Barriers and Driving Factors for Implementing Building Information Modelling (BIM) in Libya

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In the name of Allah, the Gracious, the Merciful

# ABSTRACT

Building Information Modelling (BIM) is an integrated system which includes everything related to a construction project and places it in one template. It's considered a central database to provide the project documents to all project parties. Moreover, it contains the entire project documents whether they are plans or specifications, bill of quantities or even the project schedule.

In this study questionnaire survey technique is used to determine what the actual barriers that hamper its implementation and what are the driving factors that could enhance its pace of implementation in the Libyan construction industry. Additionally, Cronbach Coefficient, Relative Importance Index (RII), Pearson Correlation, and Hypotheses testing were used to analyse the data obtained and to identify the most significant barriers and driving factors. Results of this study showed that the main barriers for implementing BIM are: lack of BIM education, lack of publicity and awareness, and lack of understanding of BIM and its benefits. Moreover, the primarily driving factors are: provide BIM education at university level, top management support and enhancement, and desire for innovation with competitive advantages and differentiation in the market. In order to achieve successful widespread application of BIM in Libya, encourage and support from the government alone is not sufficient. All construction industry players should increase their roles in promoting BIM and use it in their construction projects.

Keywords: Building Information Modelling, BIM, BIM Barriers, Libya, Construction Industry, Driving Factors.

ÖZ

Yapı Bilgisi Modelleme (YBM), bir inşaat projesi ile ilgili herşeyi içeren ve tek bir şablona yerleştiren entegre bir sistemdir. Dolayısıyla proje belgelerini bütün taraflara sağlayan bir merkezi veritabanı olarak kabul edilmektedir. Ayrıca YBM, plan, şartname, birim fiyat listesi ve hatta iş programı gibi tüm proje belgelerini içerir. Bu makalede sunulan çalışma, Libya inşaat endüstrisinde YBM'nin yürürlüğe konulmasını önleyen gerçek engelleri ve uygulama hızını arttırabilecek itici faktörleri belirlemek amaçlı anket çalışmasını kullananmaktadır. Dahası, elde edilen verileri analiz etmek, ve en belirgin engelleri ve itici fakörleri tanımlamak için Cronbach Katsayısı, Göreceli Önem Endeksi (GÖE), Pearson Korelasyonu ve Hipotez testi kullanılnmıştır. Böylece bu çalışmanın sonuçları YBM'nin uygulanmasının önündeki ana engeller olarak aşağıdaki nedenleri ortaya çıkarmıştır: 1) Yetersiz YBM eğitimi, 2) Yetersiz tanıtım ve farkındalık, ve 3) YBM ve yararlarının yeterince anlaşılmaması. Sonuçlara göre, belirgin itici faktörler ise: 1) YBM eğitiminin Üniversite düzeyinde sağlanması, 2) Yüksek yönetim'in desteği, ve 3) Şirketlerin piyasaya göre rekabetçi avantajlar ve farklılaşım kazanmaya yönelik yenilikler için olan motivasyonu.

Sonuç olarak, YBM'nin Libya'da başarıyla yaygın bir şekilde uygulanması için hükümetin teşviği tek başına yeterli olmaktan uzaktır. Bütün inşaat endüstrisi aktörleri YBM'nin desteklenmesinde üzerlerine düşen rolleri arttırmalı ve projelerinde kullanmalıdır.

Anahtar Kelimeler: Yapı Bilgisi Modelleme, YBM, YBM Engeller, Yapı sektörü, Libya

DEDICATION

I dedicate this thesis to my family whom they supported me throughout my study and to my brothers and friend.

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LIST OF SYMBOLS AND ABBREVIATIONS

SYMBOLS

$\bar{x}$	Mean score of the values
$\sum$	Summation of the total scores
σ	The standard deviation
x	Each value in the population
N	The total number of scores
r	Pearson Correlation Coefficient
H_0	Null Hypothesis
H_1	Alternative Hypothesis
α	Cronbach Alpha Coefficient

ABBREVIATIONS

AEC:	Architecture, Engineering, and Construction
AECFM:	Architecture, Engineering, and Construction Facilities Management
AIA:	American Institute of Architects
BCIS:	Building Cost Information Service
BIM:	Building Information Modelling
CIFE:	Center for Integrated Facilities Engineering
IPD:	Integrated Project Delivery
MEP:	Mechanical, Electrical and Plumbing
RII:	Relative Important Index
SD:	Standard Deviation

Chapter 1

INTRODUCTION

1.1 Introduction

In the 21st century, advances in computer science have assisted the achievement in each technology development. The main outcome of every evolution is to provide more knowledge and information to ease for achieving desired goals. The reflection of this technical evolution can be noticed in the Architecture, Engineering, and Construction (AEC) Industry. For the past decade, there was a strongly noticed improvement of the design tools in the construction industry from two-dimensional (2D) modelling to three-dimensional (3D) modelling (Yan & Damian, 2008).

One of the major issues in the construction industry is that, the traditional 2D presentations used in delivery methods can prevent or slow down the exchange of information between owners, engineers, architects, and contractors. This obstacle occurs in all project phases, from the design phase and through the construction stage until the point of operation and maintenance of a facility.

Building Information Management (BIM) is a multi-dimensional tool, considered as a developed information technology that assists virtual design and construction techniques. In addition BIM supports a cooperative process for the AEC and Facilities Management (AECFM) industry, placing together all project members throughout the whole facility lifecycle (Rohena, 2011).

1.2 Problem Statement

There is clearly an increasing pressure for the Libyan construction industry to implement BIM processes and in adapting traditional work methods so as to act as an enabler for transformation and adjust with the considerable increasing levels of construction technology around the world.

Currently there is low adoption levels of technology in Libyan AEC industry and no utilisation of BIM in Libya, which highlights the control of hurdles that discourages the adoption, it is therefore very important to determine the barriers and BIM facilitating factors. It is important to recognise them first before establishing a roadmap for BIM implementation. By determining the barriers and drivers they enable greater levels of BIM adoption possibilities in the future.

1.3 Aim and Objectives

The main aim of this study is to identify and study both most critical barriers and influential factors for implementing BIM in Libyan AEC industry.

Furthermore, an important purpose of the study is to provide Libya’s construction stakeholders, managers, architects, engineers, and contractors, a comprehensive information of what are the top barriers and drivers of implementing BIM. This will assist in developing the AEC industry by using modern information technology and help to develop a roadmap for the implementation of new technologies in the construction industry.

Briefly the objectives will be as follows:

1. To identify the main barriers of implementing BIM in Libya construction industry; and
2. To identify the main facilitating factors of implementing BIM in Libya construction industry.

1.4 Limitations

The study is limited to BIM implementation in Libya. The questionnaire was sent and collected from Libyan AEC industry practitioners and academics. Moreover, relevant data are gathered from all across the country, for representing a comprehensive result.

1.5 Methodology

To fulfil the study objectives, the main data will be a conducted quantitative questionnaire collected from Libyan AEC organisations. The research was designed focusing mainly on project parties (Architects, Contractors, Managers, Engineers, Clients, etc.).

The questionnaire is divided into three main sections. The first part is about gathering some basic information of respondents and the firm they work in.

Meanwhile, the second part is about collecting opinions about BIM implementation barriers. The third section is related to the driving factors for implementing BIM in Libya.

The questionnaire was distributed and collected through the internet in an electronic form using Google Forms and by personnel distribution. A total of seventy-five (75) questionnaires were completed. Forty-seven (47) copies of the questionnaires received using Google Forms, while twenty-eight (28) copies retrieved in person.

As a part of this study the results were analysed using below mentioned methods:

1. Factor Analysis and Reliability Test.
2. Relative Importance Index (RII) with Mean Score and Standard Deviation.
3. Pearson Correlation Analysis and Significance Test Analysis.
4. Research Hypotheses using the t-test method.

1.6 Thesis Structure

This thesis has been structured into five chapters. Chapter 1, includes the background of the thesis subject and it contains an introduction, problem statement, aim and objectives, limitations, methodology, and thesis structure.

Chapter 2 involves a comprehensive literature review on BIM's process and previous studies on BIM implementation barriers and drivers within the construction industry.

Chapter 3 presents the methodologies and data analysis used to conduct the study.

Chapter 4 involves data analysis and discussion of the results regarding the significant barriers and driving factors for implementing BIM.

In Chapter 5 conclusions of the study with the substantial findings and recommendations of further research areas are presented.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

The main purpose of this chapter is to give a comprehensive literature review related to Building Information Modelling BIM as a new era in the construction industry. The first sections of this review focuses on the nature of BIM as an innovation which includes the definition and concept of BIM followed by the benefits of BIM afterwards the middle part of this chapter is a broad review of BIM major software's and a view of BIM dimensions.

The last sections will be critical evaluation of the previous work done related to the major barriers and driving factors in implementing BIM, these previous efforts is not conducted on the Libyan construction industry along with an insufficient categorisation of the barriers and driving factors.

2.2 Building Information Modelling Definition

Building Information Modelling is a new phrase introduced in 2002 by Autodesk to explain an innovative approach in designing and construction of building (Rundell and Stowe, 2005).

BIM can mean different things to various researchers (Aranda-Mena et al., 2009), and there are several definitions of BIM each seeing from different perspective. For instance based on a number of software solutions BIM can be considered to be a collaborative tool that is being used by members of the architectural, engineering and construction (AEC) industries (Latiffi et. al., 2013). From an integrated project approach is BIM defined as the process of information management of a building from earliest conception phase of planning, designing and building to demolition phase (lifecycle of a building) which enables the different parties in the construction project to cooperate and collaborate in a smooth way and communicate seamlessly (Enegbuma and Ali, 2011).

