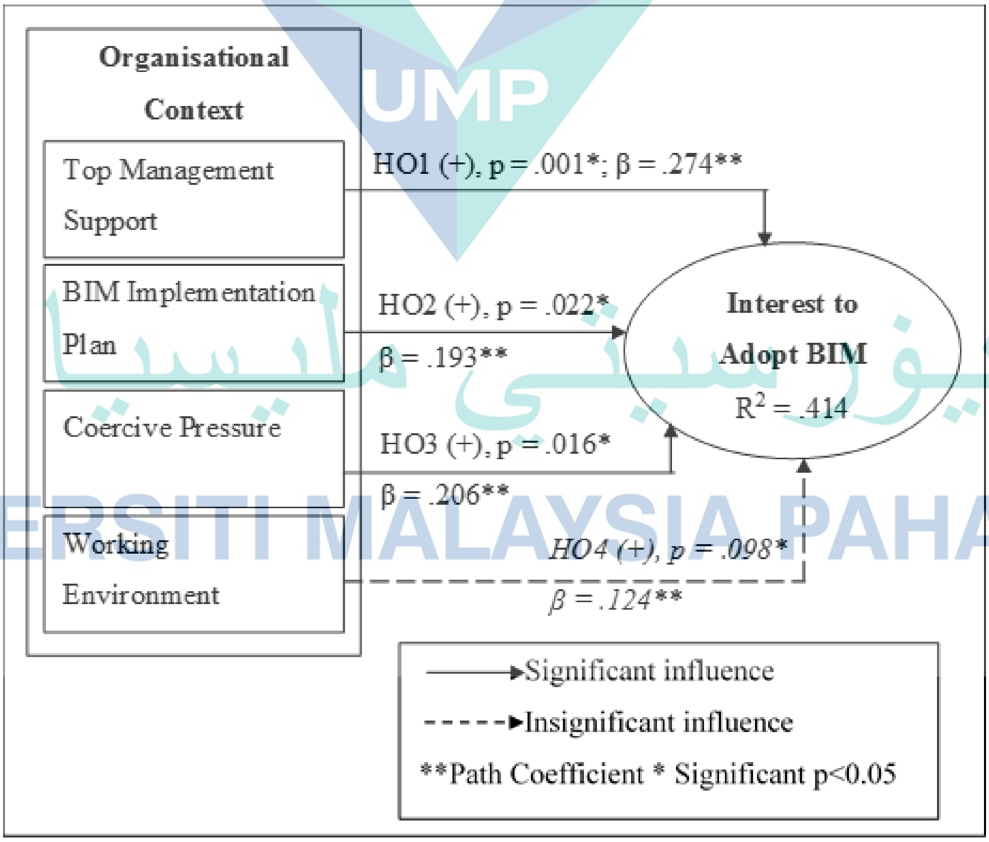

Figure 4.15 Relationship between independent variables and dependent variables for organisational context

4.5.4.3 The Role of People Context toward Interest to Adopt Building Information Modelling (BIM)

The resistance of people to change is one of the main barriers for any organisation to adopt BIM in their construction projects (Khemlani, 2004). There are a lot of factors on why people are reluctant to change from establishing working procedures into new working procedure especially when related to new technology. Therefore, to examine the role of people on the adoption of BIM, there are four variables will be examined, namely; Training and Education, Experienced Staff, BIM Competency Team and New Roles and Responsibilities. In order to examine the relationship between these variables towards BIM adoption, the following hypotheses were developed and tested;

HP1: Participate in Training and Education program by the people has a significant, positive impact on people's interest to adopt BIM.
HP2: Having higher experienced staff has a significant, positive impact on people's interest to adopt BIM.
HP3: Strong support from BIM Competency Team has a significant, positive impact on people's interest to adopt BIM.
HP4: Clearer new roles and responsibilities for staff have a significant, positive impact on people's interest to adopt BIM.

The second multiple regression models will investigate the effect of people, which consists of Training and Education (P1), Experienced Staff (P2), BIM Competency Team (P3) and New Roles and Responsibilities (P4) on Interest to Adopt BIM. The multiple linear regression models are described as follows:

Interest to Adopt BIM = $\alpha + \beta 1\ (P1) + \beta 2\ (P2) + \beta 3\ (P3) + \beta 4\ (P4)$;
* Where;
- α = is the Y intercept (the value of Y when all the X values are zero)
- βn = coefficients measuring relationship strength

Table 4.15 shows the result from multiple regression analysis for people context.

Table 4.15 Result from Multiple Regression Analysis for People Context (N = 152)

Model		Unstandardized Coefficient B	Unstandardized Coefficient Std. Error	Standardised Coefficient β	t	Sig.	Collinearity Statistic VIF
1	(Constant)	1.787	.256		6.979	.000	
	P1: Training & Education	.169	.075	.229	2.268	.025	2.349
	P2: Experienced Staff	.070	.071	.091	.980	.329	1.998
	P3: BIM Competency Team	.154	.058	.215	2.662	.009	1.505
	P4: New Roles & Responsibilities	.147	.060	.210	2.442	.016	1.707

Coefficient [a]

**Model Summary: R = .603[a], R^2 = .364, Adjust R^2 = .347, F (4,147) =21.002, p < .05, Durbin-Watson = 1.728*

**Note: a. Predictors: (Constant) P1, P2, P3, P4; Dependent Variable: Interest to Adopt*

Table 4.15 and Appendix G revealed that this model is statistically significant in predicting the dependent variable which is Interest to Adopt because the result from regression analysis show the F test is (4, 147) = 21.002, p<.05. The data also free from the autocorrelation problem because the value of Durban-Watson is 1.728 which is falls between the acceptable ranges (1.5 to 2.5) (Chong et al., 2009). There is no multicollinearity issue because the VIF values are less than 10 (Tabachnick & Fidell, 2007 and Pallant, 2005). Table 4.15 also revealed that three predictor variables that have a significant effect towards interest to BIM adoption, are Training & Education (β = .229, p < .05), BIM Competency Team (β = .215, p < .05) and New Roles and Responsibilities (β = .210, p < .05) with only about 36.4% of the variability in the Interest to Adopt BIM can be explained by the predictor variables. While the survey respondents believed the factor of having experienced staff does not have a significant effect towards to BIM adoption. The assumption why the survey respondents acknowledge the factor of having experienced staff does not have a significant effect towards to BIM adoption because since the implementation of BIM in Malaysia still new therefore it is hard to find staff equipped with BIM capabilities. It is easy for them to send their staff undergo training instead keep looking the staff with BIM capabilities.

This result also revealed that having or providing Training & Education (β = .229) is the strongest contribution that can speed up the process of BIM adoption by the people compared to having BIM Competency Team (β = .215) and creating New Roles and Responsibilities (β = .210). These results indicated that the survey respondents acknowledged training and education factor plays important roles in influencing the adoption of BIM. One possible explanation is that having adequate training and education it easy for the user to understand and utilise the capabilities of BIM and inadequate training will reduce the potential benefits gained from the use of BIM. Training can be done internally or externally and it depends on the strategies of the organisations.

The data from Table 4.15 also found that, the hypothesis HP2 was rejected due to $p > .05$. Figure 4.16 shows the relationship between people factors and interest to adopt BIM.

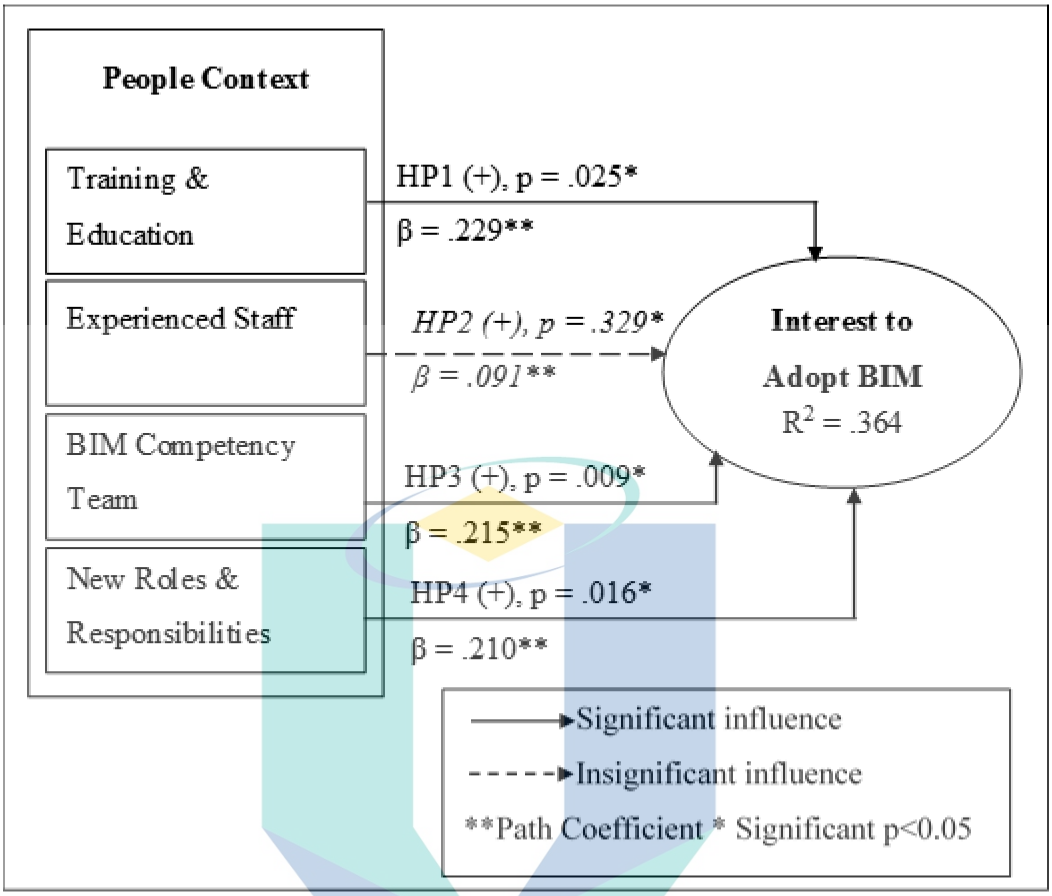

Figure 4.16 Relationship between independent variables and dependent variables for people context

4.5.4.4 The Role of Technological Context toward Interest to Adopt Building Information Modelling (BIM)

In order to implement BIM, utilisation of technology cannot be denied. But in Malaysia, BIM technologies seemly new and there are a lot of factors why issues of technology could hinder the adoption of BIM. Investing on BIM technology will increase the operational cost is one of the factors, while other factors that hampered the pace of adoption of BIM is the complexity and the compatibility of the technology (Meadati & Irizarry, 2010; Howard & Bjork, 2008). Besides that, the issue of interoperability between BIM technologies also the reasons the construction players delay in investing in BIM technologies. This is because, some BIM technology cannot communicate with other BIM technology, resulting to inability to provide a seamless information exchange in the construction industry (Giligan & Kunz, 2007 and Smith & Tardiff, 2009). Therefore, to examine the role of technology in the adoption of BIM, there are four variables will be examined, namely; Compatibility, Interoperability, Complexity and Cost. In order to investigate the relationship between these variables towards BIM adoption, the following hypotheses were developed and tested;

HT1: High level of compatibility of BIM technology may have a significant, positive impact toward the adoption of BIM.
HT2: Low level of complexity of BIM technology may have a significant, positive impact toward the adoption of BIM.
HT3: High level of interoperability of BIM technology may have a significant, positive impact toward the adoption of BIM.
HT4: Lower cost of BIM technology may have a significant, positive impact toward the adoption of BIM.

The third multiple regression models will investigate the effect of technological toward the interest to adopt BIM. The technological context consisting of Compatibility (T1), Complexity (T2), Interoperability (T3) and Cost (T4). The multiple linear regression models are described as follows:

Interest to Adopt BIM = $\alpha + \beta 1\ (T1) + \beta 2\ (T2) + \beta 3\ (T3) + \beta 4\ (T4)$;
* Where;
- α = is the Y intercept (the value of Y when all the X values are zero)
- βn = coefficients measuring relationship strength

Table 4.16 shows the result from multiple regression analysis for technological context.

Table 4.16 Result from Multiple Regression Analysis for Technological Context (N = 152)

		Coefficient [a]					
Model		Unstandardized Coefficient		Standardised Coefficient			Collinearity Statistic
		B	Std. Error	β	t	Sig.	VIF
1	(Constant)	1.289	.246		5.229	.000	
	T1: Compatibility	.166	.046	.254	3.649	.000	1.366
	T2: Complexity	.035	.051	.048	.694	.489	1.357
	T3: Interoperability	.233	.050	.319	4.642	.000	1.330
	T4: Cost	.230	.053	.296	4.340	.000	1.313

**Model Summary*: $R = .692^a$, $R^2 = .479$, Adjust $R^2 = .465$, $F\ (4,147) = 33.756$, $p<.05$, Durbin-Watson = 1.671*

**Note: a. Predictors: (Constant) T1, T2, T3, T4; Dependent Variable: Interest to Adopt*

Table 4.16 and Appendix G shown that this model is statistically significant in predicting the dependent variable which is Interest to Adopt because the result from regression analysis show the F test is (4, 147) = 33.756, p < .05. The data also is free from the autocorrelation problem because the value of Durban-Watson is 1.671 which falls between the acceptable ranges (1.5 to 2.5) (Chong et al., 2009). There is no multicollinearity issue because the VIF values are less than 10 (Tabachnick & Fidell, 2007 and Pallant, 2005). Table 4.16 also discovered that three predictor variables that have a significant effect towards to BIM adoption which are Compatibility (T1) (β = .254, p < .05), Interoperability (T3) (β = .319, p < .05) and Cost (T4) (β = .296, p < .05) with only about 47.9% of the variability in the Interest to Adopt BIM can be explained by the predictor variables. The factor of complexity of BIM technology did not have a significant effect towards to BIM adoption. One possible assumption is, the factor of complexity is temporary issue because, when they finish undergo training and using the BIM application regularly, then this issue will eventually diminish.

The results revealed that the strongest contribution that can increase the interest to adopting BIM is having high Interoperability (β = .319) followed by Cost of the technology (β = .296) and Compatibility of the technology (β = .254). These results indicated the survey respondents acknowledged having higher interoperability of BIM technology plays important roles in influencing the adoption of BIM. It's important because to have an efficient communication tools between different project participants is critical. By having the issues of interoperability, it will limit the process of exchanging information between different project participants that could lead to ineffective of designing.

The data from Table 4.16 also found that, the hypothesis HT2 was rejected due to p > .05. Figure 4.17 shows the relationship between technological factors and interest to adopt BIM.

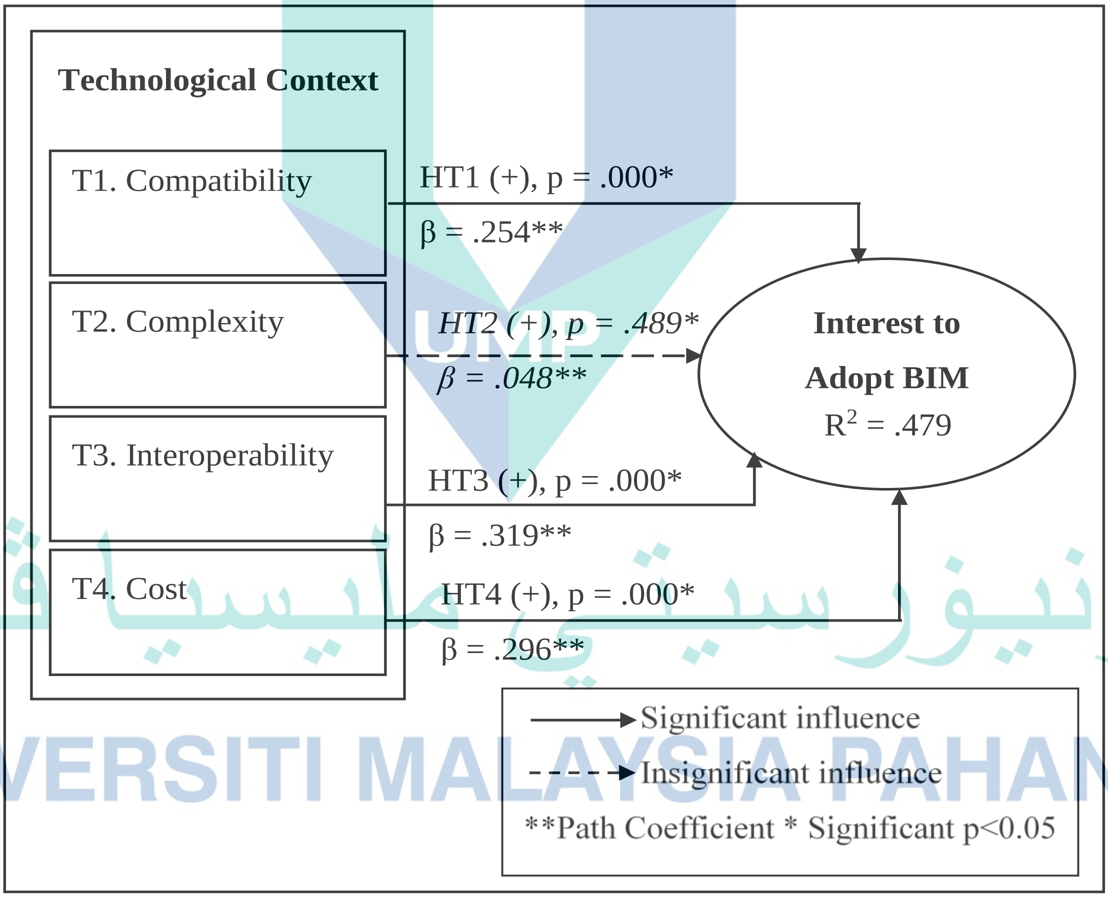

Figure 4.17 Relationship between independent variables and dependent variables for technological context

4.6 Refining the Building Information Modelling (BIM) Adoption Model

Table 4.17 shows the summary of the result of testing the hypotheses of BIM Adoption Model and revealed that, for organisational context, having conducive environment is not a significant factor in influenced the adoption of BIM. The most significant factors in the context of organisation are support from top management (β = .274). This result is consistent with Gilligan & Kunz (2007); O'Brien (2000); Son, Lee & Kim (2015); Song, Migliaccio, Wang & Lu (2017); Cao, Li, Wang & Huang (2017); Ozorhon & Karahan (2017) and Jin et al. (2017) said that a support from top management has been identified as a vital variable in technology implementation studies and by having full support from them is the main success factor for adopting BIM technology. It is understandable that majority of survey respondents have chosen this factor because to implement new technology such as BIM, a serious commitment from top management is a must because it involved in providing adequate resources to support the application of BIM. Inadequate support from top management could send a wrong signal to staff, which they will interpret the implementation of BIM is not serious and can they take lightly.

On top of that, top management can play a role as 'Change Agent' that will influence the acceptance of BIM among staff. Top management could issue any instruction such as instruction to adopt BIM, therefore, there is no excuse for staff to ignore the instruction. Same goes to enforcement from client when the client enforces to use BIM in their project whether like it or not, the bidders have to comply with the requirements.

The second most influenced factor is having coercive pressure (β = .206) and followed by having BIM implementation plan (β = .193). Although feedback from interview session revealed that most of the companies agreed having a conducive environment could support the process of BIM adoption, but majority of the survey respondents believed that having support from top management and coercive pressure are enough to push the adoption of BIM. It is aligned with the opinion from the interviewed companies which the best approach to push the adoption of BIM are top down approach and having a pressure whether it from internal or external.

For the context of people, having experienced staff is not a significant factor in influencing the adoption of BIM. Majority of the survey respondents know that, since the implementation of BIM in the Malaysian construction industry is still new therefore to find an experienced staff with BIM knowledge is difficult and limited. The idea of outsourcing the expert in BIM is the best way to promote the implementation of BIM within organisation. It could be a jump start to implement BIM. This idea is aligned with the view from interviewed companies as per discussed early in this Chapter, where the early stage of forming BIM unit they appointed external BIM expert to assist their BIM unit. This external BIM expert has given an opinion and solutions when problems occurs.

The most influenced factors are providing training and education (β = .229), forming BIM competency team (β = .215) and provide a clear roles and responsibilities (β = .210). These findings are consistent with Love, Irahi, Li, Cheng & Tse (2001); Stewart & Mohamed (2002); Thorpe (2003); McGraw Hill (2014); Lee & Yu (2016) and Song et al. (2017) which reported many organisations did not achieve a satisfactory level of BIM implementation because of lack of training. Majority of survey respondents believed that by having continuous training and education play a significant role to enhance the confidence and knowledge of the staff. By having this knowledge and confidence it will help them handling any difficult task in the future. Dewan, Lorenzi & Zheng (2004) added any organisation introduce new approach or new work process would face the resistance from their staff at the early stage and this resistance cannot be totally eliminated but it can be managed by providing the training and education program. By having these training programs, staff will feel more confident and it will increase their knowledge.