These definitions can be compiled and express that BIM is an integrated system which includes everything related to a construction project and place it in one template, BIM is considered a central database to provide the project documents to all project parties, and it contains the entire project documents whether they are plans or specifications, bill of quantities or even the project schedule.

2.3 Building Information Modelling Concept

BIM is mainly a 3D illustration of a construction and its characteristics (Hergunsel, 2011). For example, a column in the traditional construction is drawn as a square with four sides but in BIM the column is selected from the elements listed in the program and adding the required area and length in order to display it in 3D, also defining the column specifications and the site execution method can be accomplished, by starting with reinforcement and then concrete pouring afterwards the removal of the formworks and then the finishes.

BIM can also determine the time period for the execution of elements of the project. For example, a person can add the period of time for the completion of the columns and specify the date of materials delivery to the site and the date of starting the activity and also the preceded and the next activity. This addition represents the fourth dimension (4D).

The cost factor of the components of the project can be added. For example adding the cost of concrete per cubic meter and labour costs and any other costs, the program shall calculate the cost of each element accurately. Quantity surveying is done with high accuracy without waste or an increase in the cost of construction components and labour. Thus, the monthly costs are clear to the client and the contractor. This addition represents fifth dimension (5D).

This methodology is considered as design, planning, management and control at the same time, which provides accuracy in implementation and follow-up of project works. Using this technique, the project owner can imagine and understand the project details before the construction stage, It is an integrated virtual building model of the project before actually execution on the ground, which allows the client to predict any future risks that can be avoided at an early stage and therefore less likely to have changes in the design (Barakat, 2012).

Other BIM characteristic is that all the architectural, structural, electrical, and plumbing plans of the project are represented into one three-dimensional scheme.

2.4 Benefits of BIM

In order to expedite embracement of BIM in Libyan construction industry an overall view of BIM benefits is going to be revealed to assist individuals and organisations either owners, designers, contractors or managers to apprehend the concept of BIM, which will be a crucial driver for efficient BIM adoption (Ahuja et al., 2009). The main benefits of BIM are gathered and summarised below:

1. To improve and enhance the design, planning, and construction of projects.
2. To streamline information processing such as studying contract documents, schedule, budget, and project plans and so on.
3. To accurate quantity take-off.
4. To improve collaboration and communication between construction parties.
5. Clash detection during the design phase which will reduce conflicts and changes during construction.
6. Time-saving.
7. Greater productivity.
8. To improve quality control which will lead to high quality of work.
9. To support sustainable design including better analysis and decision-making of sustainable building design.
10. Waste management for planning and accurately estimating the volume and information of every material need to be demolished or renovated.
11. To improve safety (risk reduction).
12. To improve facility management (FM) by improving space management, effectual energy usage, simplified maintenance and improve lifecycle management.
13. Efficient resource utilisation.
14. Cost reduction in construction and lifecycle of building as well as accurate cost estimation due to the precise quantity take-off.

There are many researches done to comprehend the key benefits of BIM, as indicated in Table 1. Eastman et al. (2011) has presented a list of BIM implementation benefits in various project phases.

Table 1: Benefits of BIM in different project phases

Projects Phases	Benefits From BIM Implementation
Preconstruction for client	• Improved concept, feasibility and design benefits; • Increased building performance and quality; • Improved collaboration using Integrated Project Delivery IPD.
Design	• Earlier and more accurate visualizations of a design; • Automatic low-level correction while changes happen; • Generation of accurate and consistent 2D drawing at any stage of the design; • Earlier Collaboration of multiple design disciplines; • Easy verification of consistency of the design intent; • Easy extraction of cost estimates during the design stage; • Improvement of energy efficiency and sustainability.
Construction and fabrication	• Using of design models as basis for fabrication components; • Quick reaction to design changes; • Discovery of design errors and omissions before construction; • Synchronization of design and construction planning; • Better implementation of lean construction techniques; • Synchronization procurement with design and construction.
Post construction benefits	• Improved commissioning and handover of facility information; • Better management and operation of facilities; • Integration with facility operation and management systems.

Stanford University Center for Integrated Facilities Engineering (CIFE) found the following benefits of using BIM-based upon 32 large projects (CIFE, 2007).

- The cut of unbudgeted change up to 40%.
- Increase the accuracy of cost estimation by 3%.

- Up till 80% reduction in cost estimating time.
- Savings of contract price up to 10% due to clash detections.
- Up to 7% of project time is deducted.
- A growth in field efficiency in the range of 20-30%.

Still continuous researches worldwide are done to evaluate the effectiveness of BIM. Libyan construction industry lacks these studies that facilitate the implementation of information technology in the construction industry.

2.5 BIM programs

In the past years, many software companies focused on developing Building Information Modelling programs, which lead into introducing many types of BIM software solutions (Latiffi et al., 2013). These tools are utilized to manage various construction project activities (Lévy, 2011), and used for different fields such structural engineering, architecture, mechanical, electrical and plumbing (MEP) engineering or facilities management (FM) (Mankki, 2013).

Comprehensive BIM software solutions that are well known and most widely used in the construction market are provided in Table 2 (The Associated General Contractors of America, 2007).

Some leading program suppliers, like Autodesk provide a suite of programs that cover all building lifecycle stages (design, construction and operation), which means any files produced in a particular program can be imported or exported amongst other programs fast and with ease.

Table 2: Different BIM software summary

Product Name	Manufacturer	BIM Use	Primary Function
Revit	Autodesk	Architecture, structural, MEP and site design	Architectural, structural, MEP modelling and parametric design.
Bentley BIM Suite	Bentley Systems	Multi-discipline	Architectural, Structural, Mechanical, Electrical and Generative Components – all within the 3D modelling environment
Allpan	Nemetschek	Multi-discipline	Architectural, structural and MEP modelling
SketchUp Pro	Google	Multi-discipline	3D Architectural and Structural modeling
ArchiCAD	Graphisoft	Architecture, MEP and site design	3D Architectural Modeling
Tekla Structures	Tekla	Structural and Construction Management	3D Structural Modeling, Detailing, Fabrication and Construction Management
Digital Project	Gehry Technologies	Multi-discipline	Digital Project Designer is a high performance 3D modeling tool for architectural design, engineering, and construction. Designer provides an extensive set of tools for creating and managing building information throughout the building lifecycle.
Vectorworks	Nemetschek	Architecture	3D Architectural Modeling
Fastrak	CSC (UK)	Structural	3D Structural Modeling
SDS/2	Design Data	Structural	3D Structural Modeling and Detailing
MEP Modeler	Graphisoft	MEP	3D MEP Modeling
Navisworks	Autodesk	Clash Detection and Scheduling	Linking 3D model to popular project schedule applications (e.g. MS Project or Primavera)

Continued on the next page.

Table 2 continued.

ProjectWise Navigator	Bentley	Clash Detection and Scheduling	Coordination between models and disciplines. Linking 3D model to popular project schedule applications (e.g. MS Project or Primavera)
Synchro Professional	Synchro Ltd.	Planning & Scheduling	Schedule-driven site coordination. Scheduling (4D), sequencing linking to popular project schedule applications (e.g. MS Project or Primavera)
Vico Office	Vico Software	Multiple function	Schedule is scientifically derived from the resource-loaded, cost loaded, location-based BIM
Visual Simulation	Innovaya	Scheduling	Linking 3D model to popular project schedule applications (e.g. MS Project or Primavera)

2.6 BIM Dimension

As Sebastian (2010) stated BIM is not only a tool to create digital 3D or 2D drawings rather it's an object-based illustration of construction. From 2D drawing up to object-oriented modelling the dimensions of BIM have emerged in an effort to clarify and illustrate the use of several BIM processes. These dimensions are illustrated below.

2.6.1 3D Model

3D is the three geometrical dimensions XYZ, by creating a 3D model of a construction at an early phase a clear vision of the design is obtained. As Muzvimwe cited in (Shangvi, 2012) pointed out 3D models are useful to owners, designers and contractors for design coordination, clash detection of tasks in a building. These benefits improve the design at an early phase before construction leading to saving of time, cost and quality (Abbasnejad & Moud, 2013).

2.6.2 4D Scheduling

4D process means adding time to the 3D model. Linking the construction schedule to the 3D model enable numerous project actors to envision in time the progress of a construction phase or the duration of an activity (BIM Objective, 2015) leading to entire construction coordination (Zhyzheuski, 2011), besides improving collaboration and revealing possible bottlenecks . Furthermore, (Azhar, 2011; Eastman et al., 2011) stated that 4D offers an accurate prediction of the duration of construction activities, the succeeding tasks and the related required resources. Akinci et al., (2002) continued saying that by using 4D models a contractor has the ability to determine day-by-day where workers, equipment, materials, and space requirements will be and for what period/duration, this will optimise the project timeline.

2.6.3 5D Cost

The 5D model which is “cost” added to 4D model expressed as (time and cost). It’s mainly purposed for estimating the cost. By using 5D based upon cost data of materials, labour, area and size, the cost estimation of the whole construction project will be achievable (Zhyzheuski, 2011). The cost information can be entered to each object of the model resulting in automatic approximate cost estimation. Furthermore, the project members can meet online and review the design changes resulting in an instant cost updating (Abbasnejad & Moud, 2013; Eadie et al., 2013). Though the total project price would still need a cost estimator judgment.