For technological context, complexity of BIM technology is not a significant factor in influencing the adoption of BIM, while the most significant factors are the capability of interoperability by BIM technology (β = .319), cost of BIM technology (β = .296) and the issue of compatibility (β = .254). The majority of survey respondents viewed complexity is not a critical factor in adopting BIM because, it is true to learn new thing will take time and once the staff use it daily then they will master it. Some of respondents believed that, younger generation are easy to adapt but for senior generation take time to master it. But from the observation, once they always operate the system and getting know the system the issue of complexity will diminish gradually according to majority respondents as per discussed in this early Chapter.

Issue of capability of interoperability and compatibilities are more critical in order to archive BIM level 2 and 3 according interviewed companies. A study conducted by Robert, Henry, Clare & Sean (2015) revealed that about 71% of survey respondents agreed that the if the issues of interoperability can be solved to an acceptable level, it will increase their confident to invest more in BIM technology. Besides that, to achieve BIM level 2 and 3, which to have a single shared model, the BIM technology must have capability of interoperability and compatibility to avoid losing any information or data during the integration process between various model such as architect model, structural model, mechanical, electrical and plumbing model. This result is consistent with Smith & Tardif (2009); Eastman et al. (2011); Redmond, Hore, Alshawi & West (2012); Son, Lee & Kim (2015) and Kim, Chin, Han & Hoi (2017), which has found issue of interoperability is the critical factor that influencing the owners to adopt BIM because it will affect users' perceived ease of use.

Based on the result of multiple linear regression analysis, the conceptual of BIM adoption model was further refined and concluded as shown in Figure 4.18.

Table 4.17 Summary result of hypotheses testing

Hypothesis	Result
1. Organisational Context	
HO1: Strong support from top management within organisation has a significant and positive impact toward BIM adoption.	*Accept HO1*
HO2: Organisation that have BIM implementation plan has a significant, positive impact toward BIM adoption.	*Accept HO2*
HO3: High level of coercive pressure received by the organisation has a significant, positive impact toward BIM adoption.	*Accept HO3*
HO4: Having a supportive working environment within organisation has a significant and positive impact toward BIM adoption.	Reject HO4
2. People Context	
HP1: Participate in Training and Education program by the people has a significant, positive impact on people's interest to adopt BIM.	*Accept HP1*
HP2: Having higher experienced staff has a significant, positive impact on people's interest to adopt BIM.	Reject HP2
HP3: Strong support from BIM Competency Team has a significant, positive impact on people's interest to adopt BIM.	*Accept HP3*
HP4: Clearer new roles and responsibilities for staff have a significant, positive impact on people's interest to adopt BIM.	*Accept HP4*

Table 4.17 Continued

Hypothesis	Result
3. Technological Context	
HT1: High level of compatibility of BIM technology may have a significant, positive impact toward BIM adoption.	*Accept HT1*
HT2: Low level of complexity of BIM technology may have a significant, positive impact toward BIM adoption.	Reject HT2
HT3: High level of interoperability of BIM technology may have a significant, positive impact toward BIM adoption.	*Accept HT3*
HT4: Lower cost of BIM technology may have a significant, impact toward BIM adoption..	*Accept HT4*

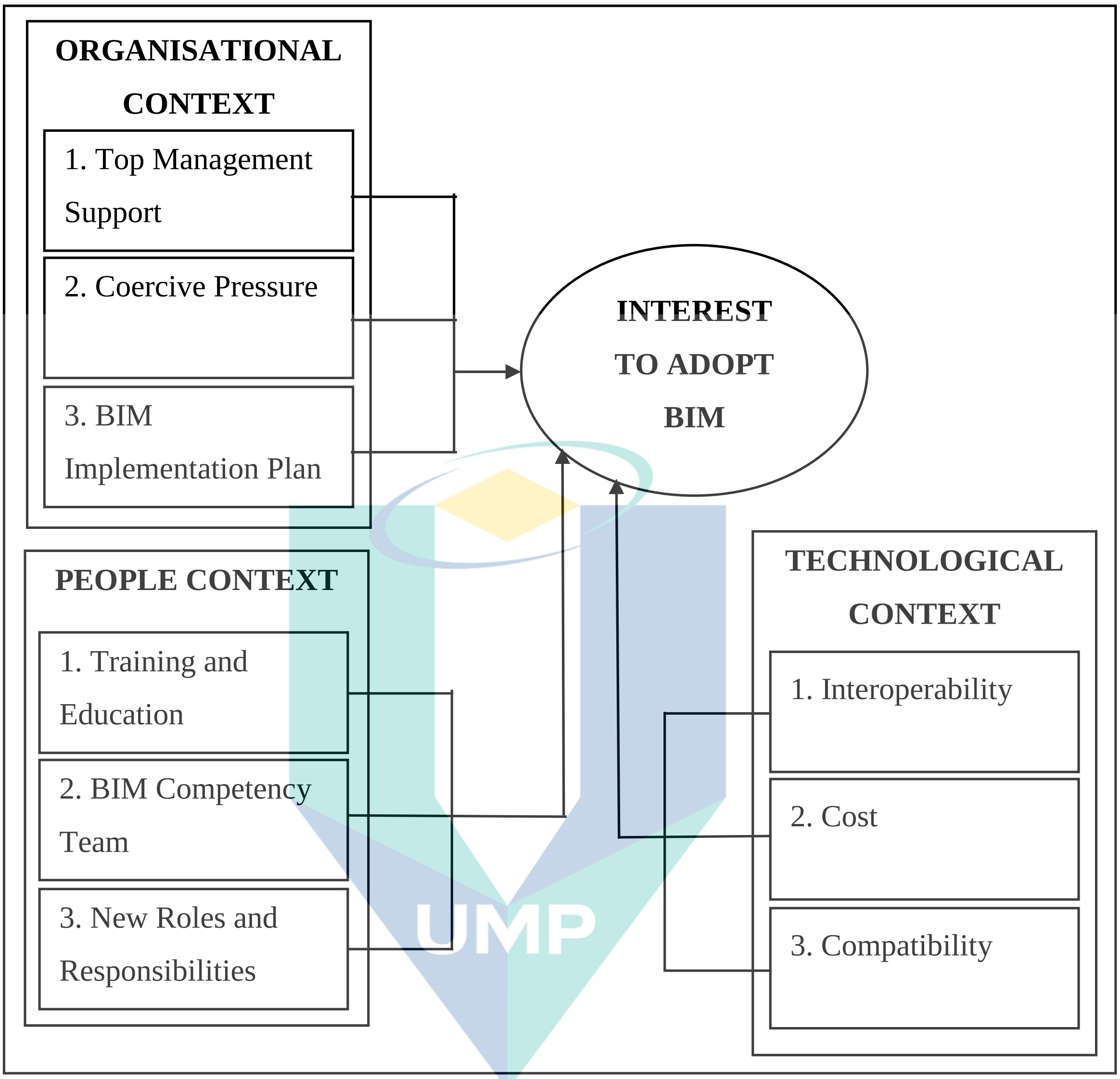

Figure 4.18 Final model for BIM Adoption from the perspective of Civil and Structural Consulting Firm

4.7 Summary

This chapter, revealed that, the challenges to adopting Building Information Modelling (BIM) came from legal, financial, technology and management aspects. In order to speed up the adoption rate there are 12 factors that could influence the adoption of BIM namely, support from top management, working environment, coercive pressure, BIM implementation plan, training and education, experienced staff, BIM competency team, new roles and responsibilities, compatibility, complexity, interoperability and cost. These factors then will be clustered into organisational context, people context and technological context. It was found that the current BIM implementation level in

Malaysia is still at level 1. Besides that, to start using BIM, it is advisable to implement it through small scale or pilot project because it can minimise the risk during the transition period. From the multiple linear regression analysis found that, from 12 factors being tested, only 9 factors that having a strong relationship that could speed up the adoption of BIM which are support from top management, coercive pressure, BIM implementation plan, training and education, BIM competency team, new roles and responsibilities, compatibility, interoperability and cost. Finally, the conceptual BIM adoption model being finalised after make an adjustment based on findings from multiple linear regression analysis.

CHAPTER 5

CONCLUSION

5.1 Introduction

This chapter will conclude the findings for this study started with research findings and conclusions, followed by limitation of the research, contribution of the research and end with recommendation for future research.

5.2 Research Findings and Conclusions

The aim of this study is to examine the relationship between organisations, people and technology towards making decisions in adopting of Building Information Modelling (BIM). In order to achieve the aim of this study, there is the needs to study current BIM implementation in Malaysia and found that the implementations of BIM in Malaysia is still lagging behind compared to other countries especially in the US, UK and Europe, although the introduction of BIM has begun in the early 2007. In 2015 the rate of BIM adoption in Malaysia by the construction players is about 17% compare to Japan (43%), South Korea (52%). Lots of factors contribute to these issues such as resistance from the people, no clear path to follow, lack of support from clients, lack of support from BIM expert, unknown BIM technology and concern of cost are some of the challenges that they faced. But the critical issues in adopting BIM for early adopter are no clear guideline and plan for implement BIM, lack of support from BIM expert and government or client to push to implement BIM. Without having a clear guideline or implement plan especially for Malaysian context, the early adopter feel that they are doing it without purpose and the risks they are facing are inevitable. Therefore, they believed that the effort done by Construction Industry Board (CIDB) and Public Work Department (PWD) to develop BIM guideline especially for context of Malaysia will increase the rate of BIM adoption among Malaysian construction players. Beside the government must provide the technical parts such as providing BIM guideline and implementation plan, push by the government such as the government target the rate of BIM adoption by 2020 up to 40%

also can contribute to the increasing of BIM adoption among Malaysian construction players. It is the same strategy that the government has used to increase the use of Industrial Building System (IBS) in Malaysia, where, the government regulate all government project must use certain percentage of IBS components.

In order to increase the adoption rate of BIM, there is the needs to identify the driven factors that can expedite the adoption of BIM. In principle there are 12 factors that have influenced in adopting BIM and these factors; top management support, having a conducive working environment, having internal and external pressure, having BIM implementation plan, type of the organisation, conduct training and education, having an experienced staff, support from BIM competency team, having a clear new role and responsibility and compatibility, complexity, interoperability and cost of technology. Then, these factors were clustered into three, namely; organisational context, people context and technological context.

To identify the factors that has a positive relationship toward BIM adoption, multiple linear regression was used to analyse the data from 152 participants. The analysis from multiple linear regression, provided new empirical evidence for the organisational context which that, factor of working environment is not a significant factor in influencing the adoption of BIM because it has the value of $p > .05$ ($p = .098$). This factor was excluded in the process of refining the conceptual BIM adoption model. The most influenced factors are support from top management ($\beta = .274$; $p = .001$), then followed by factor of having coercive pressure ($\beta = .206$; $p = .016$) and having BIM implementation plan ($\beta = .193$; $p = .022$). The strongest factor that influencing the BIM adoption is support from top management which is having beta (β) score .274. Thus, the top management should play a significant role to ensure the process of adoption run smoothly. This is because without support from the top management, the transition from traditional to BIM will be stagnant or in other word top management should become head of change.

For people context this study provided new evidence by revealing the factor of having experienced staff is not influencing the adoption of BIM, and this factor was excluded in the process of refining the conceptual BIM adoption model because having the value of $p > .05$ ($p = .329$). The factors that have the most influenced for the adoption of BIM are having training and education courses (β = .229; p = .025), followed by having BIM competency team (β = .215; p = .009) and lastly having a clear new roles and responsibilities (β = .210; p = .016). For the context of people, the strongest factor that has influenced the BIM adoption is training and education which is having beta (β) score .229. Through training and education could increase the skill and self-confidence of the users. By having the BIM knowledge, organisation could face less resistance from the people.

While for the context of technological this study provided new evidence which factor of complexity did not influence the adoption of BIM this factor was excluded in the process of refining the conceptual BIM adoption model because it has the value of p > .05 (p = .489). The factors that have the most influenced of the adoption of BIM are the capability of interoperability of BIM technology (β = .319; p = .000) followed by having a lower cost of BIM technology (β = .296; p = .000) and capability of compatibility of BIM technology (β = .254; p = .000). The strongest factor that influencing the BIM adoption is the capability of interoperability of BIM technology (β = .319). Issues of interoperability cannot be taken lightly because from the previous case studies revealed that majority of new users did not gain any benefit by using BIM due to the problem of data exchange between project team. Thus, in order to select BIM technology, he/she must take consideration of capability of interoperability before selecting the BIM technology.

Result from the multiple linear regression, this study concludes that there are 9 factors that have a positive relationship toward BIM adoption. And these factors as follows, having top management support, having coercive pressure, having BIM implementation plan, provide training and education program, establish BIM competency team, provide clear any new roles and responsibilities related with BIM, having BIM technology that has the capability of interoperability, cost of BIM technology and less issue of compatibility of BIM technology. Finally, after the adjustment has being made the model of BIM adoption can be found in Figure 5.

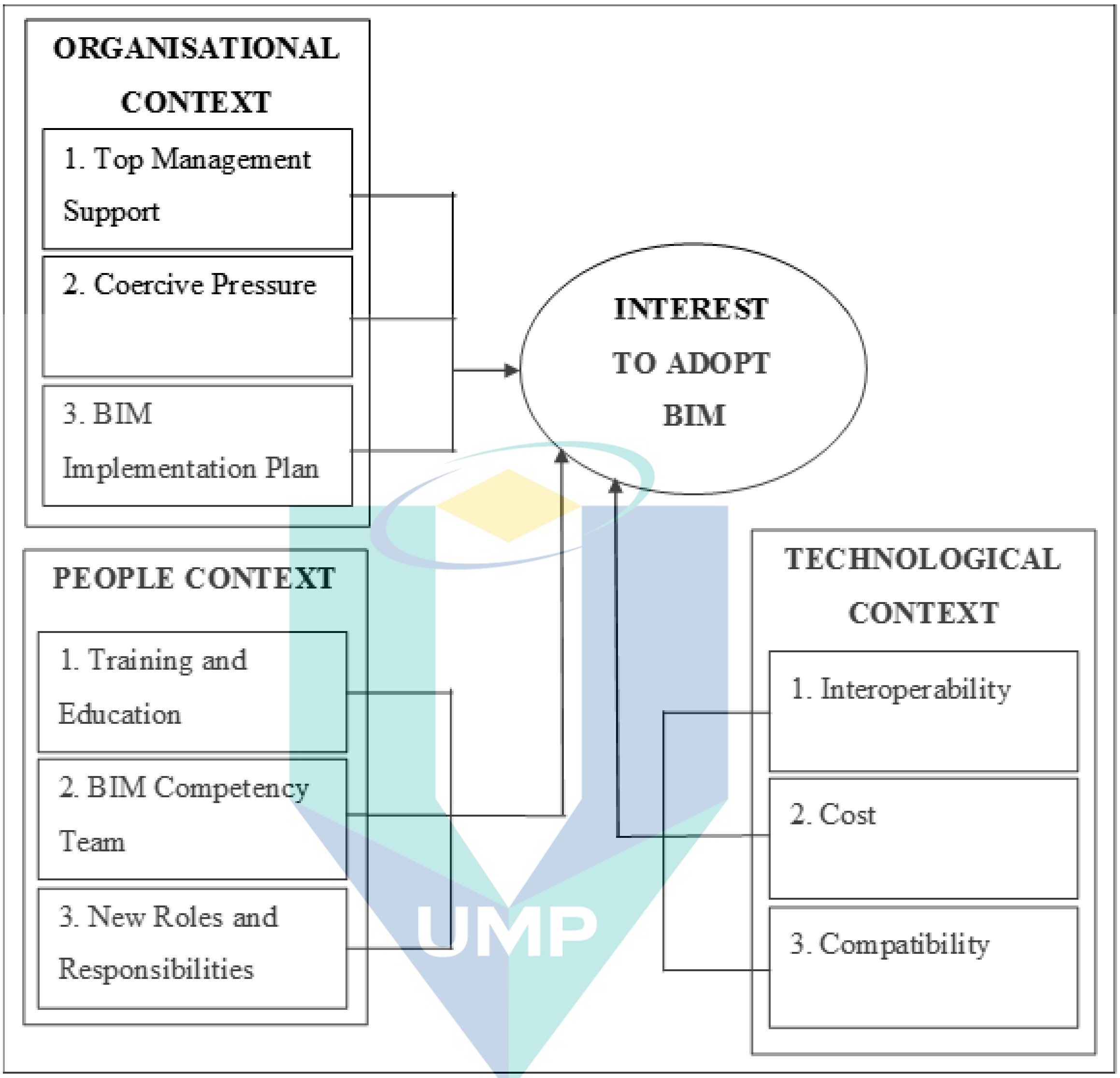

Figure 5 Final model for BIM Adoption from the perspective of Civil and Structural Consulting Firm

5.3 Research Limitations

In Malaysia, the adoption of Building Information Modelling (BIM) in the construction project is still new and still evolving. For this reason, during the exploratory interview, the sample size only meets the minimum requirement for interviewing process. It is due to the limited number of companies that have experience using BIM in their project and their willingness to participate in interview session resulting these situations. These limitations could create the generalising issue to reveal what is the real situation of BIM implementation happened in Malaysian construction industry and it also limited the numbers of identifying the adoption factors among Malaysian construction players although it was complemented with quantifiable data.

Quantifiable data from the survey findings related to BIM adoption was limited due to the limitation of Civil and Structure (C&S) consultant firms implementing BIM in their project and at the same time it was difficult to identify individuals who fully understand BIM, having experience using BIM and willingness to answer the survey. These issues lead to obstacle in increasing the sample size for this study that could create the issue of generalisation.

5.4 Contribution of the Research

By using survey data from 152 organisations, this study practically could help explain empirically the organisational intent to adopt Building Information Modelling (BIM). This empirical data highlighted on vital factors that positively influenced the adoption of BIM by describing the relationship between these factors can guide or as a starting point for organisation decision makers to make decisions in adopting BIM. Besides that, these factors might help any organisation to understand the factors that could ease the process of adoption.

This study also offers a new insight from the perspective of Civil and Structure (C&S) consultant firms on the adoption of BIM and could improve the rate of BIM adoption. At the same time, it could fill the gap from previous studies by extending the study of BIM adoption and by investigating from the perspective of C&S consultant firms and complementing the overall view of BIM adoption from all participants.

However, the findings for this study is limited to Malaysian construction industry context with specific focus on the Civil and Structure (C&S) consultant firms.

5.5 Recommendation for Future Research

This study is focusing on the adoption factors of Building Information Modelling (BIM) from the perspective of Civil and Structure (C&S) consultant firms. Therefore, to have a comprehensive finding from the Malaysian construction players it would be useful to explore and compare the influence factors that could increase the BIM adoption from the perspective of Architect, C&S, Mechanical, Electrical and Plumbing (MEP), Quantity

Surveyor (QS), Contractor and Facilities Manager (FM). By comparing the opinions from the construction players, it could identify any discrepancies on specific topics related to the use of BIM from the perception of different discipline. The findings will represent the whole project life cycle in term to identify the influencing factors that could increase the BIM adoption. At the same time, the status of BIM adopting among Malaysian construction players can be identified because currently Construction Industry Development Board (CIDB) reported only 17% Malaysian construction players adopting BIM without detailing the breakdown.

From the data analysis, it was found that only 6% the respondents have the experience using BIM in their project and it would be more interesting to evaluate the different effects of those variables between adopters and non-adopters beside examining factors that are not included in this study.

REFERENCES

Abdullah, S.A, Sulaiman, N, Latiffi, A.A, and Baldry, D. (2014). *Building Information Modeling (BIM) from the Perspective of Facilities Management (FM) in Malaysia*. Paper presented at Conference of International Real Estate Symposium.

Abdul Rahman, H., Berawi, M.A., Berwai, A.R., Mohamed, O., Othman, M., and Yahya, I.A. (2006). Delay mitigation in the Malaysian construction industry. *Journal of Construction Engineering and Management*, 132(2), 125-135. https: DOI/10.1061/ASCE/0733-9364/2006/132:2/125

A. Fontana, and J.H. Frey (2000). *The Interview: From Structured Questions to Negotiated Text. 2nd Edition:* Sage Publication.

Ahmad Latiffi, A., J. Brahim, S. Mohd, and M.S. Fathi. (2014). The Development of Building Information Modelling (BIM) Definition. *Applied Mechanics & Materials*, 567, 625-630.
https: DOI/10.5923/s.ijcem.201309.01.

Ahmad Latiffi, A., Mohd, S., Kasim, N., and Fathi, S. M., (2013) Building Information Modeling (BIM) application in the Malaysian construction industry. *International Journal of Construction Engineering and Management*, 2(4A), 1-6.

Alaghbari, W., Kadir, M.R.A. & Salim, A. (2001). The significant factors causing delay of building construction projects in Malaysia. *Malaysian Construction Research Journal*, 14(2):192-206.
https://DOI/10.1108/09699980710731308

Alreshidi, E., Mourshed, M., and Rezgui, Y. (2014). Exploring the Need for a BIM Governance Model: UK Construction Practitioners' Perceptions. *Computing in Civil and Building Engineering*, 151-158.
https:/DOI/10.1061/9780784413616.020

Alshawi M. (2007). *Rethinking IT in construction and engineering: organisational readiness:* Taylor and Francis.

Ahmad Tarmizi Haron, Amanda J. Marshall-Ponting, Zahrizan Zakaria, Mohd Nasrun Mohd Nawi, Zuhairi Abd Hamid, and Kamarul Anuar Mohamad Kamar (2015). An Industrial Report on the Malaysian Building Information Modelling (BIM) Taskforce: Issues and Recommendations. *Malaysian Construction Research Journal*, 17(2):21-36.

Ali, K., Ibrahim, S.N.N.S., and Boon, T.C. (2013). *Building information modelling: awareness and readiness among QS and QS firms: A technical report.* RISM press.

Almanza, B., and Ismail, J. (2009). Identifying the underlying structure of perceived service fairness in restaurants. *International Journal of Contemporary Hospitality Management*, 21(4),375-392.
https://doi.org/10.1108/09596110910955659

Anderson, G. (1998). *Fundamental of Educational Research.* Falmer Press.

Aranda-Mena, G., Crawford, J., Chevez, A., and Froese, T. (2009). Building information modelling demystified: does it make business sense to adopt BIM*? International Journal of Management Projects in Business*, 2(3). https://DOI/10.1108/17538370910971063

Arayici, Y., Coates, P., Koskela, L., Kagioglou, M., Usher, C., and O'Reilly, K. (2011) Technology adoption in the BIM implementation for lean architectural practice, *Automation in Construction*, 20(2).189-195. https://DOI/10.1016/j.autcon.2010.09.016

Ashcraft, H. (2008). Building information modelling: A framework for collaboration. *Construction Lawyer*, 28(5), 5-11.

Azhar, S. (2011). Building Information Modeling (BIM): Trends, Benefits, Risks, and Challenges for the AEC Industry. *Leadership Manage. Eng*, 11(3), 241-252 https://doi.org/10.1061/(ASCE)LM.1943-5630.0000127

Bew, M., and Underwood, J. (2010). Delivering BIM to the U.K market. In Underwood, J., and Isikdag, U. (Eds.) *Handbook of Research on Building Information Modelling and Construction Informatics: Concepts and Technologies.* IGI Publishing.

Bryde D., Broquetas M., and Volm J.M. (2013). The project benefits of Building Information Modelling (BIM). *International Journal of Project Management*, 31(7), 971-980. https://doi.org/10.1016/j.ijproman.2012.12.001

Budruk, M. (2010). Cross-language measurement equivalence of the place attachment scale: A multigroup confirmatory factor analysis approach. *Journal of Leisure Research*, 42(1), 25-42. https://doi.org/10.1080/00222216.2010.11950193

BuidlingSMART Australasia (2012). *National Building Information Modelling Initiative, Vol. 1: Strategy for focussed adoption of building information modelling and related digital technologies and processes for Australian build environment sector:* Department of Industry, Innovation, Science, Research and Tertiary Education.

Cabinet Office (2011). *Government Construction Strategy:* London, TSO.

Cao, D.P.; Li, H.; Wang, G.B., and Huang, T. (2017). Identifying and contextualizing the motivations for BIM implementation in construction projects: An empirical study in China. *International Journal in Project Management*, 35(4), 658-669. https://doi.org/10.1016/j.ijproman.2016.02.002

Cascio, R., Mariadoss, B., and Mouri, N. (2010). *The impact of management commitment alignment on salespersons' adoption of sales force automation technologies*: An empirical investigation, Industrial Marketing Management.

Cemesova, A., C. J. Hopfe, and R. S. McLeod (2015). Passiv BIM: Enhancing Interoperability Between BIM and low Energy Design Software. *Automation in Construction*, 57(4),17-32. https://doi.org/10.1016/j.autcon.2015.04.014

Chakrabarty, S., Whitten, D., and Green, K.W. (2007). Understanding service quality and relationship quality in IS outsourcing: Client orientation & promotion, project management effectiveness, and the task-technology-structure fit. *Journal of Computer Information Systems*, 48(2),1-15.

Chatterjee, S., Hadi, A. S., and Price, B. (2000). *Regression Analysis by Example (3rd Ed.):* John Wiley and Sons, Inc.

Chebrolu, S. B. (2010). *Assessing the relationships among cloud adoption, strategic alignment and information technology effectiveness* (Doctoral dissertation).

Chen, L. H., Ye, Y., Chen, M., and Tung, I. (2010). Alegrial flow in leisure and life satisfaction: The mediating role of event satisfaction using data from acrobatics show. *Social Indicators Research*, 99,301-313. https://doi.org/10.1007/s11205-010-9581-z

Chin, W.W. (1998). Issues and opinion on structural equation modelling. *MIS Quarterly*, 22(1), 5-15.

CIBER (2012). *Building Information Modelling (BIM): An Introduction and International Perspective, Research report:* Centre for Interdisciplinary Build Environment Research, The University of Newcastle.

CIDB (2009). *Leverage on Information and Communication Technology in The Construction Industry:* CIDB press.

CIDB (2011). *Annual Report 2010*: CIDB Press.

CIDB (2014). *Building Information Modelling (BIM) roadmap for Malaysia's construction industry*: CIDB Press.

CIDB (2015). *Construction Industry Transformation Programme (CITP) 2016 -2020.* CIDB Press.

CIDB (2016). *CIDB BIM Report:* CIDB Press.

CIMP (2007). *Construction Industry Master Plan 2006 – 2015 (CIMP 2006 – 2015):* CIDB Press.

Chuang T.H., Lee B.C. and Wu I.C. (2011). *Applying cloud computing technology to BIM visualization and manipulation.* Paper presented at 28th International Symposium on Automation and Robotics in Construction.

Chong, A.Y.L., Ooi, K.B., Lin, B.S., and Raman, M. (2009). Factors affecting the adoption level of c-commerce: An empirical study. *Journal of Computer Information Systems*, 50(2), 13-22.

Clough, R.H. and Sears G.A. (1994). *Construction Contracting. (6th edition)*. John Wiley & Sons Inc, New York.

Computer Integrated Construction Research Program. (2011). *BIM Project Execution Planning Guide –Version 2.1:* The Pennsylvania State University.

Cohen J, Cohen P, West SG, Aiken LS (2003). *Applied multiple regression/correlation for the behavioural sciences:* Lawrence Erlbaum Associates.

Cohen J, Lawrence Manion and Keith Morrison (2007). *Research Methods in Education (6th Ed.).* Routledge.

Cooper, D. R., and Schindler, P. S. (2006). *Business Research Methods (9th edition):* McGraw-Hill.

Damanpour, F. (1991). Organizational innovation: A meta-analysis of effects of determinants and moderators. *Journal of Management*, 34(3),555-590. https://doi.org/10.2307/256406

Davis, K. A., and Songer, A. D. (2008). Resistance to IT change in the AEC industry: an individual assessment tool. *Journal of Information Technology in Construction (ITcon)*, 13, 52-58.

Department of Statistics Malaysia. (2014). *Annual Gross Domestic Product 2005–2013*: DOSM.1955-0751.

Detmar Straub (1989). Validating Instruments in MIS Research. *MIS Quarterly*, 13(2),147-169. https://doi.org/10.2307/248922

Deutsch, R. (2011). *BIM and integrated design: strategies for architectural practice: New* Jersey: John Wiley & Sons.

Dewan, N. A., Lorenzi, N. M., and Zheng, S. (2004). Overcoming resistance to new technology. *Behavioural Health Management*, 4(3), 148-152.

Diamantopoulos, A., and Siguaw, J.A. (2006). Formative versus reflective indicators in organizational modelling implications. *Journal of Modelling in Management*, 17(4),263-282. https://doi.org/10.1111/j.1467-8551.2006.00500.x

Ding, L., Zhou, Y., Akinci, B. (2014). Building Information Modelling (BIM) application framework: The process of expanding from 3D to computable nD. *Automation in Construction*, 46, 82–93. https://doi.org/10.1016/j.autcon.2014.04.009

DiMaggio, P.J., and Powell, W.W. (1983). The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields. *American Sociological Review*, 48(2),147-160. https://doi.org/10.2307/2095101

Donna M. Mertens (2010). Transformative Mixed Methods Research. *Qualitative Inquiry*, 56(6),147-160. https://doi.org/10.1177/0002764211433797

Dossick, C.S., and Neff, G. (2010). Organisational divisions in BIM-enabled commercial construction. *Journal of Construction Engineering and Management*, 136(4),459-467. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000109

Eadie, R.; Browne, M.; Odeyinka, H.; Mckeown, C.; Mcniff, S. (2013). BIM implementation throughout the UK construction project lifecycle: An analysis. *Automation in Construction*, 36,145-151. https://doi.org/10.1016/j.autcon.2013.09.001

Eastman, C. M., C, Teicholz, P, Sacks, R and Liston, K (2011). *BIM Handbook: A Guide to Building Information Modelling for Owners, Managers, Designers, Engineers and Contractors:* John Wiley and Sons.

Enegbuma, W.I., Ali, K.N. (2011). *A preliminary critical success factor CSFs analysis of building information modelling (BIM) implementation in Malaysia*. Paper presented at International Conference on Product Lifecycle Management.

Ernawati Mustafa Kamal, Syarmila Hany Haron, Norhidayah Md Ulang and Faizal Baharum (2012). The Critical Review on the Malaysian Construction Industry. *Journal of Economics and Sustainable Development*, 3(13), 81-87.

Fornell, C., and Larcker, D.F. (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. *Journal of Marketing Research*, 18(1),375-381. https://doi.org/10.1177/002224378101800104

Fortner, B., Wilson, S., PE, M., Tsztoo, D., Handford, C., Rossi, K., and Horvath, J. (2008). SPECIAL REPORT: Are You Ready For BIM? *Civil Engineering-Reston*, 78, 44-57.

Fox, S., and Hietanen, J. (2007). Inter-organizational use of building information models: Potential for automation, informational and transformational effects. *Construction Management and Economics*, 25(3),289-296. https://doi.org/10.1080/01446190600892995

Gemunu Kulasekara, Himal Suranga Jayasena and K. A. T. O. Ranadewa (2013). *Comparative effectiveness of quantity surveying in a building information modelling implementation*. Paper presented at the Second World Construction Symposium.

Giligan, B., and Kunz, J. (2007). *VDC Use in 2007: Significant value, dramatic growth, and apparent business opportunity. CIFE Technical Rep. No TR171:* Palo Alto, CA: Stanford University.

Grantham, C. E. and Nichols, L. D. (1993). *The digital workplace: Designing groupware platforms:* Vnr computer library.

Granholm, L. (2011), *Finland, Norway, Singapore, USA Lead Progress in Construction*: BIMsight, Insight on Building Information Modelling.

Grau, D., Back, W.E., and Prince, J.R. (2012). Benefits of on-site design to project performance measures. *Journal of Management in Engineering*, 28(3),232-242. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000097

Green, S. B. (1991). How many subjects does it take to do a regression analysis? *Multivariate Behavioural Research*, 26(3),499-510. https://doi.org/10.1207/s15327906mbr2603_7

Gregory William Ticehurst and Anthony James Veal (2000). *Business Research Methods: A Managerial Approach:* Longman.

Gu, N., and London, K. (2010). Understanding and facilitating BIM adoption in the AEC industry. *Automation in construction*, 19(8),988-999. https://doi.org/10.1016/j.autcon.2010.09.002

Hair, J. F. Jr., Black, W. C., Babib, B. J., Anderson, R. E., and Tatham, R. L. (2006). *Multivariate data analysis (6th ed.):* Pearson.

Hamzah, N., Khoiry, M. A., Arshada I., Tawil, N. M., and Che Ani, A. I. (2011). *Cause of Construction Delay: Theoretical Framework.* Paper presented at the 2nd International Building Control Conference.

Hardin, B. (2009). *BIM and construction management: proven tools, methods, and workflows:* Wiley Publishing Inc.

Harris M, Che Ani AI, Haron AT, Husain AH. (2014). The way forward for Building Information Modelling (BIM) for contractors in Malaysia. *Malaysian Construction Research Journal*, 15(2), 1-9.

Haron, A. T. (2013). Organisational Readiness to Implement Building Information Modelling: A Framework for Design Consultants in Malaysia. (Doctoral Dissertation, University of Salford Manchester, Salford)

Hartmann, T., and Fischer, M. (2008). *Applications of BIM and hurdles for widespread adoption of BIM. CIFE Working Paper. No WP105 No. 105*: Palo Alto, CA: Stanford University.

Hartmann, T., Fischer, M. and Haymaker, J. (2009). Implementing information systems with project teams using ethnographic-action research. *Advanced Engineering Informatic*, 23(1),57-67. https://doi.org/10.1016/j.aei.2008.06.006

Howard, R.; Restrepo, L. and Chang, C.Y. (2017). Addressing individual perceptions: An application of the unified theory of acceptance and use of technology to building information modelling. *International Journal of Project Management*, 35(2),107-120. https://doi.org/10.1016/j.ijproman.2016.10.012

Hu, Q., Hart, P., and Cooke, D (2006). *The Role of External Influences on Organizational Information Security Practices: An Institutional Perspective*. Paper presented at the 39th Annual Hawaii International Conference on System Sciences.

Hulland, J., Chow, Y. H. and Lam, S. (1996). Use of Causal Models in Marketing Research: A Review. *International Journal of Research in Marketing*, 13(2),181-197. https://doi.org/10.1016/0167-8116(96)00002-x

Hussein, M. H. (2010). The peer interaction in primary school questionnaire: Testing for measurement equivalence and latent mean differences in bullying between gender in Egypt, Saudi Arabia and the USA. Social Psychology of Education. *An International Journal*, 13, 57–76.

Ifinedo, P. (2008). Impacts of business vision, top management support, and external expertise on ERP success. *Business Process Management Journal*, 14(4), 551-568. https://doi.org/10.1108/14637150810888073

Jason W. Osborne and Elaine Waters (2002). Four Assumptions of Multiple Regression That Researchers Should Always Test. *Practical Assessment, Research & Evaluation*, 8(2), 1-5.

J. Osman, S. Mazlina S. Khuzzan and A., R. Sapian (2015). *Building Information Modelling: Proposed Adoption Model for Quantity Surveying Firms.* Paper presented at International Conference on Information Technology & Society.

Jiao Y., Zhang S., Li Y., Wang Y. and Yang B. (2013). Towards cloud augmented reality for construction application by BIM and SNS integration. *Automation in Construction*, 33, 37-47. https://doi.org/10.1016/j.autcon.2012.09.018

Jin, R.; Hancock, C.; Tang, L.; Chen, C.; Wanatowski, D.; Yang, L. (2017). Empirical study of BIM implementation–based perceptions among Chinese practitioners. *Journal in Management Engineering*, 33(5), 37-47. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000538

Jung, Y. and Kang, S (2007). Knowledge-Based Standard Progress Measurement for Integrated Cost and Schedule Performance Control. *Journal of Construction Engineering and Management*, 133, 10-21. https://doi.org/10.1061/(ASCE)0733-9364(2007)133:1(10)

Jung, Y., and Gibson, G. E. (1999). Adoption of the Building Information Modelling (BIM) for Construction Project Effectiveness: The Review of BIM Benefits. *Journal of computing in civil engineering*, 4(3), 74-79. https://doi/10.12691/ajcea-4-3-1

Kamal, E. M. and R. Flanagan (2012). Understanding Absorptive Capacity in Malaysian Small and Medium Sized (SME) Construction Companies. *Journal of Engineering, Design and Technology*, 2(2), 180-198. https://doi.org/10.1108/17260531211241176

Kaner, I., Sacks, R., Kassian, W., Quitt, T. (2008). Case Studies of BIM Adoption for Precast Concrete Design by Mid-Sized Structural Engineering Firms. *Information Technology in Construction*, 13, 303-323.

Kementerian Kewangn Malaysia (2014). *Senarai ePerunding*, Bahagian Khidmat Perunidng, Kementerian Kewangan Malaysia

Khanzode, A., Fischer, M., and Reed, D. (2008). Benefits and lessons learned of implementing building virtual design and construction (VDC) technologies for coordination of mechanical, electrical, and plumbing (MEP) systems on a large healthcare project. *Journal of IT in Construction*, 13, 200-219.

Khazanchi, D (2005). Information technology (IT) appropriateness: the contingency theory of "FIT" and IT implementation in small and medium enterprises. *Journal of Computer Information Systems*, 45(3), 88-95.

Khosrowshahi, F., and Arayici, Y. (2012). Roadmap for implementation of BIM in the UK construction industry. *Engineering, Construction and Architectural Management*, 19(6), 610-635. https://doi.org/10.1108/09699981211277531

Kim, S.; Chin, S.; Han, J.; Choi, C. (2017). Measurement of construction BIM value based on a case study of a large-scale building project. *Journal in Management Engineering*, 33(6), 610-635. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000551

Kim, B., and Lee, S. (2008). Factors affecting the implementation of electronic data interchange in Korea. *Computers in Human Behaviour*, 24(2), 263-283. https://doi.org/10.1016/j.chb.2006.11.002

Kiviniemi, A., and Fischer, M. (2009). *Potential obstacle to using BIM in architectural design. Collaborative Construction Information Management*, Tylor & Francis.

Kline, R. (2005). *Principles and Practice of Structural Equation Modelling 2nd ed.*, New York: Guilford Press.

Kong, A.T. and Gray, J.M. (2006). *Problems with traditional procurement in the Malaysian construction industry – A survey*. Proceedings of Australasian Universities Building Educators Association Annual Conference. University of Technology, Sydney.

Kristen Barlish, Kenneth Sullivan (2012). How to measure the benefits of BIM — A case study approach. *Automation in Construction*, 24, 149-159. https://doi.org/10.1016/j.autcon.2012.02.008

Kristiina Sulankivi, Sijie Zhang, Jochen Teizer, Charles M.Eastman, Markku Kiviniemi, Ilkka Romo, Leif Granholm (2013). *Utilization of BIM-based Automated Safety Checking in Construction Planning*. Paper presented at CIB World Building Conference.

Kripanont, N. (2007). *Examining a technology acceptance model of Internet usage by academics within Thai business schools.* (Doctoral Dissertation, Victoria University, Melbourne, Australia).

Kuan KKY, Chau PYK (2001). A Perception-Based Model for EDI Adoption in Small Business Using a Technology. *Organization Environment Framework Info. Manage*, 38(8), 507-521. https://doi.org/10.1016/S0378-7206(01)00073-8

Kunz J., and Fischer M. (2009). *Virtual design and construction: Themes, case studies and implementation suggestions. CIFE Working Paper*: Stanford University.

Ku, K. and Taiebat, M. (2011). BIM Experiences and Expectations: The Constructor's Perspective'. *International Journal of Construction Education and Research*, 7(3), 175-197. https://doi.org/10.1080/15578771.2010.544155

Kumar B., Cheng J.C.P. and McGibbney L. (2010). Cloud computing and its implications for construction IT. *Computing in Civil and Building Engineering*, 6(2), 10-16.

Kuo, Y. L. (2013). Technology readiness as moderator for construction company performance. *Industrial Management & Data System*, 13(4), 558-572. https://doi.org/10.1108/02635571311322793

Kuo-Feng Chien, Zong-Han Wu and Shyh-Chang Huang (2014). Identifying and critical risk factors for BIM projects: Empirical study. *Automation in Construction*, 45, 1-15. https://doi.org/10.1016/j.autcon.2014.04.012

Kymmell, W. (2008). *Building Information Modelling: Planning and managing construction projects with 4D CAD and simulations:* McGraw-Hill.

Latiffi, A., Mohammed, S., Kasim, N., Fathi, M.S. (2013). Building information modeling (BIM) application in construction planning. *International Journal of Construction Engineering and Management*, 45, 1-15. https://doi/10.5923/s.ijcem.201309.01.

Latiffi, A. A., Brahim, J., and Fathi, M. S. (2016). Transformation of Malaysian Construction Industry with Building Information Modelling (BIM). *Automation in Construction*, 66(22), 20-28. https://doi/10.1051/matecconf/20166600022

Lu, W. and Li, H. (2011). Building Information Modelling and Changing Construction Practices. *Automation in Construction*, 20(2), 99-106. https://doi/10.1016/j.autcon.2010.09.006

Lee, S., and Ahn, H. (2010). The organizational contexts, controls and implementation of E-business. *The Journal of Computer Information Systems*, 51(1), 114-124.