2.6.4 6D Sustainability

The latest development has brought BIM into a new sixth dimension (6D). The 6D is about everything related to building sustainability e.g. energy analysis (BIM Objective, 2015). The use of 6D technology can assist designers in accomplishing accurate and complete energy estimation in early design phase resulting in an overall decrease in energy consumption (Impararia, 2015).

2.6.5 7D Facilities Management

As a result of the substantial research and development, BIM technology now cover facility life cycle management which is revealed as 7D, the seventh dimension viewed as an “as-build” model due to the updating of the model by the designer during construction phase (Abbasnejad & Moud, 2013; Zhyzheuski, 2011).

This model consists of all important information including product details, maintenance and operation manuals, specifications, photos, warranty and replacement information, etc. The data are delivered at the end of the project to the client for future maintenance and use of the building. This 7th dimension will aid in operational lifecycle of the building from design to demolition (McAleese, 2007). Figure 1 illustrates a summary of main benefits of each BIM dimension.

Figure 1: Benefits of each BIM dimension.

2.7 BIM Barriers

Despite from BIM tremendous benefits, it has also been regularly pointed by researchers like (Ashcraft & Esquire, 2007) and (Brewer & Gajendran, 2012) that BIM does come to its challenges. BIM is considered as a new phenomenon that seeks to renovate the conducted practices of construction industries, making it more difficult to adopt and implement BIM (Kekana et al., 2014).

Many authors have divided BIM barriers into different categories, (Gu et al., 2008) displayed a way of classifying the obstacles of BIM implementation in the AEC industry. These categories are; in terms of People, Process and Product (Lindblad, 2013).

Ashcraft & Esquire (2007) and Ku & Taiebat (2011) explained barriers by dividing them into two groups which are contractual issues and personnel issues. However Gu & London (2010) have divided hurdles of BIM adoption into three different categories: Technical issues, Social context issues and process related issues and work practice.

Ozorhon et al. (2010) have conducted a survey as illustrated in Figure 2, survey results showed that economic conditions believed to be the most prevailing barrier. Respectively availability of financial resources is the 2nd most resilient barrier which induced by poor economic conditions causing low productivity amongst the industry. Ranked 3rd as the most significant barrier is the fragmented nature of the construction industry. These three factors are followed by unwillingness to change, and lack of government support.

Barriers	Mean
Economic conditions	3.9
Availability of financial resources	3.6
Fragmented nature of construction business	3.4
Unwillingness to change	3.3
Lack of government role model	3.3
Inappropriate legislation	3.3
Risk in commercializing innovations	3.2
Temporary nature of construction projects	3.2
Extensive inter-organisational change required	3,1
Lack of awareness	3.0
Lack of qualified staff	3.0
Lack of end-user involvement	3.0
Lack of innovative investments /procedures /practices (training and education)	3.0
Adversarial approaches within the supply chain	2.9
Lack of clear benefits	2.9
Belief that the industry is doing well without innovation	2.8

Figure 2: Ranked barriers to innovation.

BIM is slowly implemented this is no due to one single problem, but rather several issues combined together (Gu et al., 2008; Kiviniemi, 2013)**.** To highlight the work done a list of top barriers gathered from different authors are summarised in Table 3.

Previous studies revealed a shortfall of categorising barriers to BIM adoption, and this issue is approached in this thesis by having six categories of barriers.

Table 3: Top barriers established from different authors

AUTHORS	TOP RANKED BIM BARRIERS
Newton & Chileshe, 2012	• Lack of understanding; • Costs of education and training; • Finding trained staff; • Changing the way organisations do business.
Zuhairi et al, 2014	• Lack of BIM knowledge; • Lack of client/government demand.
Eadie et al., 2014	• Magnitude of change Required; • Lack of supply Chain Buy-in; • Lack of Flexibility.
Nanajkar, 2014	• Cost of Software and Hardware Upgrade, • Lack of employees training; • Unwillingness to change; • Slow Adoption of Technology.
Kiani et al., 2015	• Lack of legal backing from authority; • Lack of skilled BIM software operators; • High price of software; • Unclear benefits of using BIM; • Lack of client demand.
Lindblad, 2013	**1. Barriers linked to the BIM product** • Interoperability; • Different views on BIM; • Poor match with the user's needs. **2. Barriers linked to the BIM process** • Changing work processes; • Risks and challenges with the use of a single model; • Legal issues; • Lack of client demand and disinterest. **3. Barriers linked to the individuals using BIM** • Changing roles and responsibilities; • Lack of training of individuals.
Marzia, 2013	• Cost of program and training, • Current technology is enough, • Unsuitable for current projects, • People refuse to learn.
Young et al., 2008	• Lack of Adequate training; • Senior management buy-in; • Cost of software; • Legal Issues.

Table 3 continued.

Arayici et al., 2009	• Software cost; • Time consuming of training staff; • Absence of finding appropriate projects on which to use BIM.
Gu & London, 2010	• Fragmented nature of the AEC industry; • Lack of awareness and training; • Lack of clarity on roles, responsibilities and distribution of benefits.
Arayici et al., 2011; Azhar, 2011; Becerik-Gerber & Kensek, 2009; Ilozor & Kelly, 2012; Kent & Becerik-Gerber, 2010; AIA IPD, 2007	**1. Technical barriers:** • Computable digital data; • Software interoperability. **2. Non-technical barriers:** • Project delivery; • Contracts and legal issues; • Resistance to change; • Strategies and workflows;
Sebastian, 2010	• Inadequacy of the existing contractual frameworks, including the agreements on liability and risk allocation; • Uncertainty of the legal status and intellectual property of the model; • Changing roles, responsibilities, and payment arrangements; • Lack of immediate benefits of BIM for project stakeholders.
Building Cost Information Service (BCIS), 2011	• Lack of client demand; • Lack of standards; • Lack of interfaces between BIM and 3rd party applications; • Lack of training/education.

2.8 BIM Enablers

Due to BIM adoption barriers, the full adoption of BIM will remain an issue unless these barriers are approached promptly. This part will highlight previous researches done regarding BIM adoption drivers.

Ozorhon et al., (2010) surveyed the facilitators to the implementation of innovations in the AEC industry as demonstrated in Figure 3.

Findings revealed that supportive work environment and leadership were observed to be the most efficient facilitators still the major facilitators are not limited just to these two drivers as stated by (Akintoye et al., 2012) “a leader’s vision is manifested through the lens of a supportive working environment”. A survey findings by (Akintoye et al., 2012) supported Ozorhon et al., (2010) conclusion by noting the three primary drivers to innovations implementation as being empowerment, leadership, and creative culture.

Collaboration with partners is the 3rd major facilitator accredited by Ozorhon et al., (2010). Likewise Blayse & Manley, (2004) believe that collaborative working attitudes will enhance levels of transforming information due to the harmonic working environment between project stakeholders.

Enablers	**Mean**
Leadership	4.6
Supportive work environment	4.4
Collaboration with partners	4.4
Deep understanding of the customer	4.3
Education & training policy	4.1
Knowledge management practices	4.1
Encouraging staff to get involved with external networks	3.9
Use of probles solving techniques	3.7
Awards, grants, funds	3.6
Government schemes	3.5
Reward scheme	3.3
Emphasis on research & development	3.2

Figure 3: Ranked enablers of innovation.

Arayici et al. (2009) considered supportive organisational culture as a crucial factor for adopting BIM in organisations which are concurrent with the previous researchers. In addition, he described information management as a fundamental enabler, which relates to the distribution and collection of information to project stakeholders. A list of top drivers from different researchers is gathered in Table 4.

Table 4: References for top BIM facilitators

Author:	Top BIM Facilitators:
Sinclair, 2012	• Establishing a collaborative and integrated working methods and teamwork between all designers on a project; • Presence of employees with BIM experience; • New procurement routes and forms of contracts aligned to the new working methods; • Interoperability of software; • Developing BIM standards.
Tsai et al., 2014	• Design validation of BIM tools; • Support from top management; • Integration and coordination between the professions.
Zikic, 2009	• Raising the understanding of BIM; • Proper training of staff; • Coordination among project parties; • Upper management support.
Kiani et al., 2015	• Government support; • Teaching BIM in universities; • Staff training; • Decreasing the price of BIM software; • Provision of legislation on BIM usage; • Mobilizing clients on the importance of BIM; • Organisation cultural change.
Eadie et al., 2013	• Government Pressure; • Competitive Pressure; • Perceived benefits from BIM.

Table 4 continued.

Lee & Yu, 2013	• Individual or organizational confidence in the utilization of a new technology; • Provide training program; • Forcible requirement of BIM utilization through a company policy at the organizational level; • Government and client pressure of BIM utilization.
Takim et al., 2013	• Regulation, policy & industry standards; • Contractors benefits and competitive advantage; • Economic demand in the AEC industry.
Zuhairi et al, 2014	• Support and enforcing the implementation of BIM by the Government; • Promote BIM training program; • Support from top management.
Newton & Chileshe, 2012	• Reduction in the cost of the project; reduction of risk; • Perceived benefits by implementing BIM.
Building Cost Information Service (BCIS), 2011	• Increased client demand; • Interoperability of BIM outputs and 3rd party applications; • Provision of guidance and training; • Developing BIM orientated standards.
Mom et al., 2011	• Perceived benefits; • Internal readiness; • External pressure.

Given numerous of studies on the barriers and enablers of BIM adoption, there have been a lack of empirical studies reported which seeks to investigate these issues within the Libyan construction industry. The study was therefore undertaken to fill these gaps.

Chapter 3

METHODOLOGY

3.1 Introduction

In this chapter, the scope is to provide methodology of the study involving the data collection mechanism and the type of methods used for data analysis.

This study comprises review and analysis of the most significant barriers and driving factors for implementing BIM in Libya. Subsequently, the most suited methodology is the use of critical analysis on a well-structured quantitative questionnaire.

The questionnaire survey has been filled on the internet using Google Forms along with distributing the questionnaire to relevant respondents. To apprehend the survey questions to respondents an introduction to BIM including its definition and benefits were written preceding the questionnaire questions. This has helped respondents comprehend the survey purpose.

3.2 Questionnaire Survey

As previously declared, the best suitable methodology for this study is a questionnaire survey which was conducted among practitioners of the Libyan construction industry. The research was designed focusing mainly on project parties. The project parties are Architects, Contractors, Managers, Engineers and Clients etc.

Questionnaires are commonly used in research to collect information on topics that clearly cannot be recognised or extracted from documents. There are many kinds of survey questions and it is vital to choose the right type for the objective and to look for confirmation of gathered data by referencing to other sources.

Based on the literature review the questionnaire was designed using mainly closed-ended (or multiple choice) questions to collect the required data.

The questionnaire is divided into three (3) sections:

- Section A: Personnel information.
- Section B: Barriers to BIM adoption.
- Section C: Drivers to BIM adoption.

The first section, Section A is titled as Personnel information. It consisted of eight (8) closed-ended questions and one (1) open-ended question. These questions were about the working position, qualification level and years of experience of the respondent, organisational information, in terms of sector, principal industry, size of organisation employees, and the location of respondents firms. Lastly, they've been asked if they are familiar of BIM.

In section B, titled as Barriers to BIM adoption contains questions regarding factors that are considered as potential barriers to BIM adoption. This part have six (6) categories as personal barriers, BIM process barriers, business barriers, technical barriers, organisation barriers, and market barriers. The last part is section C which involves the driving factors for implementing BIM in Libya. It's divided into two (2) parts as internal and external push for implementing BIM in Libya. In section B and

C, the respondents tick the appropriate choice, ranging from 1 to 5, where “1” implies strongly disagreed and “5” implies strongly agreed.

The questionnaire contains sixty-one questions in total, nine (9) in Section A, twenty-seven (27) in section B and twenty-five (25) in section C. The questionnaire questions sample is amended in Appendix A.

3.3 Reliability of Research Instrument

It is mandatory to scrutiny the collected data to test the soundness and the questionnaire quality before conducting the data analysis. After the questionnaire was designed, its validity was checked by the author. Further, a pilot study was conducted by filling the survey by two graduate civil engineer students, followed by a discussion of the quality of questionnaire, and the possible adjustments to improve the survey. Preceding the questionnaire questions an introduction, definition and benefits of BIM were written. Thus, the questionnaire was completed, then issued and retrieved using both Google Forms and direct distribution.

3.4 Data Collection

For this research, the collected empirical data was processed through the above-mentioned approach. Implying that, the questionnaire is distributed and collected through the internet as an electronic form using Google Forms and by personnel distribution and retrieval. A total of seventy-five (75) questionnaires were completed. Forty-seven (47) copies of the questionnaires received using Google Forms, while twenty-eight (28) copies retrieved in person. The aim was to collect a minimum of 60 completed questionnaires, and this aim was accomplished.

3.5 Method of Data Analysis

The survey questions were analysed using different methods, the reason is that when having more methods for analysis, the final conclusion will be strong and more reliable.

Section A questions are analysed using both bar charts and pie charts. These charts are simple to evaluate using each bar items percentages and frequencies. Section B and C (Barriers to BIM adoption & Drivers to BIM adoption) are analysed using various methods, such as factor analysis and reliability test, Relative Importance Index (RII), descriptive statistics and Pearson correlation analysis.

3.5.1 Factor Analysis and Reliability Test

In order to verify how homogeneous the extracted factors, the reliability of internal consistency was tested using the internal consistency coefficient Cronbach's alpha (α). Where, Alpha (α) is depending on the averaged interaction among variables within each individual factor Yitmen (2011). In other means, Cronbach's alpha is the average score of each group Factor Loadings. The value of the alpha coefficient (α) ranges from 0 to 1, the higher the score, the greater reliability of the factor or the questionnaire is. Nunnaly (1978) has pointed out 0.7 is the minimum acceptable value.

3.5.2 Relative Importance Index (RII) with Mean Score and Standard Deviation

By using Relative Importance Index (RII) each of the factors was examined and ranked in an ascending order as perceived by the respondents in terms of their significant effect according to their group as well as to the overall section. (RII) in equation 1, is shown below:

$$RII = \frac{\sum W}{A \times N} \left(0 \le RII \le 1\right) \tag{1}$$

where;

W**:** is the weight given to each factor by the respondents and ranges from 1 to 5, (where “1” implies “strongly disagree” and “5” implies “strongly agree”);

A**:** the highest weight (i.e. 5 in this study) and;

N**:** the total number of respondents.

When analysing the data obtained from questionnaire survey using RII, there were some factors which scored identically, and in order to differentiate between these factors in terms of ranking, the standard deviation (SD) is also calculated. The SD is a measure that is used to quantify the amount of variation or dispersion of a set of data values. A standard deviation close to 0 indicates that the data points tend to be very close to the statistical mean (also called the expected value) of the set, while a high standard deviation indicates that the data points are spread out over a wider range of values.

In this study, in order to be significantly affecting BIM adoption, a factor’s weighted mean (Average of all values) should score 4.0 or more and RII should be at least 0.8. Equation 2 represents the equation of statistical mean score and equation 3 shows the standard deviation equation.

$$\bar{x} = \frac{\sum x}{N} \tag{2}$$

where;

$\bar{x}$: The mean score.

$\sum x$: The summation of the total scores.

N : The total number of scores.

For standard deviation:

$$\sigma = \sqrt{\frac{\sum(x - \bar{x})}{N}} \quad (3)$$

where;

σ = the standard deviation

x = each value in the population

$\bar{x}$ = the mean of the values

N = the number of values (the population)

3.5.3 Pearson Correlation and Significance Test Analysis

3.5.3.1 Pearson Correlation Analysis

Pearson correlation **(r)** also known as simple linear correlation, evaluates the significance level of relationship between variables. The correlation coefficient ranges from -1.00 to +1.00. The value of +1 indicates a perfect positive relationship while -1 indicates a perfect negative correlation. Meanwhile, a value of 0 represents no relationship exists between variables. Table 5 illustrates the relationship and strength of the correlation value ranges.

Table 5: Strength of correlation value ranges.

Correlation Coefficient (r)	Relationship
(-0.7 to -1.0) OR (0.7 to 1.0)	Strong
(-0.3 to -0.7) OR (0.3 to 0.7)	Moderate
(-0.3 to 0.3)	Weak

3.5.3.2 Significance Test

After finding the Pearson correlation coefficient value, as a post of this study it is required to perform a significance test to decide whether there is a statistically significant relationship between the two variables (categorised group barriers) or not. In order to do this the following hypotheses are tested:

If the correlation coefficient (r) value is positive (+), the data will be tested if there is a positive relationship, then:

$$H_0: \rho = 0$$

$$H_1: \rho > 0$$

If the correlation coefficient (r) value is negative (-), the data will be tested if there is a negative relationship, thus the hypothesis is as follow:

$$H_0: \rho = 0$$

$$H_1: \rho < 0$$

The significance of a relationship is indicated by a ρ-value. If the ρ-value is less than or equal to 0.05, then the relationship between the two variables is significant.

A two-tailed test is used for this statistical significance test. Two-tailed test is a statistical test in which the critical area of a distribution is two sided and tests whether a sample is either greater than or less than a certain range of values. If the sample that is being tested falls into either of the critical areas, the alternative hypothesis will be accepted instead of the null hypothesis.

3.5.4 Research Hypotheses using t-test Method

A hypothesis is tested using t-test method by Statistical Package for Social Science (SPSS). The hypothesis is executed on Section C (Driving factors) of the questionnaire by proposing three (3) hypotheses. The null hypothesis is rejected (H_0) if the ρ-value is greater than 0.05, otherwise it's failed to reject the null hypothesis (H_0).

Chapter 4

DATA ANALYSIS AND DISCUSSION OF RESULTS

4.1 Introduction

This part of the study presents the main empirical results of the analysed outputs of the questionnaire. This chapter begins with an introduction then the participant's perspectives of the questionnaire survey for the potential hurdles and influential factors for BIM implementation are analysed.

Thus, the results and findings of the analysis are composed of five sections. First the respondent's personal information questions results are displayed and interpreted with the use of graphs and tables. Sections B and C are the main segments of the questionnaire survey, they were analysed using the fore mentioned study methodologies. The Relative Important Index (RII) calculated results are demonstrated and discussed in the second part of this chapter. Pearson Correlation Analysis is the succeeding part of data analysis used; next, the fourth section detailing the results of Cronbach coefficient (α) method. Lastly, the fifth part gives the tested hypothesis results. Each of the four methodology findings are separately examined and discussed. Finally, the main results of the analyses are summarised at the end of this chapter.