Lee, S., Yu, J., and Jeong, H. (2013). BIM Acceptance Model in Construction Organizations. *Journal of Management in Engineering*, 31(3), 75-84. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000252

Lee, S. and Yu, J. (2016). Comparative study of BIM acceptance between Korea and the United States. *Journal Construction Engineering Management*, 142(3), 75-87. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001076

Lu, Y., Li, Y., Skibniewski, M., Wu, Z., Wang, R., and Le, Y. (2014). Information and communication technology applications in architecture, engineering, and construction organizations: A 15-year review. *Journal of Management in Engineering*, 31(1), 127-138. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000319

Love, P. E. D., Irahi, Z., Li, H., Cheng, E. W. L. and Tse, R. Y. C. (2001). An empirical analysis of the barriers to implementing e-commerce in small-medium sized construction contractors in the state of Victoria, Australia. *Construction Innovation*, 1(1), 31-41. https://doi.org/10.1108/14714170110814497

Mahalingam, A., Kashyap, R., and Mahajan, C. (2010). An evaluation of the applicability of 4D CAD on construction projects. *Automation in construction*, 19(2), 148-159. https://doi.org/10.1016/j.autcon.2009.11.015

Majid, T.A., M.N.A. Azman, S.A.S Zakaria, A.S. Yahya, S.S. Zaini, M.S.S. Ahamad and M.H. Hanafi (2011). Quantitative Analysis on the Level of IBS Acceptance in Malaysian Construction Industry. *Journal of Engineering Science and Technology*, 6(2), 179-190.

Malhotra, N. K. (2004). *Marketing Research: An Applied Orientation, 4th Edition:* Prentice Hall.

Market Watch (2010). *Malaysian-German Chamber of Commerce – The Construction Sector*.

Masterspec (2013). *New Zealand National BIM Survey 2013*: Construction Information Ltd.

McGraw-Hill (2008). *Construction, Building Information Modelling Trends SmartMarket Report*: McGraw-Hill.

McGraw-Hill (2012). *The business value of BIM for construction in North America: Multi-year trend analysis and user ratings (2007–2012):* McGraw-Hill Construction.

McGraw-Hill Construction (2014). *The Business Value of Building Information Modelling for construction in major global market:* McGraw Hill.

Mendelsohn, R. (1997). The constructability review process: A constructor's perspective. *Journal of Management in Engineering*, 13(3), 158-169. https://doi.org/10.1061/(ASCE)0742-597X(1997)13:3(17)

Mendenhall, W., and Sincich, T. (1989). *A second course in business statistics: regression analysis:* Dellen Publishing.

Michael Newman and Rajiv Sabherwal (1996). Determinants of Commitment to Information Systems Development: A Longitudinal Investigation. *MIS Quarterly*, 20(1), 23-54.
https://doi.org/10.2307/249541

Migilinskas, D., Popov, V., Juocevicius, V., and Ustinovichius, L. (2013). The benefits, obstacles and problems of practical BIM implementation. *Procedia Engineering*, 57, 767-774.
https://doi.org/10.1016/j.proeng.2013.04.097

Mikael Johansson, MattiasRoupé, PetraBosch-Sijtsema (2015). Real-time visualization of building information models (BIM). *Automation in Construction*, 54,69-82.
https://doi.org/10.1016/j.autcon.2015.03.018

Miles, M., B., and Huberman, M, A. (1990). *Qualitative data analysis: a sourcebook of new methods:* Sage Publications.

Mohammed, N., Che Ani, A.I., Rakmat, R.A.O.K. and Yusof, M.A. (2010). Investigation on the causes of variation orders in the construction of building project – A study in the state of Selangor, Malaysia. *Journal of Building Performance*, 1(1), 73-82.

Mohamad, M.I., Nekooie, M.A. and Al-Harthy, A.B.S. (2012). Design changes in residential reinforced concrete buildings: The causes, sources, impacts and preventive measures. *Journal of Construction in Developing Countries*, 17(2), 17-22.

Mohd Nasrun Mohd Nawi, Nazim Baluch, and Ahmad Yusni Bahauddin (2014). Impact of Fragmentation Issue in Construction Industry: An Overview. *MATEC Web of Conference.*

Monteiro, A. and Martins, J.P. (2013). A survey on modelling guidelines for quantity take off-oriented BIM based design. *Automation in Construction*, 35, 238-253.
https://doi.org/10.1016/j.autcon.2013.05.005

M.P. Gallaher, A.C. O'Connor, J.L. Dettbarn Jr., L.T. Gilday (2004). *Cost Analysis of Inadequate Interoperability in the U.S: National* Institute of Standards and Technology.

M. R. Paine K (2013). *Adoption of building information modelling (BIM): an evaluation through a case study of a regional contractor*. Paper presented at 13th International Conference on Construction Applications of Virtual Reality.

M.Saunders, P.Lewis and A.Thornhill (2007). *Research methods for business students, 4th edition:* Prentice Hall.

Mui, L. Y., Abdul Aziz, A. R., Ni, A. C., Yee, W. C., and Lay, W. S (2002). A Survey of Internet Usage in The Malaysian Construction Industry. *Journal of Information Technology in Construction (ITcon)*, 7(2), 172-181.

Murali, S and Soon, Y. W (2007). Causes and effects of delays in Malaysian construction industry. *International Journal of Project Management*, 25(5), 517-526. https://doi.org/10.1016/j.ijproman.2006.11.007

National Institute of Building Sciences (NIBS) (2007). *United States national building information modelling standard, Version 1 – Part 1: Overview, principles, and methodologies.* NIBS.

Newman, M. and Sabherwal, R. (1996). Determinants of commitment to information systems development: A longitudinal investigation. *MIS Quarterly*, 20(1), 23-54. https://doi.org/10.2307/249541

O'Brien, W. J. (2000). Implementation Issues in Project Web Sites: A Practitioner's Viewpoint. *Journal of Management in Engineering*, 16(2), 34-41. https://doi.org/10.1061/(ASCE)0742-597X(2000)16:3(34)

Olatunji, A. O. (2011a). Modelling organizations' structural adjustment to BIM adoption: a pilot study on estimating organisations. *Journal of Information Technology in Construction*, 16, 653-668.

Olatunji, A. O. (2011b). A preliminary review on the legal implications of BIM and model ownership. *Journal of Information Technology in Construction*, 16, 687-696.

Oyewobi, L.O., Ibironke, O.T., Ganiyu, B.O. and Ola-Awo, A.W. (2011). Evaluating rework cost – A study of selected building projects in Niger State, Nigeria. *Journal of Geography and Regional Planning*, 4(3), 147-151.

Ozorhon, B.; Karahan, U. (2017). Critical Success factors of building information modeling implementation. *Journal in Management Engineering*, 18(3), 55-73. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000505

Pallant, J. (2005). *SPSS Survival Manual:* Open University Press.

Palos, S., Kiviniemi, A. and Kuusisto, J. (2014). Future perspectives on product data management in building information modelling. *Construction Innovation*, 16(2), 273-281.

Panuwatwanich, K. and Peansupap, V. (2013). *Factors affecting the current diffusion of BIM: a qualitative study of online professional network.* Paper presented at proceedings of Creative Construction Conference 2013.

Patton, M.Q. (1990). *Qualitative evaluation and research methods (2nd ed.):* Sage Publications.

Pavan Meadati and Javier Irizarry (2010). *BIM-A Knowledge Repository*. Paper presented at the ASC International Proceedings of the Annual Conference.

Peslak A. (2005). The importance of information technology: An empirical and longitudinal study of the annual reports of the 50 largest companies in the United States. *The Journal of Computer Information Systems*, 45(3), 32-42. https://doi/abs/10.1080/08874417.2005.11645841

Petter, S., Straub, D., and Rai, A. (2007). Specifying formative constructs in information systems research. *MIS Quarterly*, 31(4), 623-656. https://doi.org/10.2307/25148814

Premkumar, G., and Roberts, M. (1999). Adoption of New Information Technologies in Rural Small Businesses. *The International Journal of Management Science*, 27(4), 467-484. https://doi.org/10.1016/S0305-0483(98)00071-1

Poston, R. and Grabski, S., (2001) Financial impacts of enterprise resource planning implementations. *International Journal of Accounting Information Systems*, 2(4), 271-294. https://doi.org/10.1016/S1467-0895(01)00024-0

Ramanathan, C., Potty, N.S., Idrus, A.B. (2012). Analysis of time and cost overrun in Malaysian construction. *Advanced Material Research*, 452-453, 1002-1008. https://doi.org/10.4028/www.scientific.net/AMR.452-453.1002

Redmond A., Hore A., Alshawi A. and West R. (2012). Exploring how information exchanges can be enhanced through Cloud BIM. *Automation in Construction*, 24, 175-183. https://doi.org/10.1016/j.autcon.2012.02.003

Rekola M., J. Kojima and T. Makelainen (2010) Toward Integrated Design and Delivery Solutions: Pinpointed Challenges of Process Change. *Architectural Engineering and Design Management*, 4(6), 264-278. https://doi.org/10.3763/aedm.2010.IDDS4

Revit. (2008). *White Paper: The Five Fallacies of BIM:* Autodesk press.

R. Howard, B.-C. Björk (2008). Building information modelling – experts' views on standardisation and industry deployment. *Advanced Engineering Informatics*, 22(2), 271-280. https://doi.org/10.1016/j.aei.2007.03.001

Rodgers, C., Hosseini, M.R., Chileshe, N. and Rameezdeen, R. (2015). *BIM within the Australian Construction Related Small and Medium Sized Enterprises: Awareness, Practices and Drivers.* Paper presented at 31st Annual ARCOM Conference.

Robert Eadie, Henry Odeyinka, Clare McKeown and Sean McNiff (2015). A survey of current status of and perceived changes required for BIM adoption in the UK. *Built Environment Project and Asset Management*, 5(1), 4-21. https://doi.org/10.1108/BEPAM-07-2013-0023

Rogers, E. M. (1995). *Diffusion of Innovations:* New York, Free Press.

Ronald L. Thompson, Christopher A. Higgins and Jane M. Howell (1991). Personal Computing: Toward a Conceptual Model of Utilization. *MIS Quarterly*, 15(1), 125-143.
https://doi.org/10.2307/249443

Ross, V. W. (2010). *Factors influencing the adoption of cloud computing by decision making managers* (Doctoral dissertation).

Ryan Stanley and Derek Thurnel (2014). The Benefits of, and Barriers to, Implementation of 5D BIM for Quantity Surveying in New Zealand. *Australasian Journal of Construction Economics and Building*, 14(1), 105-117.
https://doi.org/10.5130/ajceb.v14i1.3786

Sacks, S., L. Koskela, B.A. Dave and R. Owen (2010) Integration of Lean and Building Information Modeling in Construction. *Journal of Construction Engineering and Management*, 136(9), 125-137.
https://doi.org/10.1061/(ASCE)CO.1943-7862.0000203

Salman Azhar, Malik Khalfan and Tayyab Maqsood (2012). Building Information Modelling (BIM): Now and Beyond. *Australasian Journal of Construction Economics and Building*, 12(4), 15-28.
https://doi.org/10.5130/ajceb.v12i4.3032

Slyke, C. V., Johnson, R. D., Hightower, R., and Elgarah, W. (2008). Implications of researcher assumptions about perceived relative advantage and compatibility. *Database for Advances in Information Systems*, 39(2), 10-26.
https://doi.org/10.1145/1364636.1364642

Smith, D. K (2007). An Introduction to Building Information Modelling (BIM). *Journal of Building Information Modelling*, 27, 33-43.

Smith D.K and Tardiff M. (2009). *Building Information Modelling strategic implementation guide for architects, engineers, constructors and real estate asset managers:* New Jersey: John Wiley & Sons.

Smith, P. (2014). BIM & the 5D Project Cost Manager. *Procedia - Social and Behavioural Sciences*, 119, 475-484.
https://doi.org/10.1016/j.sbspro.2014.03.053

Staub-French, S., and Khanzode, A. (2007). 3D and 4D modeling for design and construction coordination: issues and lessons learned. *Journal of Information Technology in Construction (ITcon)*, 13, 217-228.

Son, H.; Lee, S.; Kim, C. (2015). What drives the adoption of building information modeling in design organizations? An empirical investigation of the antecedents affecting architect's behavioral intentions. *Automation in Construction*, 49, 92-99.
https://doi.org/10.1016/j.autcon.2014.10.012

Song, J.; Migliaccio, G.; Wang, G. and Lu, H. (2017). Exploring the influence of system quality, information quality, and external service on BIM user satisfaction. *Journal of Management Engineering*, 33(6), 192-199. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000549

Sproull, N.L. (1995). *Handbook of research methods: A guide for practitioners and students in social sciences, 2nd edition:* The Scarecrow Press.

Stewart R.A., Mohamed, S. and Daet, R. (2002). Strategic implementation of IT/IS projects in construction: a case study. *Automation in Construction*, 11(6), 681-694. https://doi.org/10.1016/S0926-5805(02)00009-2

Straub, D. W. (1989). Validating instruments in MIS research. *MIS Quarterly*, 13(2), 147-169. https://doi.org/10.2307/248922

Strauss, A., and Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques:* Sage Publications.

Succar, B. (2010). Building information modelling framework: A research and delivery foundation for industry stakeholders. *Automation in Construction*, 18(3), 357-375. https://doi.org/10.1016/j.autcon.2008.10.003

Succar, B. (2014). *Handbook of Research on Building Information Modelling and Construction Informatics: Concepts and Technologies*. IGI Publishing.

Suebsin, C. and N. Gerdsri (2009). *Key Factors Driving the Success of Technology Adoption: Case Examples of ERP Adoption.* Paper presented at PICMET 2009 Proceedings.

Sulankivi, K., Kähkönen, K., Mäkelä, T. and Kiviniemi, M. (2010). *4D-BIM for Construction Safety Planning*. Paper presented at CIB World Congress Conference 2010.

Sulankivi, K., Zhang, S., Teizer, J., Eastman, C., Kiviniemi, M., Romo, I., and Granholm, L. (2013). *Utilization of BIM-based Automated Safety Checking in Construction Planning.* Paper presented at CIB World Congress Conference 2013.

Tabachnick, B.G., and Fidell, L.S. (2007). *Using multivariate statistics:* Pearson Education, Inc.

Taylor, J.E., and Bernstein, P.G. (2008). Paradigm trajectories of building information modelling practice in project networks. *ASCE Journal of Management in Engineering*, 25(2), 69-78. https://doi.org/10.1061/(ASCE)0742-597X(2009)25:2(69)

Taylor, J.E., and Levitt, R. (2007). Innovation alignment and project network dynamics: An integrative model for change. *Project Management Journal*, 38(3), 22-35. https://doi.org/10.1002/pmj.20003

T. Chuang, B. Lee, and I. Wu (2011). *Applying cloud computing technology to BIM visualization and manipulation*. Paper presented at 28th International Symposium on Automation and Robotics in Construction.

Tenah, K.A. (2001). Project delivery systems for construction: An overview. *Cost Engineering*, 6(2), 10-18.

Thompson, R. L., Higgins, C. A. and Howell, J. M. (1991). Personal computing: Toward a conceptual model of utilization. *MIS Quarterly*, 15(1), 125-143. https://doi.org/10.2307/249443

Thorpe, D. (2003). Online Remote Construction Management trials in Queensland Department of Main Roads: a participant's perspective. *Construction Innovation*, 3(2), 65-79. https://doi.org/10.1108/14714170310814855

Ticehurst, G. W., and Veal, A. J. (2000). *Business research methods: A managerial approach*: Frenchs Forest.

Travaglini A, Radujković M, and Mancini M. (2014). Building Information Modelling (BIM) and project management: a stakeholder's perspective. *International Journal of Organisation Technology Management Construction*, 6 6(2), 1058-1065. https://DOI 10.5592/otmcj.2014.2.8

Tribelsky, E. and Sacks, R. (2010). Measuring information flow in the detailed design of construction projects. *Research in Engineering Design*, 21, 189-206.

Tsikriktsis, N (2004). A technology readiness-based taxonomy of customers a replication and extension. *Journal of Service Research*, 7(1), 208-214. https://doi.org/10.1177/1094670504266132

Tu, Y., Lin, S., and Chang, Y. (2011). Relationships among service quality, customer satisfaction and customer loyalty in chain restaurant. *Information Management and Business Review*, 3(5), 273-282. https://doi.org/10.22610/imbr.v3i5.944

Uma Sekaran (2009). *Research method for business: A skill building approach, 5th edition:* John Wiley & Sons.

Urbach, N., and Ahlemann, F. (2010). Structural Equation Modelling in Information Systems Research Using Partial Least Squares. *Journal of Information Technology Theory and Application*, 11(2), 153-165.

Venkatesh V, and Davis FD (2000). *A Theoretical Extension of the Technology Acceptance Models*: Four Longitudinal Field Studies. Manage. Sci.

Vogt, W. (2007). *Quantitative research methods for professionals:* Pearson.

Wade, M. and J. Hulland (2004). The resource-based view and information systems Research: review, extension, and suggestions for future research. *MIS Quarterly*, 28(1), 107-142.
https://doi.org/10.2307/25148626

Waleed, A.M.T., Lee Wah Peng, M.R.A. Kadir, Mohd. Saleh Jaafar and Mohd. Sapuan Salit (2003). *The essential characteristics of industrialized building system*. Paper presented at International Conference on Industrialised Building Systems.

Wang, Y. (2000) Coordination issues in Chinese large building projects. *Journal of Management in Engineering*, 16(6), 54-60.
https://doi.org/10.1061/(ASCE)0742-597X(2000)16:6(54)

Weiner, B. J. (2009). A theory of organizational readiness for change. *Implement Science*, 4(1), 67-76.
https://doi/10.1186/1748-5908-4-67

Won, J., Lee, G., Dossick, C., and Messner, J. (2013). Where to focus for successful adoption of building information modelling within organizations. *Journal of Construction Engineering and Management*, 139(11), 267-276.
https://doi.org/10.1061/(ASCE)CO.1943-7862.0000731

Wu, I. and S. H. Hsieh (2012). A framework for facilitating multi-dimensional information integration, management and visualization in engineering projects. *Automation in Construction*, 23, 71-86.
https://doi.org/10.1016/j.autcon.2011.12.010

Wu, W., and Issa, R. R. A. (2014). BIM Education and Recruiting: Survey-Based Comparative Analysis of Issues, Perceptions, and Collaboration Opportunities. *Journal of Professional Issues in Engineering Education and Practice*, 140(2), 171-186.
https://doi.org/10.1061/(ASCE)EI.1943-5541.0000186

Xu, H.; Feng, J., and Li, S. (2014). Users-orientated evaluation of building information model in the Chinese construction industry. *Automation in Construction*, 39, 32-46.
https://doi.org/10.1016/j.autcon.2013.12.004

Yaxin Wang, Xiaolong Xue and Yan Li (2013). A Critical Review on the Impact Factors of BIM Application. *International Journal of Digital Content Technology and its Applications*, 90, 183-201.
https://doi/10.1016/j.advengsoft.2015.08.009

Yeliz Tulubas Gokuc and Julide Bozoglu (2015). *The Factors Affecting the Acceptance of BIM Software Tools.* Paper presented at Green Age Symposium III.

Yin, R.K. (2009). *Case study research: Design and methods (4th ed.):* Sage Publications.

Yong Han Ahn, Young Hoon Kwak, and Sung Joon Su (2015). Contractor's Transformation Strategies for Adopting Building Information Modelling. *Journal of Management in Engineering*, 32(1), 83-101. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000390

Zhang, C., and Dhaliwal, J. (2009). An investigation of resource-based and institutional theoretic factors in technology adoption for operations and supply chain management. *International Journal of Production Economics*, 120(1), 252-269. https://doi.org/10.1016/j.ijpe.2008.07.023

Zikmund, W. G. (2003). *Sample designs and sampling procedures', Business Research Methods, 7th ed.* Ohio: South-Western Thomson

Zorn, T., Flanagin, A., and Shoham, M. D. (2011). Institutional and noninstitutional influences on information and communication technology adoption and use among non-profit organizations. *Human Communication Research*, 37(1), 1-33. https://doi.org/10.1111/j.1468-2958.2010.01387.x

LIST OF PUBLICATIONS AND PRESENTATIONS

PUBLISH

Zahrizan, Z., Nasly, M.A, Haron, A.T., Marshall-Ponting, A.J., and Hamid, Z.A. (2012). *The Potential of implementing Building Information Modelling (BIM) in Malaysian Construction Industry: An Exploratory Study*. Paper presented at National Conference for Postgraduate Research.