4.2 Respondents Information

4.2.1 Employment Position

The responses received displayed respondents positions in their respective organisations shown in percentage in Figure 4. The respondents who completed the questionnaire were composed of architects (19%), contractors (6%), engineers (55%), managers (6%), owners (3%), and researcher and academicians (11%).

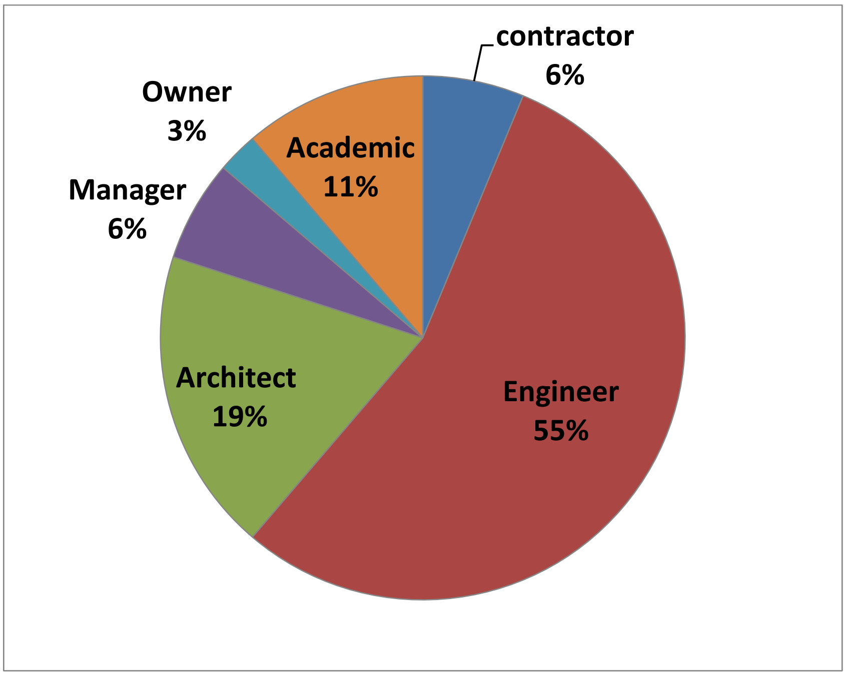

Figure 4: Working Position of the respondents with percentage

4.2.2 Educational Level

The majority of respondents' educational level was the Bachelor Degree (BSc.) (75%), and the others having MSc (13%), PhD (8%), and High Diploma (4%) as seen in Figure 5.

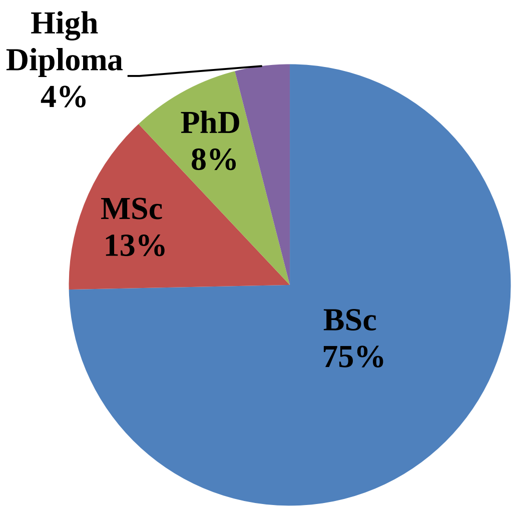

Figure 5: Respondents educational level

4.2.3 Experience

As seen in Figure 6, 40 of the respondents holding 53% have an experience of 0–5 years, and the others having 16% (5-10 yrs), 15% (10-15 yrs), and 16% (+15 yrs) as shown in the figure.

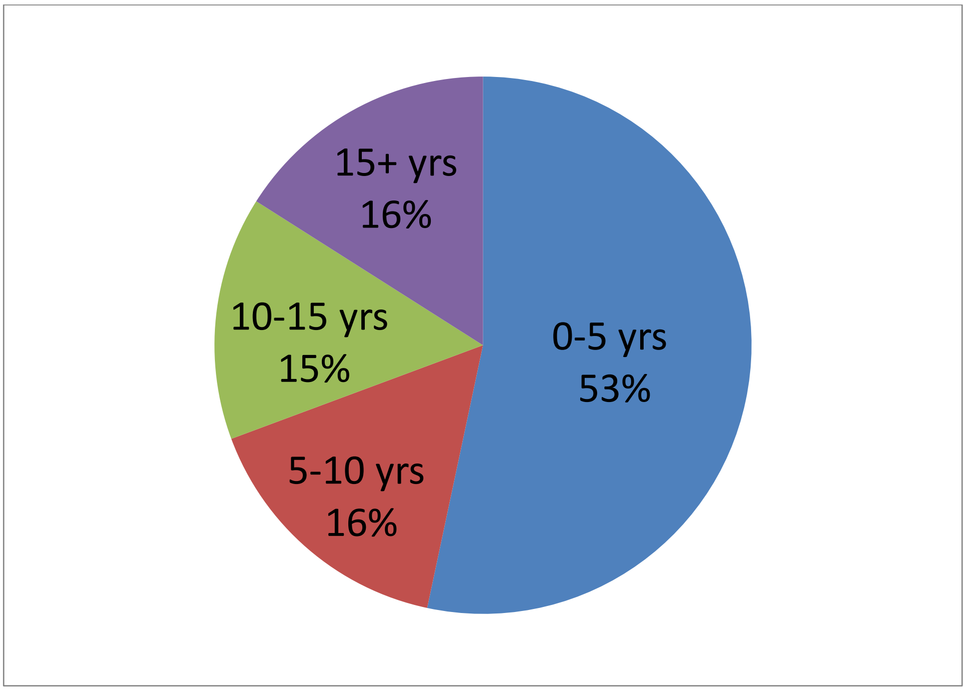

Figure 6: Respondents years of experience

4.2.4 Organisation Sector

Figure 7 shows convergent results of the ownership of the organisations. Since 39 respondents have declared that their companies were privately owned, they were asked to precisely portray their company type of work, whether it's a consultant, construction or design company. The results are shown in Figure 8.

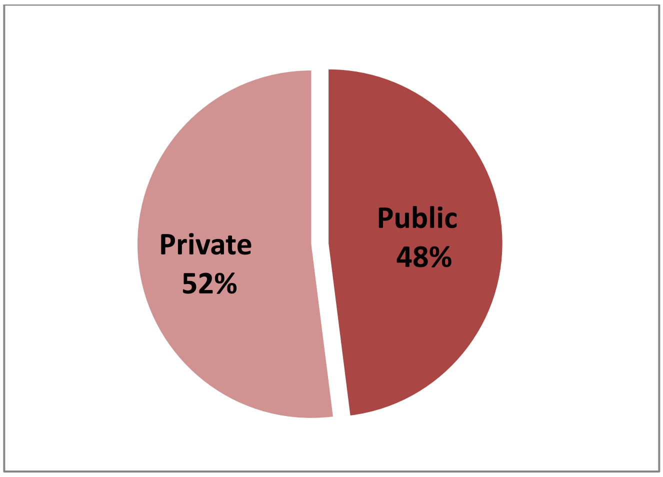

Figure 7: Ownership of the respondent's organisations

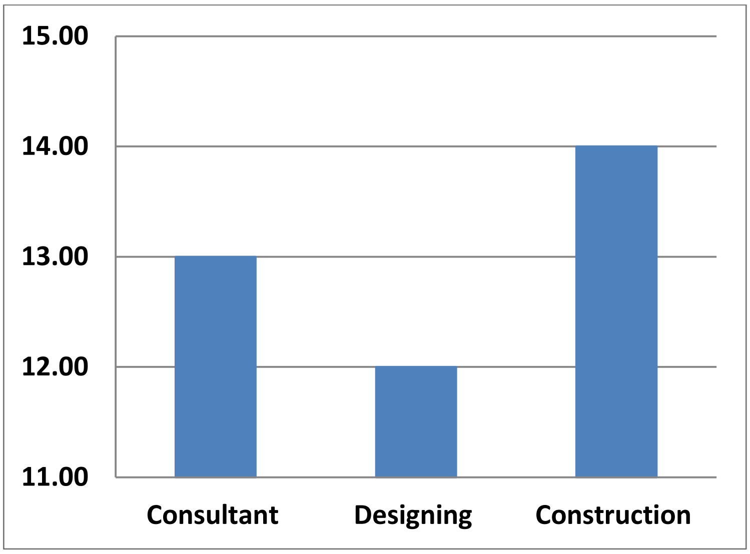

Figure 8: Private companies business types

4.2.5 Principal Industry of Organisation

Table 6, details the principle industry of the respondents' companies. One third (33.33%) of the companies are specialised in government buildings construction, and the rest as infrastructure (26.67%), residential (24%), commercial (8%), industrial (4%), and other (4%).

Table 6: Companies Principal Industry

Principal Industry	Number of Companies	Percentage (%)
Residential	18	24
Industrial	3	4
Commercial	6	8
Government	25	33.33
Infrastructure	20	26.67
Other	3	24
TOTAL	75	100

4.2.6 Organisations Employee

The majority of the respondents (44%) work in small companies that have not more than 15 employees, followed by 15 (20%) of respondents working in large companies with more than 100 employees. 14 (18.67%) respondents represent medium-sized firms with 31 to 50 employees. The respondents were from more than 30 different companies out of approximately 1,000 construction companies located in different parts of Libya. Table 7 illustrates the number of employees for each company size.