Zahrizan, Z., Nasly, M.A, Haron, A.T., Marshall-Ponting, A.J., and Hamid, Z.A. (2012). An Exploratory Study on the Potential of Implementing Building Information Modelling (BIM) in the Malaysian Construction Industry: Lesson Learnt from Singapore and Hong Kong Construction Industry. International *Journal of Civil Engineering & Geo-Environment.*

Zahrizan, Z., Nasly, M.A, Haron, A.T., Marshall-Ponting, A.J., and Hamid, Z.A. (2013). Exploring the Adoption of Building Information Modelling (BIM) in the Malaysian Construction Industry: A Qualitative Approach. *International Journal of Research in Engineering and Technology.*

Zahrizan, Z., Nasly, M.A, Haron, A.T., Marshall-Ponting, A.J., and Hamid, Z.A. (2014). Exploring the Barriers and Driven Factors in Implementing Building Information Modelling (BIM) in the Malaysian construction industry: A Preliminary Study. *Journal of the Institution of Engineers, Malaysia.*

Haron, A.T., Marshall-Ponting, A.J., Zakaria Z., Kamar, K.A.M., and Hamid, Z.A. (2015). An industrial report on the Malaysian building information modelling (BIM) taskforce: issues and recommendations. *Malaysian Construction Research Journal.*

Hamada, Hussein, Haron, Ahmad, Zakaria, Zahrizan and Humada, Ali Mahmood. (2016). Benefits and Barriers of BIM Adoption in the Iraqi Construction Firms. *International Journal of Innovative Research in Advanced Engineering (IJIRAE).*

Hamada, Hussein, Haron, Ahmad, Zakaria, Zahrizan and Humada, Ali Mahmood. (2017). *Factor Affecting of BIM Technique in the Construction Firms in Iraq.* Presented at International Symposium on Civil and Environmental Engineering 2016 (ISCEE 2016).

UNPUBLISH

Zahrizan, Z. (2013). *The Implementation of BIM: The Importance of People, Organisation and Technology to the success of the Strategic BIM Implementation Plan (SBIP)* presented at BIM AWARENESS FOR MALAYSIAN CONSTRUCTION INDUSTRY Seminar organise by Unit Kerjasama Antara Swasta (UKAS), Jabatan Perdana Menteri di Dewan Pameran, Menara Usahawan. (07 February 2013) (Presenter)

Zahrizan, Z. (2014). *Business Value in Implementing Building Information Modelling (BIM) for Contractors* presented at Seminar & Workshop: Contractor's Acceptance of Building Information Modelling (BIM) Towards Improvement of Project Performance and Profitability at Cyberview Lodge Resort and Spa, Cyberjaya. (25 February 2014) (Presenter)

APPENDICES

APPENDIX A:

INTERVIEWING PROTOCOL FOR VALIDATE ADOPTION FACTORS

Faculty of Civil Engineering & Earth Resources
Universiti Malaysia Pahang
Lebuhraya Tun Razak
26300 Gambang
Kuantan, Pahang Darul Makmur

To whom it may concern,

A Study on the Adoption of Building Information Modelling (BIM) in the Malaysian Construction Industry from the perspective of Civil & Structurer Firms

Dear Datuk / Datin / Prof. / Associate Prof. / Dr / Ir / Mr. / Mrs.

Refer to above mention, I, Zahrizan Bin Zakaria a PhD student at Universiti Malaysia Pahang (UMP) currently conducting a research in the Adoption of Building Information Modelling (BIM) in the Malaysian Construction Industry from the perspective of Civil & Structurer Firms under supervision of Dr Ahmad Tarmizi Haron from University Malaysia Pahang I would like to take this opportunity to invite Datuk / Datin / Prof. / Associate Prof. / Dr / Ir / Mr. / Mrs. to participate in this interview. This interview purposely to;

i. Identity the current BIM practices in Malaysia.
ii. Identity challenges facing during the adoption of BIM.
iii. To validate the theoretical adoption factors.

2. The data collected in this study are confidential, only to be used for academic purposes only and may appear in the PhD dissertation and other related publications such as local and international journal. However, no personal details or details about the organisation will be disclosed. Any data/information collected by the researcher which might identify you and your organisation, either in hardcopy or softcopy formats, will be securely stored for the duration of the research and then safely kept by the supervisor for a period of five years. These can only be assessed by the researchers unless you consent otherwise. To ensure the anonymity of the respondents, this survey tool is utilised to provide anonymous response collection. All data is collected and coded such that your name and your email are not associated with them.

3. There are no known or anticipated risks in this study; however, you can choose not to answer any question that makes you uncomfortable.

4. If desired, you could receive a summary of the investigation's findings upon completion of the research.

5. Participation in this study is voluntary and you can withdraw and you may skip any questions if you do not want to answer them.

We would be happy to answer any questions that may arise concerning the study. Please direct your questions or comments to: zahrizan@ump.edu.my

Many thanks for your consideration for the participation in this research project.

Zahrizan Hj Zakaria
PhD Student
Tel: +6013-622 3983
Tel: +609-549 2999 ext 3007
zahrizan@ump.edu.my

THE INTERVIEW QUESTIONS.

1. BACKGROUND OF THE COMPANY

1.1 What type of business is your company involved in?

1.2 What is the current number of employees in your company?

2. CURRENT STATUS OF BIM IMPLEMENTATION

2.2 What is the motivation of your organisation to use BIM on your projects?

2.3 Could you explain the benefits of BIM?

2.4 From your point of view what are the main obstacles to implement BIM successfully in the Malaysian construction industry internally and externally?

2.5 Currently what stage has BIM been implemented within the company?

3. VALIDATION OF BIM ADOPTION FACTORS

3.1 ORGANISATIONAL CONTEXT

3.1.1 Are supports from top management important for adopting BIM? Why there is the belief that by having managing support could ease the adoption of BIM?

3.1.2 Changing the working process is challenging, and could change the working environment within company. In your opinion what are the important criteria of the work environment in the organisation to support the adoption of BIM?

3.1.3 Is it true, to expedite the adoption of BIM is top down approach where client or government enforce the used of BIM in their project?

3.1.4 Did your organisation develop a BIM implementation plan? What are the main elements in that plan and how did your organisation develop the plan? How important this plan for your organisation?

3.1.5 Based on your experience, is it BIM suitable only for consultants?

3.2 *PEOPLE CONTEXT*

3.2.1 Can you share your experience and the reaction of the personnel when your organisation intended to implement BIM and does it affect job stability?

3.2.2 Based on your opinion, what can you comment about the belief that training will help reduce user resistance to embrace BIM? How was the training conducted (i.e; Internal/external, Group, individual, frequency, length)?

3.2.3 How did your organisation identify and access the competency of your personnel or new employees to fill in the new posts?

3.2.4 As we know BIM is a new approach to design, some people find BIM transformation is challenging. To ensure the smooth transition is it compulsory to have an expert group to assist the adoption of BIM?

3.2.5 Due to implement BIM, did your organisation create new posts (i.e; BIM Project Manager, BIM Champion (External BIM Implementation Advisor), BIM Coordinator, BIM Integrator, BIM Manager, BIM Technician and BIM Modeller)? If, yes can you explain more details? What are the names, the roles and the responsibilities of the new posts? Why these posts are important?

3.3 *TECHNOLOGICAL CONTEXT*

3.3.1 Did the BIM implementation cause changes to current hardware and infrastructure? What changes has BIM introduced? Is it cost is the main concern in changes of hardware and infrastructure?

3.3.2 What is the BIM software that your organisation used? Have you experienced any compatibility and interoperability issues when sharing with others? How your organisation dealt with this issue and how did you control the risks?

3.3.3 What do you think about the belief that employees will either accept or reject a new information technology especially BIM technology based on whether they find the new technology to be easy or hard to use?

3.3.4 How did the company select the BIM software and is there any criteria were used for the selection (i.e; interoperability, compatibility and complexity)? Why these criteria important? What are the strategies used in selecting the right software?

APPENDIX B:

DEPLOYMENT OF SURVEY QUESTIONNAIRE TO ACCESS THE ADOPTION MODEL

Faculty of Civil Engineering & Earth Resources
Universiti Malaysia Pahang
Lebuhraya Tun Razak
26300 Gambang
Kuantan, Pahang Darul Makmur

To whom it may concern,

A Study on the Adoption of Building Information Modelling (BIM) in the Malaysian Construction Industry from the perspective of Civil & Structurer Firms

Dear Datuk / Datin / Prof. / Associate Prof. / Dr / Ir / Mr. / Mrs.

Refer to above mention, I, Zahrizan Bin Zakaria a PhD student at Universiti Malaysia Pahang (UMP) currently conducting a research in the Adoption of Building Information Modelling (BIM) in the Malaysian Construction Industry from the perspective of Civil & Structurer Firms under supervision of Dr Ahmad Tarmizi Haron from University Malaysia Pahang. As part of the PhD program, we are interested in your opinions about BIM adoption factors; therefore, you are invited to participate in this research by answering the questionnaire form attached.

2. The data collected in this study are confidential, only to be used for academic purposes only and may appear in the PhD dissertation and other related publications such as local and international journal. However, no personal details or details about the organisation will be disclosed. Any data/information collected by the researcher which might identify you and your organisation, either in hardcopy or softcopy formats, will be securely stored for the duration of the research and then safely kept by the supervisor for a period of five years. These can only be assessed by the researchers unless you consent otherwise. To ensure the anonymity of the respondents, this survey tool is utilised to provide anonymous response collection. All data is collected and coded such that your name and your email are not associated with them.

3. There are no known or anticipated risks in this study; however, you can choose not to answer any question that makes you uncomfortable.

4. If desired, you could receive a summary of the investigation's findings upon completion of the research.

5. Participation in this study is voluntary and you can withdraw and you may skip any questions if you do not want to answer them.

We would be happy to answer any questions that may arise concerning the study. Please direct your questions or comments to: zahrizan@ump.edu.my

Many thanks for your consideration for the participation in this research project.

Zahrizan Hj Zakaria
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Tel: +6013-622 3983
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BUILDING INFORMATION MODELLING (BIM) ADOPTION SURVEY

SECTION A: GENERAL BACKGROUND

This section aims to understand the respondents' profile and information. Please tick with 'x' in the box for each question.

1. Your current position.

☐ Principal ☐ Senior Engineer ☐ Engineer ☐ Other

2. How many years you have been in this industry?

☐ More than 10 years ☐ 5 – 10 years ☐ Less than 5 years

3. Do you have knowledge about Building Information Modelling (BIM)?

☐ Yes ☐ No

4. Do you have any experience involved with project using Building Information Modelling (BIM) previously?

☐ Yes ☐ No

SECTION B: ORGANISATIONAL CONTEXT

This section aims to understand the factors of organisational that could influence the pace of BIM adoption. Please indicate with 'x' in the right column after the statement, to state you agree or disagree with each of the following statements;

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

NO	ITEMS	1	2	3	4	5
QO1	Sufficient support from top management could enhance the adoption of BIM.					
QO2	Adequate allocation of resources for attending training by the top management could increase the pace of BIM adoption.					
QO3	The organisation that provides tangible rewards such as bonus, promotion, etc. to their staffs who are capable to operate BIM application could increase the pace of BIM adoption.					
QO4	Motivation and encouragement from the top management to use and learn about BIM could enhance the adoption of BIM.					
QO5	To adopt BIM, an organisation needs a clear workflow process plan on the use of BIM application with within organisation.					
QO6	To adopt BIM, an organisation required a new business plan that provides a collaborative framework.					
QO7	To adopt BIM, an organisation needs a clear workflow process plan on the use of BIM application with another organisation.					
QO8	An organisation could increase their pace of adoption BIM when their competitors have adopted BIM and being perceived favourably by the clients.					
QO9	An organisation would start adopting BIM when their clients insist on adopting BIM in the near future.					

QO10	An organisation would start adopting BIM when the government enforces to use BIM in their projects.					
QO11	The knowledge sharing attitude among staffs is one of the elements that could ease the adoption process.					
QO12	Organisations that support and motivate their staffs to create new ideas or inventions are easy to adopt BIM.					
QO13	Organisations that are willing to hear the suggestion from the operational level of improvement the current practices are easy to adopt BIM.					

SECTION C: PEOPLE CONTEXT

This section aims to understand the factors of people that could influence the pace of BIM adoption. Please indicate with 'x' in the right column after the statement, to state you agree or disagree with each of the following statements;

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

NO	ITEMS	1	2	3	4	5
QP1	Training on BIM application by the users could increase the pace of BIM adoption.					
QP2	In the process of adopting BIM, training has been most effective when done internally as opposed to externally.					
QP3	Adequate training on the use of BIM technology could speed up the BIM adoption.					
QP4	It is important to have previous experience in the use of CAD application in order to effectively use BIM technology and could increase the pace of BIM adoption.					
QP5	Having staffs that have experience in the use of BIM technology could ease the adoption process.					
QP6	To effective use of BIM technology, it is vital to have practical experience in both design and construction knowledge as compared to have CAD skills alone.					

QP7	To ease the adoption of BIM, it is important to have a team with BIM capability.					
QP8	Support from the BIM technical support team is a vital to ensure the success of BIM adoption.					
QP9	To increase the pace of adoption it is essential to create alliances with organisations that have the BIM experience and competency.					
QP10	Uneven capabilities of the participating teams on the use of BIM technology could create problems during the process of BIM adoption.					
QP11	Creating new roles such as BIM Manager, BIM Coordinator, BIM Technologist and BIM Modeller could facilitate the adoption process.					
QP12	Having a clearly defined responsibilities for new roles in the BIM workflow could increase the pace of BIM adoption.					
QP13	By empowering new roles such as BIM Manager, BIM Coordinator, BIM Technologist and BIM Modeller could ease the adoption process.					

SECTION D: TECHNOLOGICAL CONTEXT

This section aims to understand the factors of technology that could influence the pace of BIM adoption. Please indicate with ‘x’ in the right column after the statement, to state you agree or disagree with each of the following statements;

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

NO	ITEMS	1	2	3	4	5
QT1	BIM software must be compatible with existing work processes to ensure the adoption of BIM success.					

QT2	BIM software that is compatible with existing hardware is important in the process of BIM adoption.					
QT3	BIM software that is compatible with existing software is vital to ease the process of BIM adoption.					
QT4	The complexity of BIM software applications prohibits increased BIM adaptation.					
QT5	The complexity of BIM software contributes to long learning curve and resulting in the increasing cost of training and could hinder the adaptation.					
QT6	The similarity of the user graphic interface (GUI) of BIM software with existing software could ease the adoption process.					
QT7	Interoperability is important in order to enhance the use of BIM technology.					
QT8	To solve interoperability issues and to increase the adoption of BIM, using the same BIM software family is one of the approaches.					
QT9	Mandating the selected BIM software by the clients could minimise the interoperability issues and able to increase the adoption of BIM.					
QT10	High cost to set up the hardware in adopting BIM is one of the issues hinders the BIM adoption.					
QT11	High cost in purchasing the BIM software is one of the issues hinders the BIM adoption.					
QT12	Difficult to justify the cost and benefits of BIM technology is one of the factors impended the pace of BIM adoption.					

SECTION E: INTEREST TO ADOPT BIM

This section aims to understand the factors the intention to adopt BIM. Please indicate with 'x' in the right column after the statement, to state you agree or disagree with each of the following statements;

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

NO	ITEMS	1	2	3	4	5
QT1	Our organisation will adopt BIM.					
QT2	It is likely that our organization will take steps to adopt BIM in the near future.					
QT3	I feel comfortable to adopt BIM.					
QT4	I adopt BIM because, it can strengthen our organisation's reputation.					
QT5	I adopt BIM because, it can maintain our business resiliency in the face of a constantly changing risk environment.					
QT6	I adopt BIM because it can improve our service to our clients.					

APPENDIX C:

RESULT OF CRONBACH's ALPHA FOR PILOT TESTING

Reliability
Scale: O1

Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded[a]	0	.0
	Total	30	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.816	.820	4

Item Statistics

	Mean	Std. Deviation	N
QO1	4.2667	.69149	30
QO2	3.8333	.94989	30
QO3	4.0667	.73968	30
QO4	4.0000	.69481	30

Reliability
Scale: O2

Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded[a]	0	.0
	Total	30	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.804	.815	3

Item Statistics

	Mean	Std. Deviation	N
QO5	4.0333	.55605	30
QO6	3.8667	.68145	30
QO7	4.0667	.44978	30

Reliability
Scale: O3

Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded[a]	0	.0
	Total	30	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.834	.833	3

Item Statistics

	Mean	Std. Deviation	N
QO8	3.9667	.71840	30
QO9	3.8667	.86037	30
QO10	4.1333	.73030	30

Reliability
Scale: O4

Case Processing Summary

	N	%

		N	%
Cases	Valid	30	100.0
	Excluded[a]	0	.0
	Total	30	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.900	.904	3

Item Statistics

	Mean	Std. Deviation	N
QO11	4.1667	.69893	30
QO12	4.1000	.71197	30
QO13	4.1000	.60743	30

Reliability
Scale: P1

Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded[a]	0	.0
	Total	30	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.837	.840	3

Item Statistics

	Mean	Std. Deviation	N
QP1	4.1667	.64772	30

QP2	3.8667	.77608	30
QP3	3.9333	.73968	30

Reliability
Scale: P2

Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded[a]	0	.0
	Total	30	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.843	.844	3

Item Statistics

	Mean	Std. Deviation	N
QP4	4.2667	.58329	30
QP5	4.1667	.59209	30
QP6	4.1333	.57135	30

Reliability
Scale: P3

Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded[a]	0	.0
	Total	30	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.858	.858	4

Item Statistics

	Mean	Std. Deviation	N
QP7	4.2000	.80516	30
QP8	4.1667	.74664	30
QP9	3.9667	.76489	30
QP10	3.7333	.78492	30

Reliability
Scale: P4

Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded[a]	0	.0
	Total	30	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.766	.778	3

Item Statistics

	Mean	Std. Deviation	N
QP11	4.0333	.61495	30
QP12	4.0667	.58329	30
QP13	3.9333	.73968	30

Reliability
Scale: T1

Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded[a]	0	.0
	Total	30	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.794	.803	3

Item Statistics

	Mean	Std. Deviation	N
QT1	4.0667	.63968	30
QT2	4.0000	.74278	30
QT3	4.1000	.66176	30

Reliability Scale: T2

Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded[a]	0	.0
	Total	30	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.649	.654	3

Item Statistics

	Mean	Std. Deviation	N
QT4	3.7333	.78492	30
QT5	3.9667	.71840	30
QT6	3.8000	.76112	30

Reliability
Scale: T3

Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded[a]	0	.0
	Total	30	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.808	.811	3

Item Statistics

	Mean	Std. Deviation	N
QT7	3.8000	.80516	30
QT8	4.0000	.58722	30
QT9	3.9000	.71197	30

Reliability
Scale: T4

Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded[a]	0	.0
	Total	30	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.769	.768	3

Item Statistics

	Mean	Std. Deviation	N
QT10	4.0333	.66868	30
QT11	3.9333	.52083	30
QT12	4.0667	.58329	30

Reliability
Scale: INT_TO_ADOPT

Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded[a]	0	.0
	Total	30	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.695	.698	6

Item Statistics

	Mean	Std. Deviation	N
QD1	3.7667	.62606	30
QD2	3.9333	.69149	30
QD3	3.8667	.50742	30

QD4	3.8667	.50742	30
QD5	3.9333	.52083	30
QD6	3.8333	.46113	30

APPENDIX D:

NORMALITY TEST

Explore

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
O1	152	100.0%	0	0.0%	152	100.0%
O2	152	100.0%	0	0.0%	152	100.0%
O3	152	100.0%	0	0.0%	152	100.0%
O4	152	100.0%	0	0.0%	152	100.0%

Descriptive

			Statistic	Std. Error
O1	Mean		4.3289	.04177
	95% Confidence Interval for Mean	Lower Bound	4.2464	
		Upper Bound	4.4115	
	5% Trimmed Mean		4.3607	
	Median		4.2500	
	Variance		.265	
	Std. Deviation		.51502	
	Minimum		3.00	
	Maximum		5.00	
	Range		2.00	
	Interquartile Range		.75	
	Skewness		-.580	.197
	Kurtosis		-.066	.391
O2	Mean		4.2741	.04245
	95% Confidence Interval for Mean	Lower Bound	4.1903	
		Upper Bound	4.3580	
	5% Trimmed Mean		4.2909	
	Median		4.0000	
	Variance		.274	
	Std. Deviation		.52334	
	Minimum		3.00	
	Maximum		5.00	
	Range		2.00	

	Interquartile Range		.67	
	Skewness		-.034	.197
	Kurtosis		-.742	.391
O3	Mean		4.1645	.05151
	95% Confidence Interval for Mean	Lower Bound	4.0627	
		Upper Bound	4.2662	
	5% Trimmed Mean		4.1925	
	Median		4.0000	
	Variance		.403	
	Std. Deviation		.63501	
	Minimum		2.33	
	Maximum		5.00	
	Range		2.67	
	Interquartile Range		1.00	
	Skewness		-.296	.197
	Kurtosis		-.484	.391
O4	Mean		4.1908	.04756
	95% Confidence Interval for Mean	Lower Bound	4.0968	
		Upper Bound	4.2848	
	5% Trimmed Mean		4.2120	
	Median		4.0000	
	Variance		.344	
	Std. Deviation		.58633	
	Minimum		3.00	
	Maximum		5.00	
	Range		2.00	
	Interquartile Range		.67	
	Skewness		-.177	.197
	Kurtosis		-.723	.391

Descriptive

			Statistic	Std. Error
P1	Mean		4.2259	.04216
	95% Confidence Interval for Mean	Lower Bound	4.1426	
		Upper Bound	4.3092	
	5% Trimmed Mean		4.2471	
	Median		4.3333	
	Variance		.270	
	Std. Deviation		.51981	
	Minimum		3.00	

	Maximum		5.00	
	Range		2.00	
	Interquartile Range		.67	
	Skewness		-.214	.197
	Kurtosis		-.184	.391
	Mean		4.1996	.04060
	95% Confidence Interval for Mean	Lower Bound	4.1193	
		Upper Bound	4.2798	
	5% Trimmed Mean		4.2032	
	Median		4.0000	
	Variance		.251	
P2	Std. Deviation		.50057	
	Minimum		3.33	
	Maximum		5.00	
	Range		1.67	
	Interquartile Range		.58	
	Skewness		.140	.197
	Kurtosis		-.717	.391
	Mean		4.2368	.04352
	95% Confidence Interval for Mean	Lower Bound	4.1509	
		Upper Bound	4.3228	
	5% Trimmed Mean		4.2602	
	Median		4.2500	
	Variance		.288	
P3	Std. Deviation		.53657	
	Minimum		3.00	
	Maximum		5.00	
	Range		2.00	
	Interquartile Range		.75	
	Skewness		-.538	.197
	Kurtosis		-.410	.391
	Mean		4.1140	.04445
	95% Confidence Interval for Mean	Lower Bound	4.0262	
		Upper Bound	4.2019	
	5% Trimmed Mean		4.1252	
P4	Median		4.0000	
	Variance		.300	
	Std. Deviation		.54807	
	Minimum		3.00	
	Maximum		5.00	
	Range		2.00	

	Interquartile Range		.92	
	Skewness		.098	.197
	Kurtosis		-.560	.391

Descriptive

			Statistic	Std. Error
T1	Mean		4.2325	.04760
	95% Confidence Interval for Mean	Lower Bound	4.1384	
		Upper Bound	4.3265	
	5% Trimmed Mean		4.2519	
	Median		4.0000	
	Variance		.344	
	Std. Deviation		.58688	
	Minimum		3.00	
	Maximum		5.00	
	Range		2.00	
	Interquartile Range		1.00	
	Skewness		-.060	.197
	Kurtosis		-.929	.391
T2	Mean		4.0833	.04235
	95% Confidence Interval for Mean	Lower Bound	3.9997	
		Upper Bound	4.1670	
	5% Trimmed Mean		4.0926	
	Median		4.0000	
	Variance		.273	
	Std. Deviation		.52214	
	Minimum		3.00	
	Maximum		5.00	
	Range		2.00	
	Interquartile Range		.67	
	Skewness		-.035	.197
	Kurtosis		-.358	.391
T3	Mean		4.0921	.04257
	95% Confidence Interval for Mean	Lower Bound	4.0080	
		Upper Bound	4.1762	
	5% Trimmed Mean		4.1023	
	Median		4.0000	
	Variance		.275	
	Std. Deviation		.52487	
	Minimum		3.00	
	Maximum		5.00	

	Range		2.00	
	Interquartile Range		.67	
	Skewness		-.034	.197
	Kurtosis		-.376	.391
	Mean		4.1711	.04009
	95% Confidence Interval for Mean	Lower Bound	4.0918	
		Upper Bound	4.2503	
	5% Trimmed Mean		4.1862	
	Median		4.0000	
	Variance		.244	
T4	Std. Deviation		.49424	
	Minimum		3.00	
	Maximum		5.00	
	Range		2.00	
	Interquartile Range		.67	
	Skewness		-.267	.197
	Kurtosis		-.142	.391

Case Processing Summary

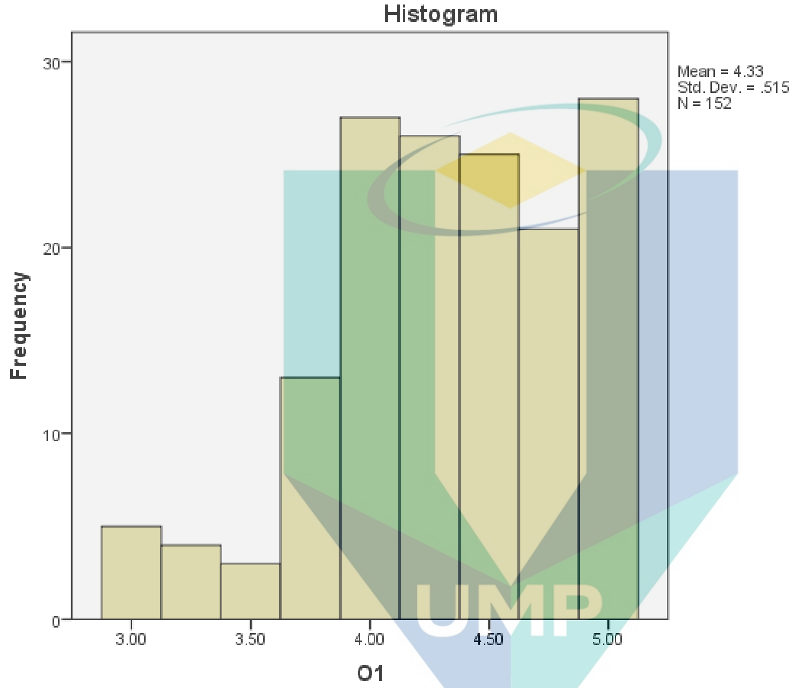
	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
DEC_TO_ADOPT	152	100.0%	0	0.0%	152	100.0%

Descriptive

			Statistic	Std. Error
DEC_TO_ADOPT	Mean		4.0526	.03117
	95% Confidence Interval for Mean	Lower Bound	3.9910	
		Upper Bound	4.1142	
	5% Trimmed Mean		4.0597	
	Median		4.0000	
	Variance		.148	
	Std. Deviation		.38430	
	Minimum		3.17	
	Maximum		4.83	

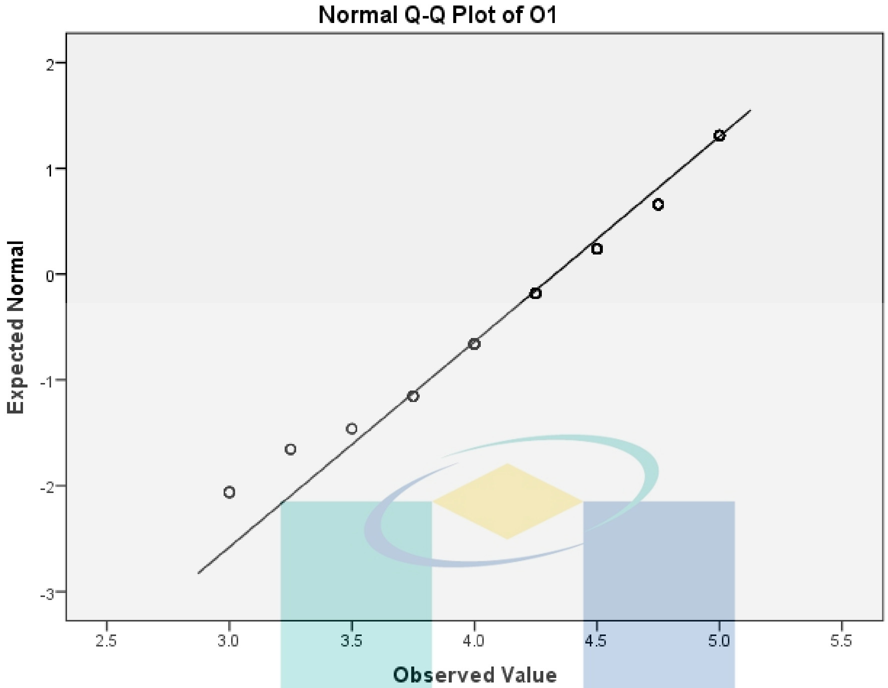
	Range	1.67	
	Interquartile Range	.50	
	Skewness	-.215	.197
	Kurtosis	-.465	.391

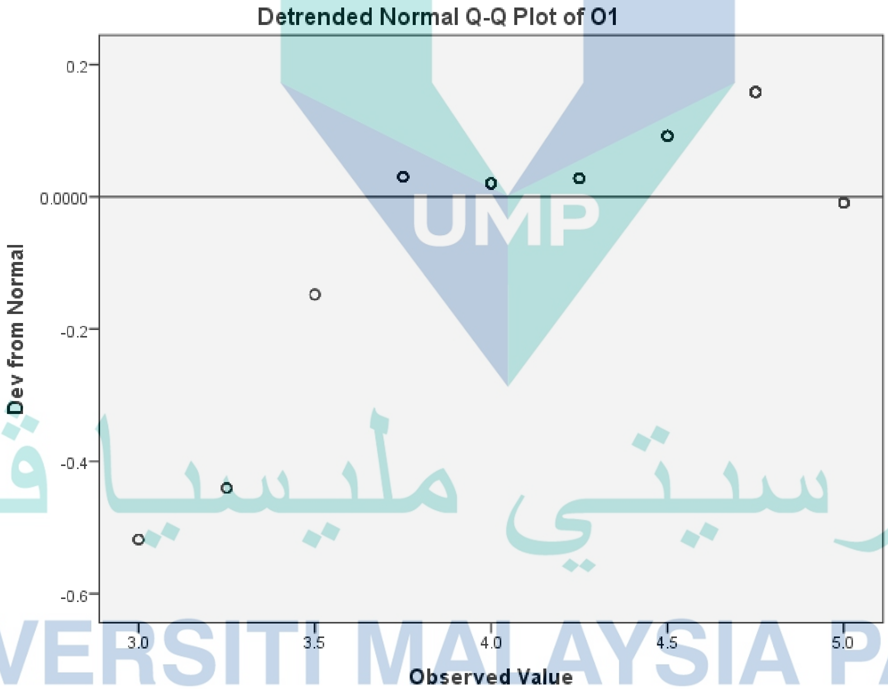
O1

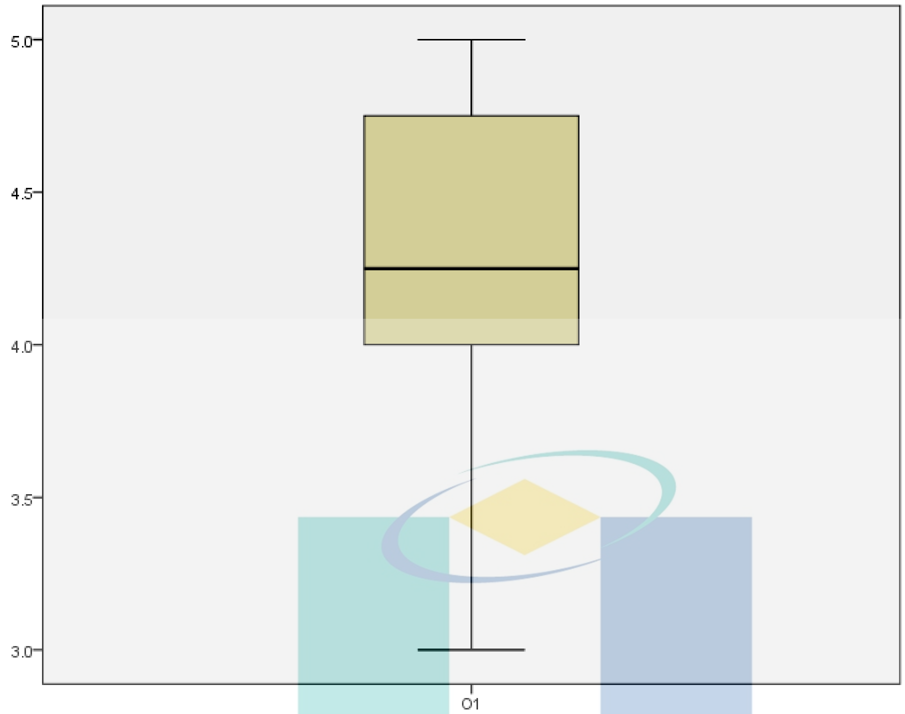


O1 Stem-and-Leaf Plot

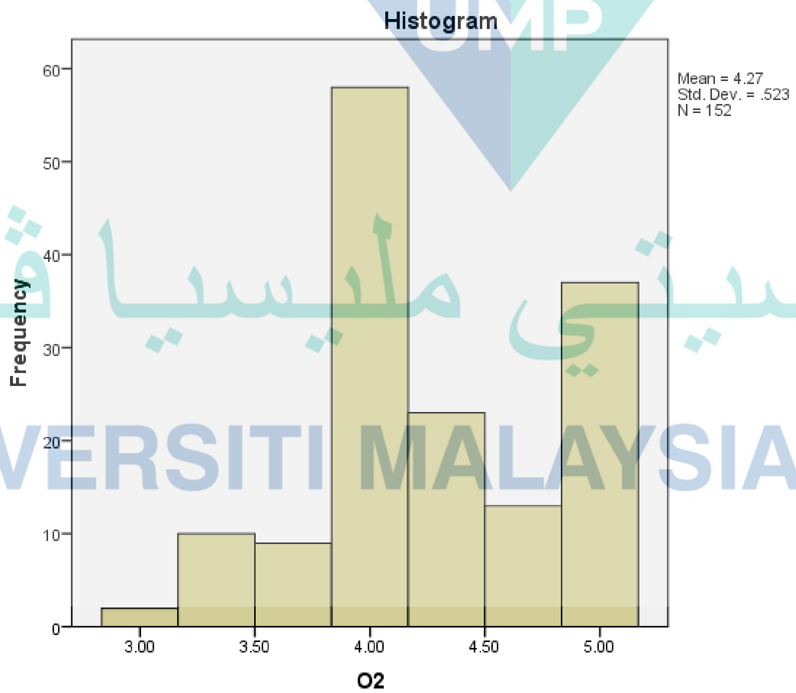
```
 Frequency    Stem &  Leaf

     5.00        3 .  00000
     4.00        3 .  2222
     3.00        3 .  555
    13.00        3 .  7777777777777
      .00        3 .
    27.00        4 .  000000000000000000000000000
    26.00        4 .  22222222222222222222222222
    25.00        4 .  5555555555555555555555555
    21.00        4 .  777777777777777777777
      .00        4 .
    28.00        5 .  0000000000000000000000000000

 Stem width:      1.00
 Each leaf:       1 case(s)
```


Normal Q-Q Plot of O1
Expected Normal
Observed Value
2
1
0
-1
-2
-3
2.5
3.0
3.5
4.0
4.5
5.0
5.5


Detrended Normal Q-Q Plot of O1
Dev from Normal
Observed Value
0.2
0.0000
-0.2
-0.4
-0.6
3.0
3.5
4.0
4.5
5.0



O2



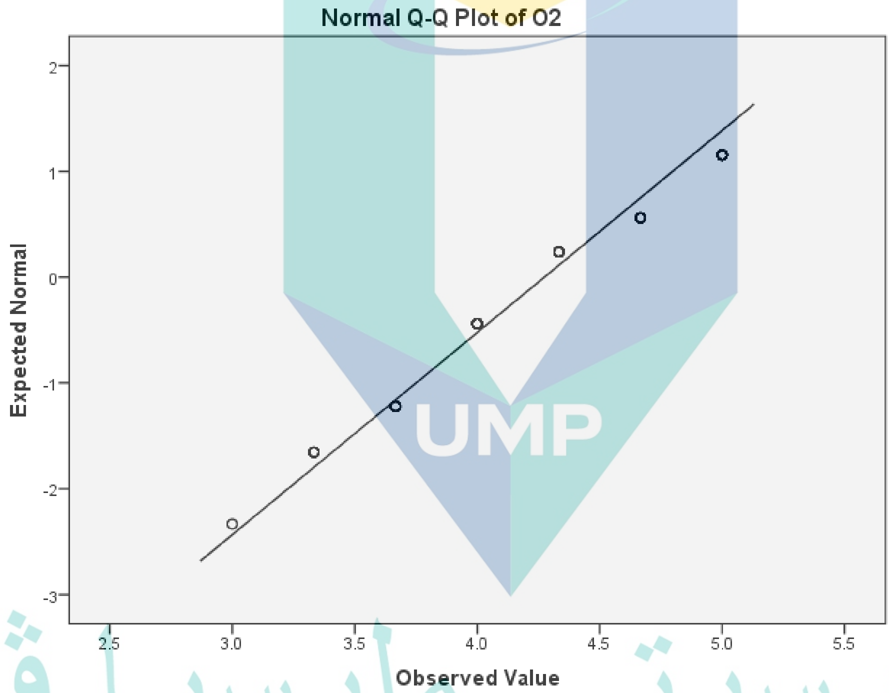
O2 Stem-and-Leaf Plot

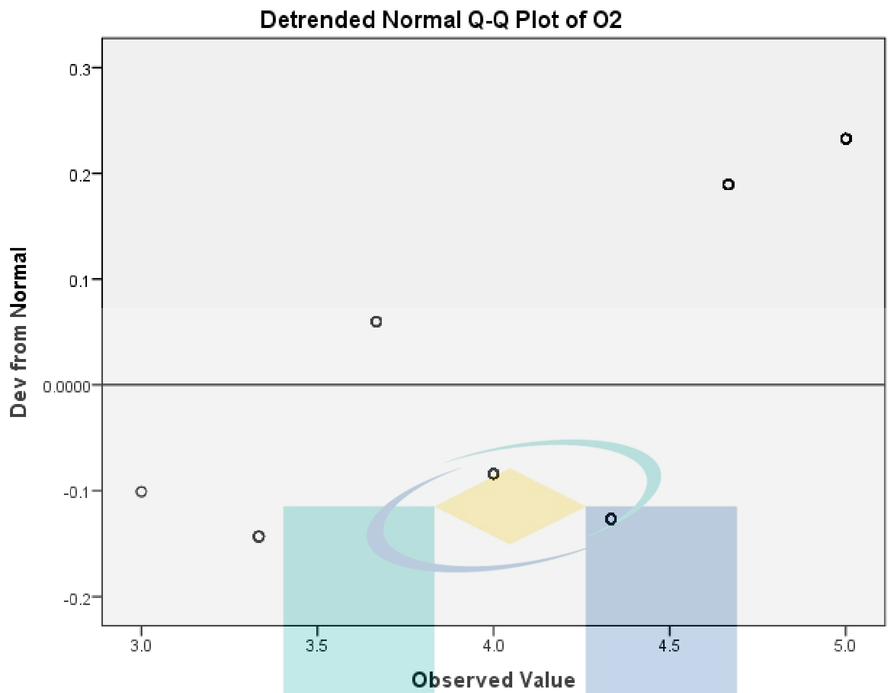
Frequency   Stem & Leaf

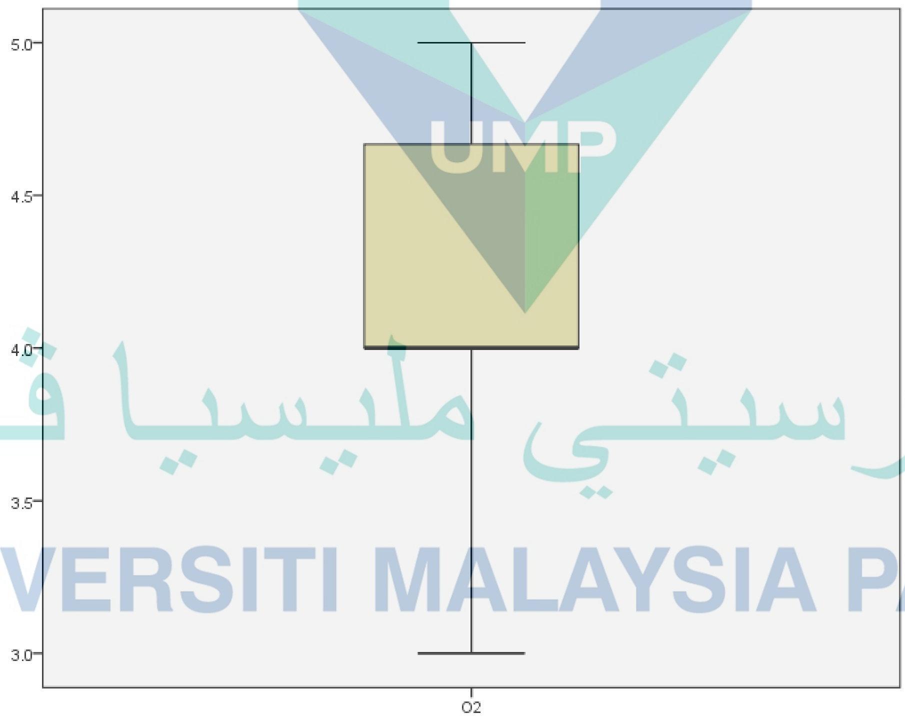
2.00   3 . 00

10.00   3 . 3333333333
.00   3 .
9.00   3 . 666666666
.00   3 .
58.00   4 . 0000000000000000000000000000000000000000000000000000000000
23.00   4 . 33333333333333333333333
.00   4 .
13.00   4 . 6666666666666
.00   4 .
37.00   5 . 0000000000000000000000000000000000000