Table 7: Number of employees working in the respondent's organisations

Company Size	Number of Respondents	Percentage (%)
1-15	33	44
16-30	8	10.67
31-50	14	18.67
51-100	5	6.67
Over 100 employees	15	20
TOTAL	75	100

4.2.7 Location of the Companies

The respondents have been asked to locate their organisation headquarter, because this will guide the study to have a comprehensive and broad view of the respondents' background about the AEC industry.

Figure 9 demonstrates the location of the respondents' organisations. As it's clearly observed the majority of respondents 44 (58.67%) work in firms located in the capital city Tripoli. This is due to the capital population being more than 1.5 million and hence having an abundance of construction works. This is followed by Zintan city with 16%. In terms of the economic activities and executed construction projects the location of respondents are fitted quite agreeably.

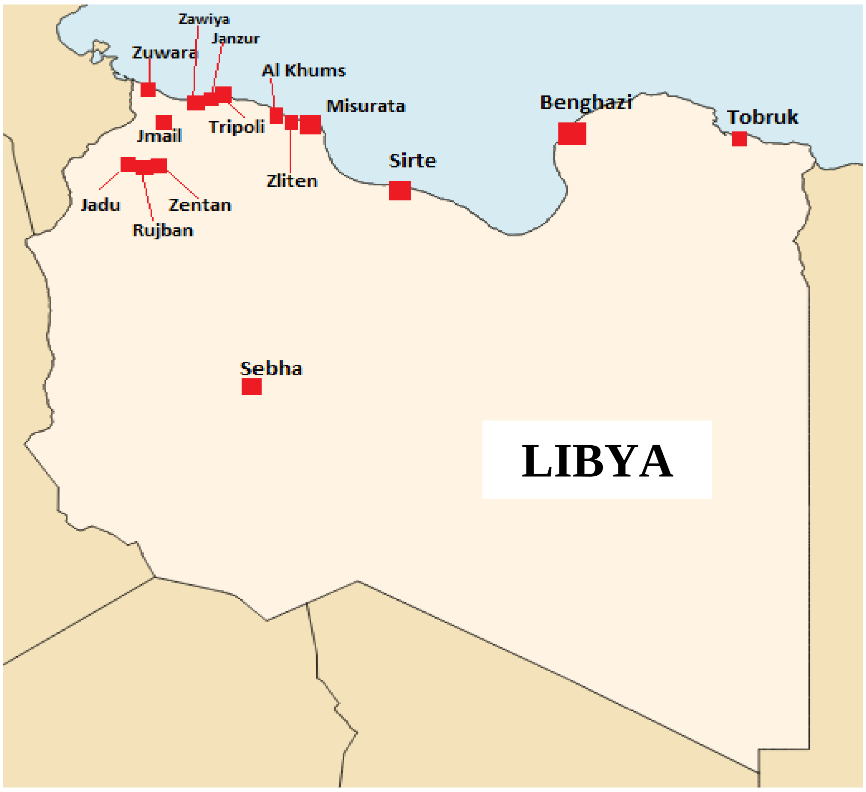

Figure 9: Location of respondents companies

4.2.8 Awareness of BIM

This part outlines the survey respondents' feedbacks based on their knowledge about BIM and to what extent.

As seen in Figure 10, 34 (45.33%) respondents have revealed that they are familiar or have known about BIM applications and solutions, on the other hand 41 (54.67%) of the survey respondents have no idea or are unfamiliar with BIM.

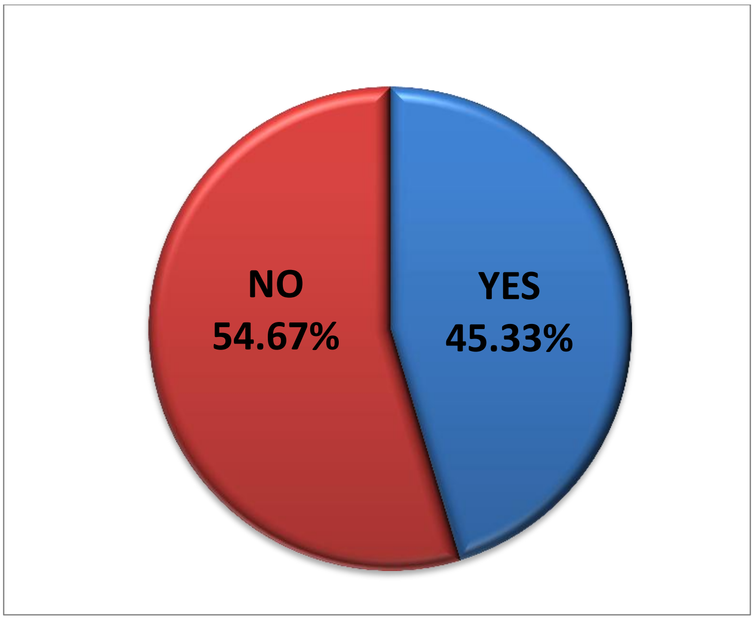

Figure 10: Awareness of BIM

4.3 Factor Analysis and Reliability Test (Cronbach α)

For ensuring the reliability of the questionnaire factors, Cronbach's alpha is being used to check the internal consistency of these factors. This reliability coefficient (α) has been determined for each of the categories aforementioned. The loading factors had a minimum value of 0.593 and a maximum of 0.856, indicating that some factors have high and low acceptable levels of reliability. For barriers section, Personal barriers and Market barriers have scored the highest reliability coefficient (α) with values 0.797 and 0.745 respectively. Meanwhile, lack of education of BIM, lack of publicity and awareness, and lack of understanding of BIM and its benefits have achieved the highest factor loading of 0.842, 0.827, and 0.285 respectively. Table 8 display the results of Factor Analysis and Cronbach test for BIM Barriers section.

Table 8: Results of Factor Loading and Cronbach coefficient for BIM Barriers

Personal Barriers		
Barriers to BIM Implementation	**Factor Loading**	**Cronbach (α)**
Lack of education of BIM	0.842	0.797
Lack of understanding of BIM and its benefits	0.825	
Lack of insufficient training	0.814	
Lack of BIM knowledge in applying current technologies	0.758	
Lack of skills development (resisting to change)	0.747	
BIM Process Barriers		
Changing work processes (Lack of effective collaboration among project participants)	0.698	0.647
Risks and challenges with the use of a single model (BIM)	0.642	
Legal issues (ownership of data)	0.601	
Business Barriers		
The changing roles, responsibilities and payment arrangements	0.695	0.637
Cost of training	0.648	
Doubts about Return on Investment	0.644	
High Cost of implementation.	0.638	
Unclear benefits	0.606	
Complicated and time-consuming modelling process	0.593	
Technical Barriers		
Insufficient technology infrastructure	0.775	0.689
Lack of BIM technical experts	0.704	
Absence of standards and clear guidelines	0.668	
Current technology is enough	0.665	
Interoperability	0.631	

Table 8 continued.

Organisation Barriers		
Barriers to BIM Implementation	**Factor Loading**	**Cronbach (α)**
Absence of Other Competing Initiatives	0.762	0.693
Lack of Senior Management support.	0.738	
Difficulties in managing the impacts of BIM	0.664	
Unwillingness to change	0.658	
Magnitude of Change / Staff turnover	0.642	
Market Barriers		
Lack of publicity and awareness	0.827	0.745
Lack of client/government demand	0.806	
The market is not ready yet	0.602	

While for driving factors provide education at university level, top management support, and desire for innovation with competitive advantages and differentiation in the market have achieved the highest factor loading of 0.856, 0.848, and 0.846 respectively. Both External and Internal push categories have scored an acceptable reliability coefficient (α) values with 0.806 for internal and 0.793 for external push factors. Tables 9 and 10 display the results of Factor Analysis and Cronbach test for Drivers to BIM section.

Table 9: Results of Factor Loading and Cronbach coefficient for External Push Drivers

External Push for Implementing BIM in Libya		
Drivers to BIM Implementation	**Factor Loading**	**Cronbach α**
Provide education at university level	0.856	0.793
Collaboration with universities (Research collaboration and curriculum design for students)	0.842	
Clients provide pilot project for BIM	0.836	
Providing guidance on use of BIM	0.816	
Perceived benefits from BIM to client	0.818	
Promotion and awareness of BIM	0.811	
Government support and pressure in the implementation of BIM.	0.802	
Developing BIM data exchange standards, rules and regulations.	0.794	
Client pressure and demand the application of BIM in their projects	0.785	
Competitive pressure	0.708	
BIM required by other project parties	0.659	

Table 10: Results of Factor Loading and Cronbach coefficient for Internal Push Drivers

Internal Push for Implementing BIM in Libya		
Drivers to BIM Implementation	**Factor Loading**	**Cronbach α**
Top management support	0.848	0.806
Desire for innovation with competitive advantages and differentiation in the market.	0.846	
BIM training program to staff	0.829	
Improving built output quality	0.820	
Technical competence of staff	0.806	
Perceived benefits from BIM	0.804	
Safety into the construction process (reduce risk of accident)	0.801	
Cultural change	0.786	
Requirement for staff to be BIM competent	0.785	
Continuous investment in BIM	0.784	
Improving the capacity to provide whole-life value to client	0.781	
Financial resources of organization	0.77	

4.4 Relative Importance Index (RII) with Mean Scores and Standard Deviations (SD)

4.4.1 Barriers to BIM implementation

As mentioned previously, it has been considered that in order to be significant, a factor should have RII value as 0.8 or above and the weighted statistical mean (average) should score 4.0 or above. The results of the statistical mean score of each factor have been examined for their distribution using the frequencies command on SPSS. The results showed that all factors mean scores have acceptable curves graphs that are very close to a normal distributed curve. This distribution curve check strengthened the ranking of significant factors.