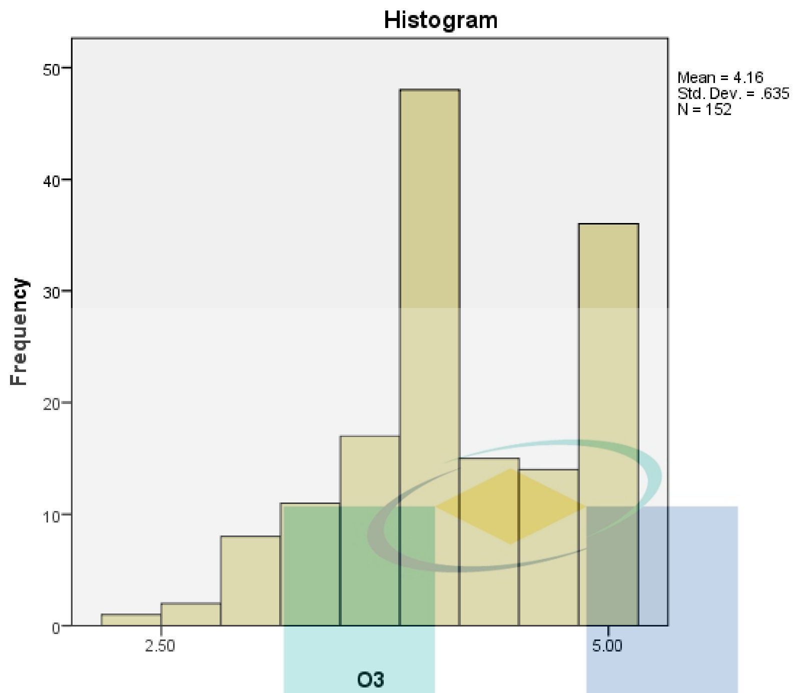
Stem width: 1.00
Each leaf: 1 case(s)




Detrended Normal Q-Q Plot of O2
Dev from Normal
Observed Value
0.3
0.2
0.1
0.0000
-0.1
-0.2
3.0
3.5
4.0
4.5
5.0

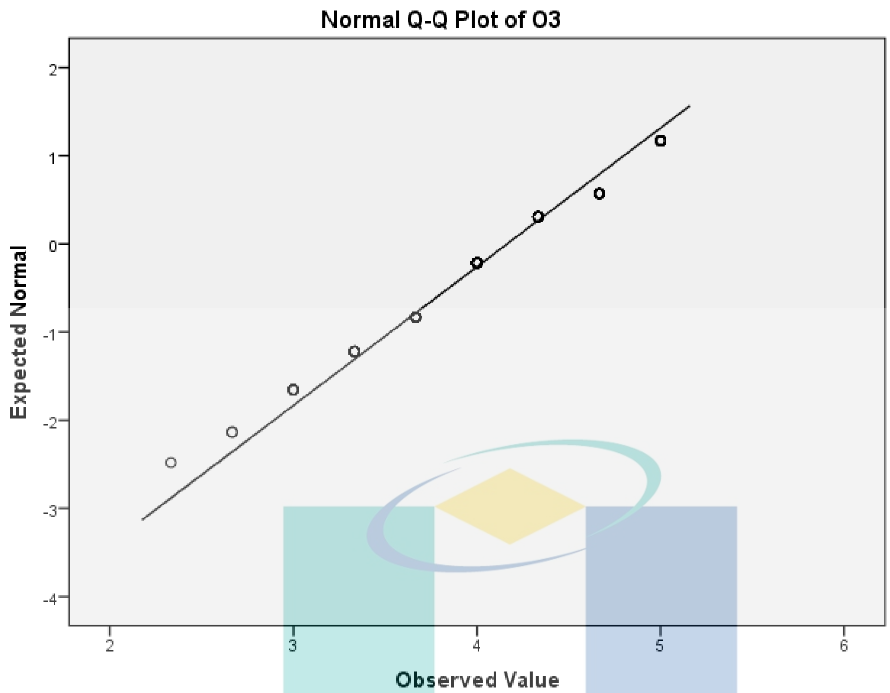

5.0
4.5
4.0
3.5
3.0
O2

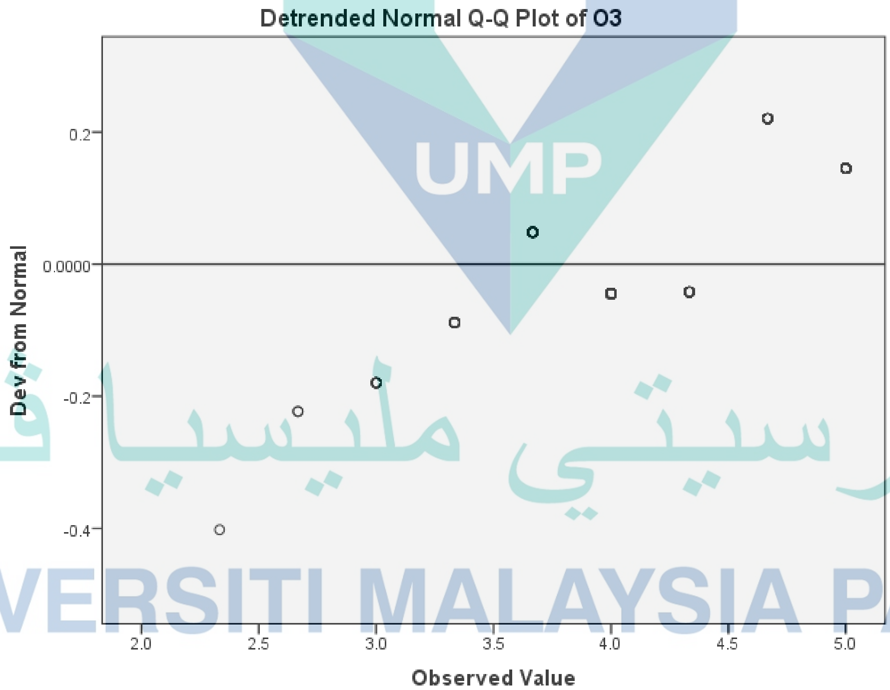
O3

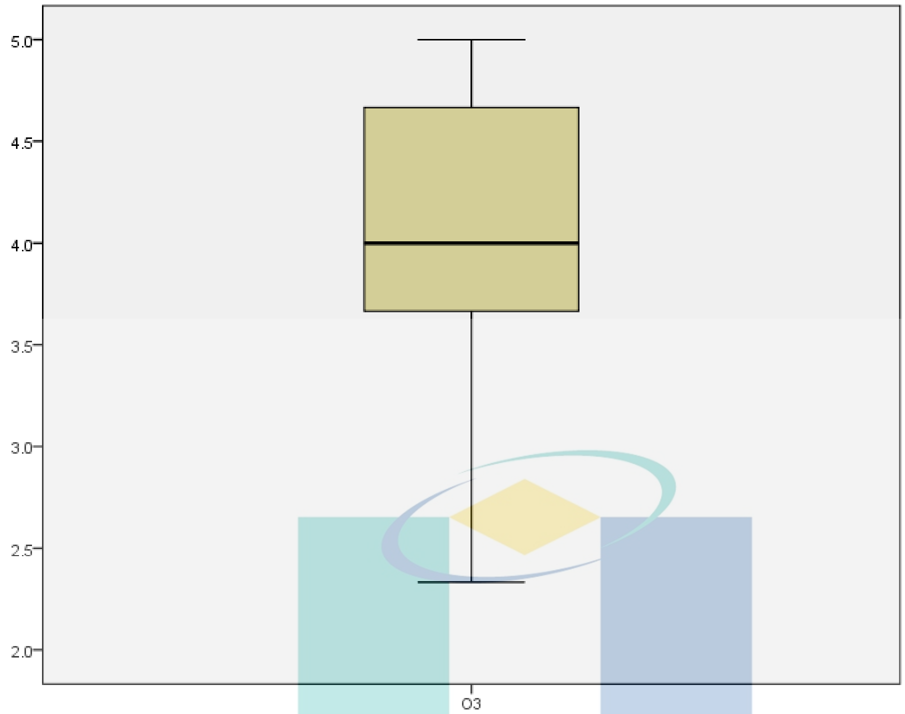


O3 Stem-and-Leaf Plot

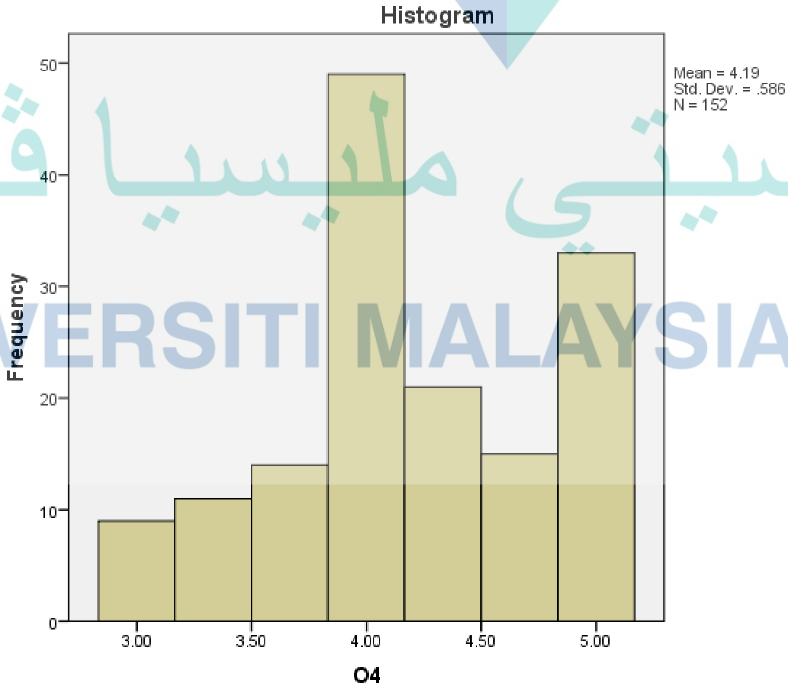
```
 Frequency    Stem &  Leaf

     1.00        2 .  3
      .00        2 .
     2.00        2 .  66
      .00        2 .
     8.00        3 .  00000000
    11.00        3 .  33333333333
      .00        3 .
    17.00        3 .  66666666666666666
      .00        3 .
    48.00        4 .  000000000000000000000000000000000000000000000000
    15.00        4 .  333333333333333
      .00        4 .
    14.00        4 .  66666666666666
      .00        4 .
    36.00        5 .  000000000000000000000000000000000000

 Stem width:      1.00
 Each leaf:       1 case(s)
```


Normal Q-Q Plot of O3
Expected Normal
Observed Value
2
1
0
-1
-2
-3
-4
2
3
4
5
6


Detrended Normal Q-Q Plot of O3
Dev from Normal
Observed Value
0.2
0.0000
-0.2
-0.4
2.0
2.5
3.0
3.5
4.0
4.5
5.0

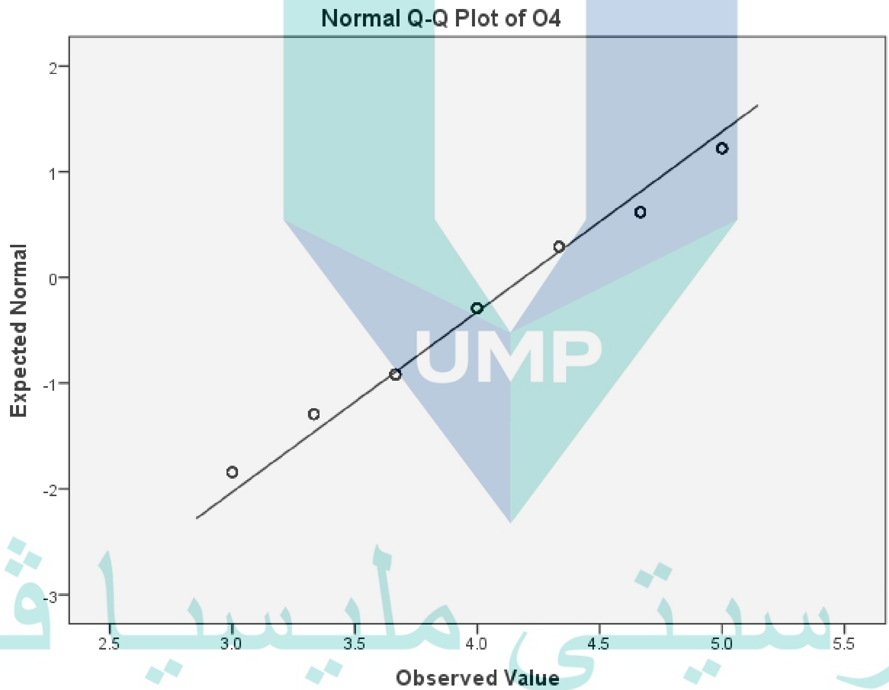


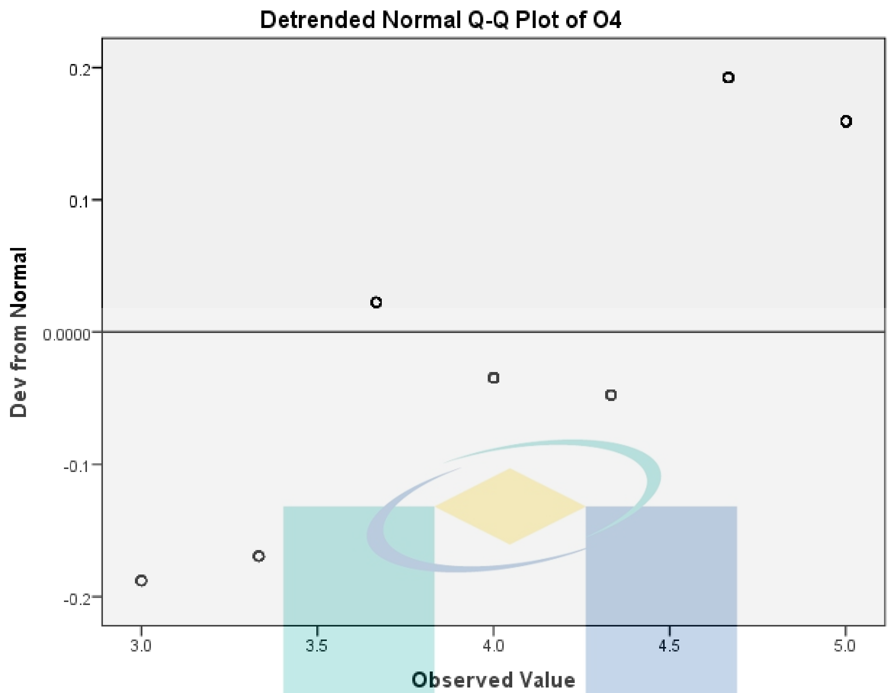
O4

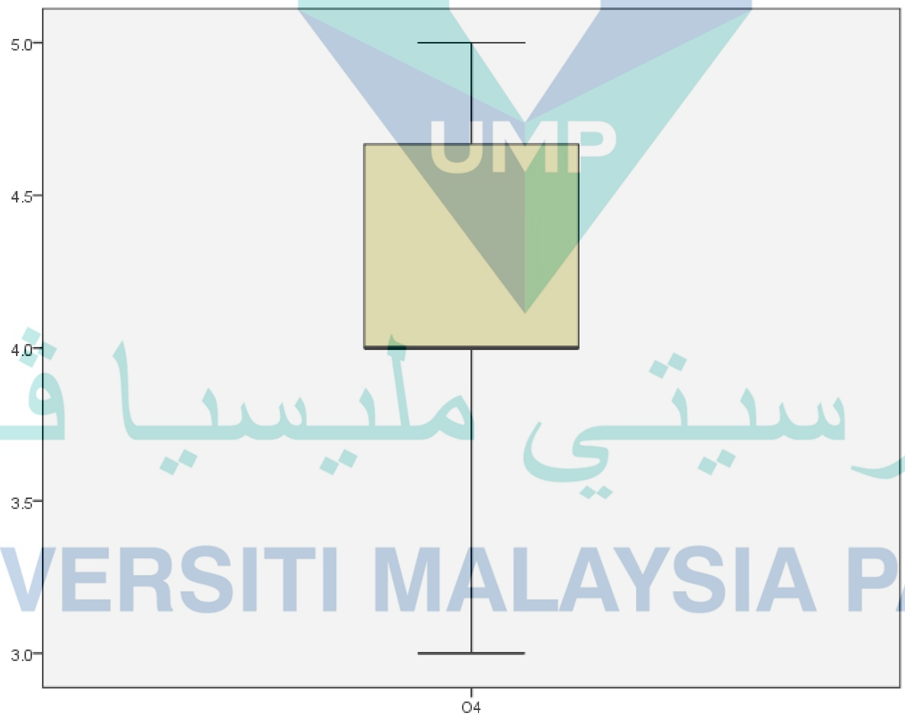


O4 Stem-and-Leaf Plot

```
Frequency    Stem &  Leaf

    9.00        3 .  000000000
   11.00        3 .  33333333333
     .00        3 .
   14.00        3 .  66666666666666
     .00        3 .
   49.00        4 .  0000000000000000000000000000000000000000000000000
   21.00        4 .  333333333333333333333
     .00        4 .
   15.00        4 .  666666666666666
     .00        4 .
   33.00        5 .  000000000000000000000000000000000

Stem width:      1.00
Each leaf:       1 case(s)
```




Detrended Normal Q-Q Plot of O4
Dev from Normal
Observed Value
0.2
0.1
0.0000
-0.1
-0.2
3.0
3.5
4.0
4.5
5.0


5.0
4.5
4.0
3.5
3.0
O4

APPENDIX E:

RESULT OF CRONBACH's ALPHA FOR ACTUAL SURVEY

Reliability
Scale: O1

Case Processing Summary

		N	%
Cases	Valid	152	100.0
	Excluded[a]	0	.0
	Total	152	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.734	.736	4

Item Statistics

	Mean	Std. Deviation	N
QO1	4.3947	.71092	152
QO2	4.3092	.73000	152
QO3	4.4079	.63408	152
QO4	4.2039	.68415	152

Scale: O2

Case Processing Summary

		N	%
Cases	Valid	152	100.0
	Excluded[a]	0	.0
	Total	152	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.767	.767	3

Item Statistics

	Mean	Std. Deviation	N
QO5	4.3355	.59739	152
QO6	4.2303	.68542	152
QO7	4.2566	.61436	152

Scale: O3

Case Processing Summary

		N	%
Cases	Valid	152	100.0
	Excluded[a]	0	.0
	Total	152	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.798	.797	3

Item Statistics

	Mean	Std. Deviation	N
QO8	4.0461	.76633	152
QO9	4.1250	.79162	152
QO10	4.3224	.69627	152

Scale: O4

Case Processing Summary

		N	%
Cases	Valid	152	100.0

	Excluded[a]	0	.0
	Total	152	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.795	.795	3

Item Statistics

	Mean	Std. Deviation	N
QO11	4.2434	.70002	152
QO12	4.1316	.68749	152
QO13	4.1974	.70042	152

Reliability
Scale: P1

Case Processing Summary

		N	%
Cases	Valid	152	100.0
	Excluded[a]	0	.0
	Total	152	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.714	.724	3

Item Statistics

	Mean	Std. Deviation	N
QP1	4.3355	.60838	152
QP2	4.0789	.72355	152
QP3	4.2632	.61694	152

Scale: P2

Case Processing Summary

		N	%
Cases	Valid	152	100.0
	Excluded[a]	0	.0
	Total	152	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.706	.703	3

Item Statistics

	Mean	Std. Deviation	N
QP4	4.2434	.66109	152
QP5	4.1579	.59917	152
QP6	4.1974	.63077	152

Scale: P3

Case Processing Summary

		N	%
Cases	Valid	152	100.0
	Excluded[a]	0	.0
	Total	152	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.751	.751	4

Item Statistics

	Mean	Std. Deviation	N
QP7	4.2368	.71629	152
QP8	4.2961	.68897	152
QP9	4.2763	.68278	152
QP10	4.1382	.74629	152

Scale: P4

Case Processing Summary

		N	%
Cases	Valid	152	100.0
	Excluded[a]	0	.0
	Total	152	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.758	.756	3

Item Statistics

	Mean	Std. Deviation	N
QP11	4.0855	.69952	152
QP12	4.1316	.61638	152
QP13	4.1250	.68390	152

Reliability

Scale: T1

Case Processing Summary

		N	%
Cases	Valid	152	100.0
	Excluded[a]	0	.0
	Total	152	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.753	.753	3

Item Statistics

	Mean	Std. Deviation	N
QT1	4.2500	.70241	152
QT2	4.2368	.73455	152
QT3	4.2105	.71532	152

Scale: T2

Case Processing Summary

		N	%
Cases	Valid	152	100.0
	Excluded[a]	0	.0
	Total	152	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.706	.707	3

Item Statistics

	Mean	Std. Deviation	N
QT4	4.0329	.67518	152
QT5	4.0921	.67456	152
QT6	4.1250	.62309	152

Scale: T3

Case Processing Summary

		N	%
Cases	Valid	152	100.0
	Excluded[a]	0	.0
	Total	152	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.723	.726	3

Item Statistics

	Mean	Std. Deviation	N
QT7	4.1118	.68619	152
QT8	4.1053	.62145	152
QT9	4.0592	.65340	152

Scale: T4

Case Processing Summary

		N	%
Cases	Valid	152	100.0
	Excluded[a]	0	.0
	Total	152	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.730	.731	3

Item Statistics

	Mean	Std. Deviation	N
QT10	4.1316	.58326	152
QT11	4.1908	.62755	152
QT12	4.1908	.62755	152

Reliability

Scale: INT_TO_ADOPT

Case Processing Summary

		N	%
Cases	Valid	152	100.0
	Excluded[a]	0	.0
	Total	152	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.717	.718	6

Item Statistics

	Mean	Std. Deviation	N
QD1	4.0197	.68542	152
QD2	4.0526	.59567	152
QD3	3.9934	.56961	152
QD4	4.1250	.60146	152
QD5	4.0132	.56365	152
QD6	4.1118	.55849	152

APPENDIX F:

RESULT OF PRINCIPAL COMPONENT ANALYSIS (PCA)

Factor Analysis

Correlation Matrix

		O1	O2	O3	O4
Correlation	O1	1.000	.556	.568	.471
	O2	.556	1.000	.579	.426
	O3	.568	.579	1.000	.447
	O4	.471	.426	.447	1.000
Sig. (1-tailed)	O1		.000	.000	.000
	O2	.000		.000	.000
	O3	.000	.000		.000
	O4	.000	.000	.000	

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.794
Bartlett's Test of Sphericity	Approx. Chi-Square	186.451
	df	6
	Sig.	.000

Communalities

	Initial	Extraction
O1	1.000	1.000
O2	1.000	1.000
O3	1.000	1.000
O4	1.000	1.000

Extraction Method: Principal Component Analysis.

Rotated Component Matrix[a]

	Component			
	1	2	3	4
O1				.910
O2		.915		
O3			.909	
O4	.949			

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.[a]

a. Rotation converged in 4 iterations.

Factor Analysis

Correlation Matrix

		P1	P2	P3	P4
Correlation	P1	1.000	.688	.513	.565
	P2	.688	1.000	.361	.517
	P3	.513	.361	1.000	.508
	P4	.565	.517	.508	1.000
Sig. (1-tailed)	P1		.000	.000	.000
	P2	.000		.000	.000
	P3	.000	.000		.000
	P4	.000	.000	.000	

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.745
Bartlett's Test of Sphericity	Approx. Chi-Square	220.583
	df	6
	Sig.	.000

Communalities

	Initial	Extraction
P1	1.000	1.000
P2	1.000	1.000
P3	1.000	1.000
P4	1.000	1.000

Extraction Method: Principal Component Analysis.

Rotated Component Matrix[a]

	Component			
	1	2	3	4
P1	.361			.862
P2	.913			.310
P3		.945		
P4			.917	

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.[a]

a. Rotation converged in 5 iterations.

Factor Analysis

Correlation Matrix

		T1	T2	T3	T4
Correlation	T1	1.000	.400	.384	.402
	T2	.400	1.000	.407	.369
	T3	.384	.407	1.000	.356
	T4	.402	.369	.356	1.000
Sig. (1-tailed)	T1		.000	.000	.000
	T2	.000		.000	.000
	T3	.000	.000		.000
	T4	.000	.000	.000	

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.756
Bartlett's Test of Sphericity	Approx. Chi-Square	104.131
	df	6
	Sig.	.000

Communalities

	Initial	Extraction
T1	1.000	1.000
T2	1.000	1.000
T3	1.000	1.000
T4	1.000	1.000

Extraction Method: Principal Component Analysis.

Rotated Component Matrix[a]

	Component			
	1	2	3	4
T1				.952
T2			.953	
T3		.956		
T4	.958			

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.[a]

a. Rotation converged in 5 iterations.

APPENDIX G:

RESULT OF MULTIPLE LINEAR REGRESSION

Regression

Descriptive Statistics

	Mean	Std. Deviation	N
DEC_TO_ADOPT	4.0526	.38430	152
O1	4.3289	.51502	152
O2	4.2741	.52334	152
O3	4.1645	.63501	152
O4	4.1908	.58633	152

Correlations

		INT_TO_ADOPT	O1	O2	O3	O4
Pearson Correlation	INT_TO_ADOPT	1.000	.556	.517	.528	.427
	O1	.556	1.000	.556	.568	.471
	O2	.517	.556	1.000	.579	.426
	O3	.528	.568	.579	1.000	.447
	O4	.427	.471	.426	.447	1.000
Sig. (1-tailed)	INT_TO_ADOPT	.	.000	.000	.000	.000
	O1	.000	.	.000	.000	.000
	O2	.000	.000	.	.000	.000
	O3	.000	.000	.000	.	.000
	O4	.000	.000	.000	.000	.
N	INT_TO_ADOPT	152	152	152	152	152
	O1	152	152	152	152	152
	O2	152	152	152	152	152
	O3	152	152	152	152	152
	O4	152	152	152	152	152

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	O4, O2, O1, O3[b]	.	Enter

a. Dependent Variable: DEC_TO_ADOPT

b. All requested variables entered.

Model Summary[b]

Model	R	R Square			Change Statistics

			Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change
1	.643[a]	.414	.398	.29828	.414	25.912

Model Summary[b]

Model	Change Statistics			Durbin-Watson
	df1	df2	Sig. F Change	
1	4[a]	147	.000	1.684

a. Predictors: (Constant), O4, O2, O1, O3

b. Dependent Variable: INT_TO_ADOPT

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.222	4	2.306	25.912	.000[b]
	Residual	13.079	147	.089		
	Total	22.301	151			

a. Dependent Variable: INT_TO_ADOPT

b. Predictors: (Constant), O4, O2, O1, O3

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.704	.239		7.131	.000
	O1	.204	.063	.274	3.260	.001
	O2	.142	.061	.193	2.317	.022
	O3	.125	.051	.206	2.437	.016
	O4	.081	.049	.124	1.665	.098

Coefficients[a]

Model		95.0% Confidence Interval for B		Correlations			Collinearity Statistics
		Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance
1	(Constant)	1.232	2.176				
	O1	.080	.328	.556	.260	.206	.566
	O2	.021	.262	.517	.188	.146	.577
	O3	.024	.226	.528	.197	.154	.559
	O4	-.015	.178	.427	.136	.105	.716

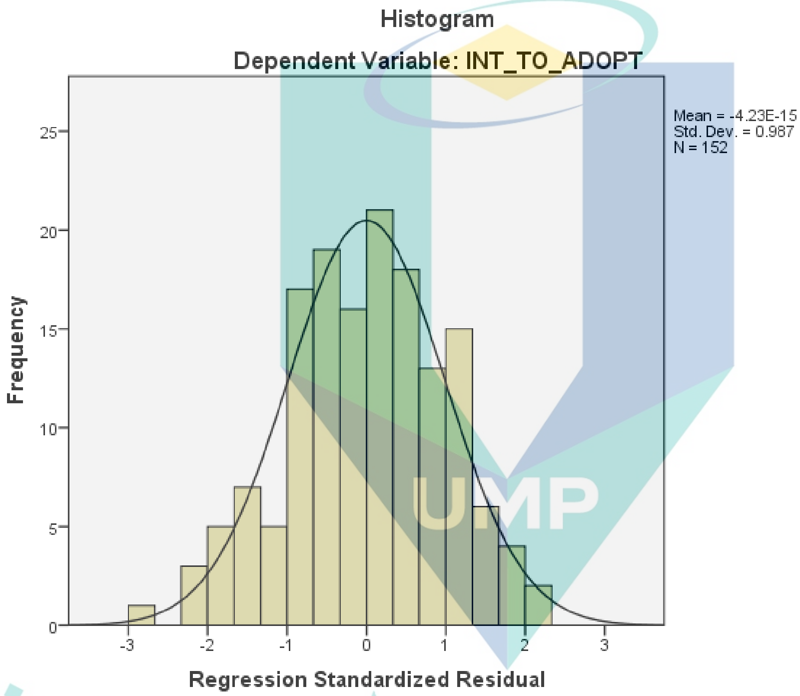
Coefficients[a]

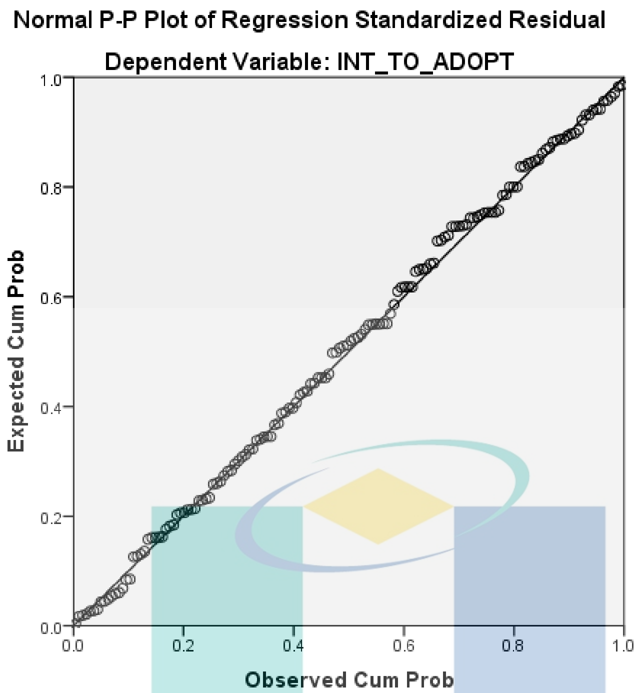
Model	Collinearity Statistics

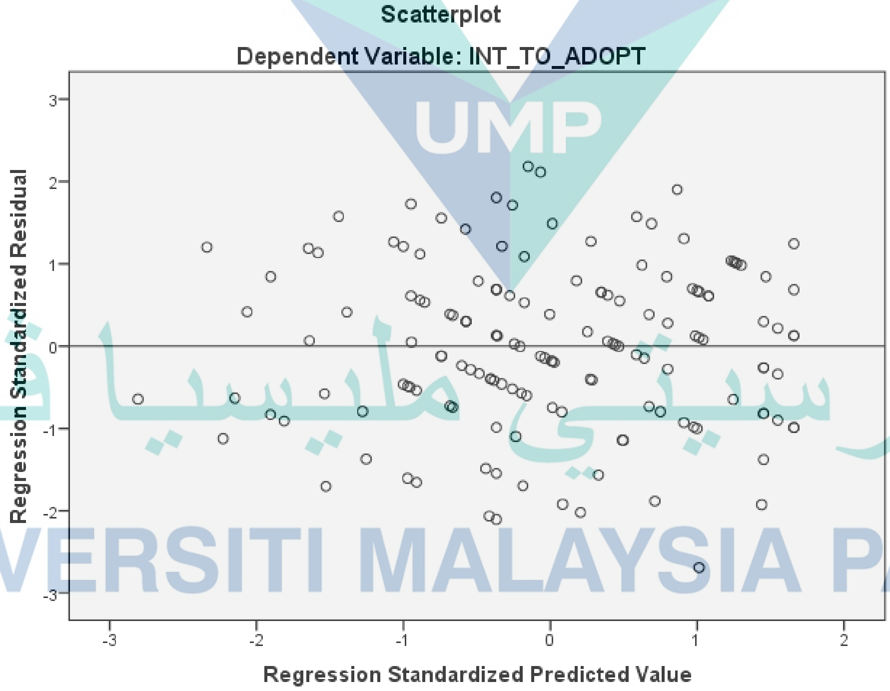
		VIF
	(Constant)	
	O1	1.766
1	O2	1.734
	O3	1.789
	O4	1.397

a. Dependent Variable: INT_TO_ADOPT

Charts







Regression

Descriptive Statistics

	Mean	Std. Deviation	N
INT_TO_ADOPT	4.0526	.38430	152
P1	4.2259	.51981	152
P2	4.1996	.50057	152
P3	4.2368	.53657	152
P4	4.1140	.54807	152

Correlations

		INT_TO_ADOPT	P1	P2	P3
Pearson Correlation	INT_TO_ADOPT	1.000	.520	.435	.472
	P1	.520	1.000	.688	.513
	P2	.435	.688	1.000	.361
	P3	.472	.513	.361	1.000
	P4	.495	.565	.517	.508
Sig. (1-tailed)	INT_TO_ADOPT	.	.000	.000	.000
	P1	.000	.	.000	.000
	P2	.000	.000	.	.000
	P3	.000	.000	.000	.
	P4	.000	.000	.000	.000
N	INT_TO_ADOPT	152	152	152	152
	P1	152	152	152	152
	P2	152	152	152	152
	P3	152	152	152	152
	P4	152	152	152	152

Correlations

		P4
Pearson Correlation	INT_TO_ADOPT	.495
	P1	.565
	P2	.517
	P3	.508
	P4	1.000
Sig. (1-tailed)	INT_TO_ADOPT	.000
	P1	.000
	P2	.000
	P3	.000
	P4	.
N	INT_TO_ADOPT	152
	P1	152
	P2	152

	P3	152
	P4	152

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	P4, P3, P2, P1[b]	.	Enter

a. Dependent Variable: INT_TO_ADOPT

b. All requested variables entered.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	.603[a]	.364	.347	.31065	.364	21.022

Model Summary[b]

Model	Change Statistics			Durbin-Watson
	df1	df2	Sig. F Change	
1	4[a]	147	.000	1.728

a. Predictors: (Constant), P4, P3, P2, P1

b. Dependent Variable: INT_TO_ADOPT

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	8.115	4	2.029	21.022	.000[b]
1	Residual	14.186	147	.097		
	Total	22.301	151			

a. Dependent Variable: INT_TO_ADOPT

b. Predictors: (Constant), P4, P3, P2, P1

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	(Constant)	1.787	.256		6.979	.000
	P1	.169	.075	.229	2.268	.025
1	P2	.070	.071	.091	.980	.329
	P3	.154	.058	.215	2.662	.009
	P4	.147	.060	.210	2.442	.016

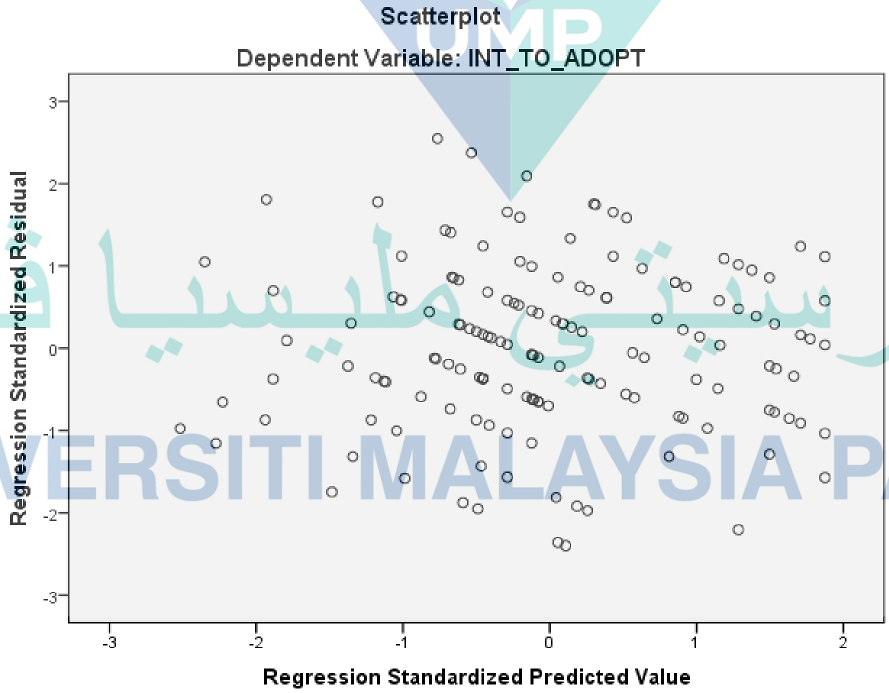
Coefficients[a]

Model		95.0% Confidence Interval for B		Correlations			Collinearity Statistics
		Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance
1	(Constant)	1.281	2.293				
	P1	.022	.316	.520	.184	.149	.426
	P2	-.071	.211	.435	.081	.064	.501
	P3	.040	.268	.472	.214	.175	.664
	P4	.028	.266	.495	.197	.161	.586

Coefficients[a]

Model		Collinearity Statistics
		VIF
1	(Constant)	
	P1	2.349
	P2	1.998
	P3	1.505
	P4	1.707

a. Dependent Variable: INT_TO_ADOPT



Regression

Descriptive Statistics

	Mean	Std. Deviation	N

INT_TO_ADOPT	4.0526	.38430	152
T1	4.2325	.58688	152
T2	4.0833	.52214	152
T3	4.0921	.52487	152
T4	4.1711	.49424	152

Correlations

		INT_TO_ADOPT	T1	T2	T3
Pearson Correlation	INT_TO_ADOPT	1.000	.515	.389	.541
	T1	.515	1.000	.400	.384
	T2	.389	.400	1.000	.407
	T3	.541	.384	.407	1.000
	T4	.530	.402	.369	.356
Sig. (1-tailed)	INT_TO_ADOPT	.	.000	.000	.000
	T1	.000	.	.000	.000
	T2	.000	.000	.	.000
	T3	.000	.000	.000	.
	T4	.000	.000	.000	.000
N	INT_TO_ADOPT	152	152	152	152
	T1	152	152	152	152
	T2	152	152	152	152
	T3	152	152	152	152
	T4	152	152	152	152

Correlations

		T4
Pearson Correlation	INT_TO_ADOPT	.530
	T1	.402
	T2	.369
	T3	.356
	T4	1.000
Sig. (1-tailed)	INT_TO_ADOPT	.000
	T1	.000
	T2	.000
	T3	.000
	T4	.
N	INT_TO_ADOPT	152
	T1	152
	T2	152
	T3	152

T4	152

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	T4, T3, T2, T1[b]	.	Enter

a. Dependent Variable: INT_TO_ADOPT

b. All requested variables entered.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	.692[a]	.479	.465	.28120	.479	33.756

Model Summary[b]

Model	Change Statistics			Durbin-Watson
	df1	df2	Sig. F Change	
1	4[a]	147	.000	1.671

a. Predictors: (Constant), T4, T3, T2, T1

b. Dependent Variable: INT_TO_ADOPT

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10.677	4	2.669	33.756	.000[b]
	Residual	11.624	147	.079		
	Total	22.301	151			

a. Dependent Variable: INT_TO_ADOPT

b. Predictors: (Constant), T4, T3, T2, T1

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.289	.246		5.229	.000
	T1	.166	.046	.254	3.649	.000
	T2	.035	.051	.048	.694	.489
	T3	.233	.050	.319	4.642	.000
	T4	.230	.053	.296	4.340	.000

Coefficients[a]

Model		95.0% Confidence Interval for B		Correlations			Collinearity Statistics
		Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance
1	(Constant)	.802	1.776				
	T1	.076	.256	.515	.288	.217	.732
	T2	-.065	.136	.389	.057	.041	.737
	T3	.134	.333	.541	.358	.276	.752
	T4	.125	.335	.530	.337	.258	.762

Coefficients[a]

Model		Collinearity Statistics
		VIF
1	(Constant)	
	T1	1.366
	T2	1.357
	T3	1.330
	T4	1.313

a. Dependent Variable: INT_TO_ADOPT