After conducting the RII analysis for the responses as seen in Table 11, the most significant barrier for personal barriers category is “Lack of BIM education” (RII= 0.853) which is also ranked 1st in the overall barriers ranking. This result is similar to Building Cost Information Service (BCIS) (2011) survey results conducted in both UK and the USA, in which the absence of BIM education were considered as a significant barrier.

The 2nd ranked barrier is “Lack of understanding of BIM and its benefits” (RII=0.835) and also it’s the 3rd most significant barrier in the overall ranking. The 3rd and last significant factor is “Lack of insufficient training” (RII= 0.824) and also it is ranked 4th in the overall ranking. Furthermore, the average group relative important index has scored a value of 0.807 making this personal barrier category a significant hurdle category for BIM implementation.

All factors of BIM process barriers, business barriers, technical barriers, and organisation barriers categories have RII values of less than 0.8, meaning that these barriers are not highly significant factors.

For the category of market barriers, the 1st ranked barrier is “Lack of publicity and awareness”, scoring a significant RII value of 0.840 which also lifts its overall barriers ranking to 2nd place. “Lack of client and government demand” is the 2nd significant barrier (RII=0.819) among market barriers and 5th significant barrier in the overall ranking. However, the average RII of this group scored the value of 0.703.

When ranking the overall barriers "The changing roles, responsibilities and payment arrangements" and "Changing work processes" barriers have scored equivalent RII value of 0.701. In order to differentiate the ranking of these two factors, the Standard Deviation (SD) for the factor "The changing roles, responsibilities and payment arrangements" scored a value of 1.005 which is less than 1.167 scored for "Changing work processes" barrier. Because of this the "The changing roles, responsibilities and payment arrangements" is ranked 12th in the overall ranking and the other is ranked 13th.

Moreover, the factors of "The market is not ready yet" and "Legal issues (ownership of data)" have the same RII score, statistical mean, and also standard deviation and therefore they are given a frequent ranking of 25th.

This concludes that personal barriers category is the dominant category among other five group of categories.

Table 11: Ranking of Barriers using Mean, Standard Deviation, and RII

Personal Barriers						
Group Rank	**Overall Rank**	**Barriers to BIM Implementation**	**Mean**	**SD**	**RII**	**Group RII**
1	1	Lack of education of BIM	4.267	1.082	0.853	0.807
2	3	Lack of understanding of BIM and its benefits	4.173	1.018	0.835	
3	4	Lack of insufficient training	4.120	1.090	0.824	
4	8	Lack of BIM knowledge in applying current technologies	3.840	1.103	0.768	
5	9	Lack of skills development	3.787	1.189	0.757	

Table 11 continued.

Group Rank	Overall Rank	Barriers to BIM Implementation	Mean	SD	RII	Group RII
BIM Process Barriers						
1	13	Changing work processes (Lack of effective collaboration among project participants)	3.507	1.167	0.701	0.655
2	20	Risks and challenges with the use of a single model (BIM)	3.253	1.015	0.651	
3	25*	Legal issues (ownership of data)	3.067	1.200	0.613	
Business Barriers						
1	12	The changing roles, responsibilities and payment arrangements	3.507	1.005	0.701	0.645
2	18	Cost of training	3.280	1.192	0.656	
3	19	Doubts about Return on Investment	3.267	1.178	0.653	
4	23	High Cost of implementation.	3.213	1.233	0.643	
5	24	Unclear benefits	3.093	1.307	0.619	
6	27	Complicated and time-consuming modelling process	2.987	1.033	0.597	
Technical Barriers						
1	6	Insufficient technology infrastructure	3.933	1.057	0.787	0.700
2	11	Lack of BIM technical experts	3.587	1.242	0.717	
3	14	Absence of standards and clear guidelines	3.387	1.184	0.677	
4	16	Current technology is enough	3.373	1.383	0.675	
5	22	Interoperability	3.213	1.211	0.643	
Organisation Barriers						
1	7	Absence of Other Competing Initiatives	3.867	1.095	0.773	0.703
2	10	Lack of Senior Management support.	3.747	1.206	0.749	
3	15	Difficulties in managing the impacts of BIM	3.373	1.228	0.675	
4	17	Unwillingness to change	3.347	1.457	0.669	
5	21	Magnitude of Change / Staff turnover	3.253	1.187	0.651	

Table 11 continued.

Market Barriers						
1	2	Lack of publicity and awareness	4.200	0.986	0.840	0.757
2	5	Lack of client/government demand	4.093	1.147	0.819	
3	25*	The market is not ready yet	3.067	1.200	0.613	

* Both factors ranked 25th, because they scored identical RII, Mean, and Standard Deviation.

The top five (5) significant factors are summarised and matched with the results obtained from previous research as seen in Table 12.

Table 12: Summary of top significant BIM Barriers in Libya matched with results from previous researches

Ranking	Top Barriers to BIM Implementation	Similar Results
1	Lack of BIM education	▪ Building Cost Information Service (BCIS), 2011
2	Lack of publicity and awareness	▪ Gu & London, 2010
3	Lack of understanding of BIM and its benefits	▪ Newton & Chileshe, 2012; ▪ Zuhairi et al, 2014
4	Lack of insufficient training	▪ Building Cost Information Service (BCIS), 2011; ▪ Gu & London, 2010; ▪ Lindblad, 2013; ▪ Nanajkar, 2014; ▪ Young et al., 2008
5	Lack of client/government demand	▪ Building Cost Information Service (BCIS), 2011; ▪ Kiani et al., 2015; ▪ Lindblad, 2013; ▪ Zuhairi et al, 2014

4.4.2 Driving factors for BIM implementation

The analysis of the results as seen in Table 13 and Table 14 displayed high RII values for the majority of BIM driving factors; nevertheless the external push factor "Provide education at university level" is the most prominent factor (RII=0.864). This goes along with the 1st ranked barrier "Lack of BIM education" as an indication that to help accelerate the adoption of BIM, educating future architects and engineers is a must. "Top management support" (RII=0.859) and "Desire for innovation with competitive advantages and differentiation in the market" (RII=0.853) are the 2nd and 3rd most overall influential factors, proving that an organization's top managers needs to support the transition from paper-based design and transactions to an electronic 3D modelling. The 3rd overall driver will allow the firm to improve its quality and efficiency of executed jobs and also will give them more advantages in the market. "Collaboration with universities (Research collaboration and curriculum design for students)" is the 4th overall ranked driver with RII value of 0.843. The result of total average of RII showed that the "Internal push drivers for implementing BIM in Libya" (RII=0.814) is larger than the External push drivers for implementing BIM in Libya" (RII=0.8) and both are considered as significantly affecting the adoption of BIM. The results show the external push group have more critical factors (8 factors) than internal push group (7 factors). Clearly this displays that, to expedite the implementation of this technology in the Libyan AEC industry, the main spotlight will be on these 15 influential factors.

Table 13: Ranking of External Push Drivers using Mean, Standard Deviation, and RII

Group Rank	Overall Rank	Drivers to BIM Implementation	Mean	SD	RII	Group RII
External Push for Implementing BIM in Libya						
1	1	Provide education at university level	4.320	1.092	0.864	0.800
2	4	Collaboration with universities (Research collaboration and curriculum design for students)	4.213	0.934	0.843	
3	5	Clients provide pilot project for BIM	4.200	1.017	0.840	
4	8	Providing guidance on use of BIM	4.133	0.991	0.827	
5	9	Perceived benefits from BIM to client	4.120	0.770	0.824	
6	10	Promotion and awareness of BIM	4.093	1.141	0.819	
7	13	Government support and pressure in the implementation of BIM.	4.053	0.943	0.811	
8	15	Developing BIM data exchange standards, rules and regulations.	4.000	0.986	0.800	
9	18	Client pressure and demand the application of BIM in their projects	3.973	1.185	0.795	
10	22	Competitive pressure	3.573	1.210	0.715	
11	23	BIM required by other project parties	3.320	1.176	0.664	

Table 14: Ranking of internal push drivers using mean, standard deviation, and RII

Group Rank	Overall Rank	Drivers to BIM Implementation	Mean	SD	RII	Group RII
Internal Push for Implementing BIM in Libya						
1	2	Top management support	4.293	0.927	0.859	0.814
2	3	Desire for innovation with competitive advantages and differentiation in the market.	4.267	0.811	0.853	
3	6	BIM training program to staff	4.173	0.992	0.835	
4	7	Improving built output quality	4.133	0.827	0.827	
5	11	Technical competence of staff	4.080	0.897	0.816	
6	12	Perceived benefits from BIM	4.067	0.875	0.813	
7	14	Safety into the construction process (reduce risk of accident)	4.053	0.999	0.811	
8	16	Cultural change	3.987	1.059	0.797	
9	17	Requirement for staff to be BIM competent	3.973	0.986	0.795	
10	19	Continuous investment in BIM	3.960	0.877	0.792	
11	20	Improving the capacity to provide whole life value to client	3.974	0.853	0.789	
12	21	Financial resources of organisation	3.920	0.882	0.784	

The resultant top significant driving factors are summarised and compared with previous researches as seen in Table 15.

Table 15: Summary of top significant BIM Drivers in Libya compared with results from previous researches

Ranking	Top Drivers to BIM Implementation	Similar Results
1	Provide education at university level	▪ Kiani et al., 2015
2	Top management support	▪ Tsai et al., 2014; ▪ Zikic, 2009; ▪ Zuhairi et al, 2014
3	Desire for innovation with competitive advantages and differentiation in the market.	▪ Takim et al., 2013
4	Collaboration with universities (Research collaboration and curriculum design for students)	-
5	Clients provide pilot project for BIM	-

4.5 Pearson Correlation and Significance test Analyses

Pearson's Correlation analysis is applied using SPSS to detect if there are some positive or negative relationships among the five (5) significant barriers found from RII analysis. Three hypotheses were tested using the aforementioned methods of analysis described in section 3.7.3. The significance of a relationship is indicated by a ρ-value. If the ρ-value is less than or equal to 0.05, then the relationship between the two variables is significant. The results are displayed in Table 16.

Table 16: Pearson Correlation Analysis for the top five significant barriers

Variables		1	2	3	4	5
Lack of education of BIM	**Correlation** ρ-value	**1.000**				
Lack of publicity and awareness	**Correlation** ρ-value	**0.468*** 0.001	**1.000**			
Lack of understanding of BIM and its benefits	**Correlation** ρ-value	**0.693*** 0.001	**0.396*** 0.001	**1.000**		
Lack of insufficient training	**Correlation** ρ-value	**0.694*** 0.001	**0.518*** 0.001	**0.529*** 0.001	**1.000**	
Lack of client/government demand	**Correlation** ρ-value	**0.565*** 0.001	**0.420*** 0.001	**0.485*** 0.001	**0.425*** 0.001	**1.000**

* Correlation is significant at the 0.01 level (2-tailed).

From the previous table above, the coefficient of correlation (r) shows the moderate correlation for all correlations between variables. Since all interactions ρ-value results are 0.001 is less than 0.05, this means that all relationships between the five barriers are significant at 99% confidence (0.01 significance level), and they all positively affect each other.

4.6 Hypotheses Testing

As mentioned in earlier, three hypotheses were tested using t-test method. Three of the hypotheses are tested to know if there is a significant correlation of the top four significant drivers resulted from RII test. Each hypothesis was tested as follows:

H_0 = Null hypothesis.

H_1 = Alternative hypothesis.

4.6.1 Hypothesis One

The 1st hypothesis will test if there is a significant correlation between the top management support of an organisation and BIM education at the universities in Libya. The hypothesis will be as follows.

H_0: Provide education at university level factor doesn't have significant interaction with Top management support factor.

H_1: Provide education at university level factor does have significant interaction with Top management support factor.

Using SPSS to generate independent sample t-test, the results revealed a significance of 0.248 obtained from the Levene's test column; this value is larger than the significance level of 5%. Thus, the values will be read from "equal variances assumed" (1st) row. Table 17 displays t-test results for tested hypothesis one, the t-test results gave a significance (2-tailed) of 0.872 which is greater than 0.05, therefore the author fails to reject the null hypothesis (H_0) and concludes that:
There is no significant interaction between "Provide education at university level" factor and "Top management support" factor in Libya.

4.6.2 Hypothesis Two

The 2nd hypothesis will be tested if there is a significant relationship between the support of top managerial level and their company's motivation towards innovations to achieve competitive advantages and desire for differentiation in the market by using new construction technologies. The 2nd hypothesis will be as follows.

H_0: Top management support doesn't have significant interaction with Desire for innovation with competitive advantages and differentiation in the market.

H_1: Top management support factor does have significant interaction with Desire for innovation with competitive advantages and differentiation in the market.

The obtained results from the t-test are given on Table 18. The significance value obtained from the Levene's test for equality of variances is 0.535 which is larger than the significance level of 0.05. Therefore, values from equal variances assumed 1st row are taken into consideration. The t-test result displayed a significance (2-tailed) value of 0.851 which is larger than 0.05. Hence, it is failed to reject the null hypothesis (H_0) and concluded that:

There is no significant interaction between top management support and the motivation of the companies towards innovation to achieve competitive advantages and differentiation over the market in the Libyan construction industry.

4.6.3 Hypothesis Three

The 3rd hypothesis will be tested if there is a significant relationship between the Libyan construction companies motivation towards innovation to achieve competitive advantages and differentiation over the market and their collaboration with universities for conducting researches on BIM implementation. The 3rd hypothesis will be as follows.

H_0: Desire for innovation with competitive advantages and differentiation in the market doesn't have significant interaction with Collaboration with universities.

H_1: Desire for innovation with competitive advantages and differentiation in the market does have significant interaction with Collaboration with universities.

The obtained results from the t-test are given on Table 19. The significance value obtained from the Levene's test for equality of variances is 0.926 which is larger than the significance level of 0.05. Therefore, values from equal variances assumed (1st) row are taken into consideration. The t-test result displayed a significance (2-tailed) value of 0.369 which is larger than 0.05. Hence, it is failed to reject the null hypothesis (H_0) and concluded that:

There is no significant interaction between the motivation of Libyan construction companies towards innovation to achieve competitive advantages plus differentiation over the market and their collaboration with universities for conducting researches on BIM implementation.

Table 17: t-test results for “Provide education at university level” and “Top management support” factors

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
scale	Equal variances assumed	1.343	.248	.161	148	.872	.02667	.16542	-.30022	.35355
	Equal variances not assumed			.161	144.164	.872	.02667	.16542	-.30029	.35363

Table 18: t-test results for “Top management support” and “Desire for innovation with competitive advantages and differentiation in the market” factors

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
scale	Equal variances assumed	.387	.535	.188	148	.851	.02667	.14219	-.25432	.30766
	Equal variances not assumed			.188	145.443	.851	.02667	.14219	-.25436	.30770

Table 19: t-test results for “Desire for innovation with competitive advantages and differentiation in the market” factor and “Collaboration with universities” factor

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
scale	Equal variances assumed	.009	.926	.902	148	.369	.13333	.14786	-.15885	.42552
	Equal variances not assumed			.902	142.427	.369	.13333	.14786	-.15895	.42561

Chapter 5

CONCEPTUAL FRAMEWORK FOR IMPLEMENTING BIM IN LIBYA

5.1 Introduction

This chapter provides a conceptual framework for implementing BIM in the Libyan construction industry developed by the researcher. This framework model represents the resulted critical factors which have vital impact to implementing BIM in the Libyan AEC industry. The framework consists of three categories they are government, people, and organisation. Moreover, the framework (Figure 11) based on seven significant factors which are placed in steps:

1. Government Support
2. BIM Education
3. Publicity and Awareness
4. Top Management Support
5. Staff Training
6. Pilot BIM Project
7. Client Demand

5.2 Government Support

Government support is one of the largest facilitators to BIM adoption. The government should take the lead to increase the demand for BIM implementation in their projects. A BIM guideline should be developed for the contractors. The government should fully support the adoption of BIM in their construction projects. Libyan Government should recognise the benefits of BIM and try to encourage private sectors to implement BIM in their projects. Also, the firms in the private sector play their role by discussing with the government to develop Libyan BIM standard and guideline through various working group discussions.

5.3 BIM Education

Most of the practicing designers are educated and trained in the conventional 2D CAD environment. To accelerate the uptake of BIM in design firms, BIM training for practitioners and future designers is indispensable. Professional bodies should work with universities to review the curriculum for civil engineering and architectural studies so as to adopt BIM as their major instructional platform.

Curricula of the courses should aim at developing students with both the drafting skills and collaborative skills in the BIM environment. However, the leading role of the government must not be ignored. Without clear BIM guidelines established by the government, the quality of these BIM courses could vary considerably.

5.4 Publicity and Awareness

Raising awareness for the Libyan construction organisations as well as industry in general is a must to facilitate BIM implementation. Raising awareness of BIM for the clients and providing guidance and support documentation as well as case studies are needed to promote the uses of BIM. Case studies will increase awareness of BIM, and the benefits of using it for a variety of clients will increase the understanding of BIM concept.

5.5 Top Management Support

The motivation to adopt BIM in Libya must be driven from the top managerial level. Implementing BIM requires commitment from every level of the business, but senior management is an essential role in the adoption of construction technologies. Managers need to be given a realistic view of the impact of the changes, as well as the potential benefits so that the budgets will be given, people will be trained and normal business activities will be disrupted.

5.6 Staff Training

This point is quite the same as the need of BIM education. Libyan companies should design appropriate training for their employees. Moreover, the government should provide training for the application of BIM in the construction industry. This will give a great push for construction firms to adopt BIM since they have BIM trained staff.

5.7 Pilot BIM Project

The Libyan construction companies should discuss how to spearhead the transition to BIM. Firms should have a BIM implementation plan for using pilot project by means of the appropriate software after training the employees on the specific software. They should also plan on a BIM pilot project to demonstrate success and then use that success story as a launch pad to rollout BIM to the rest of the organisation.

5.8 Client Demand

Client demand of BIM plays a major role in its adoption and implementation within an organisation. BIM can be required by the clients if they see the advantages and benefits of BIM such as the aforementioned BIM benefits for clients. Since Libyan Government is the largest client in the construction industry the government should take the lead to increase the demand for BIM implementation in her projects. This demand will make the contractors prepare themselves for the implementation of BIM in their own companies.

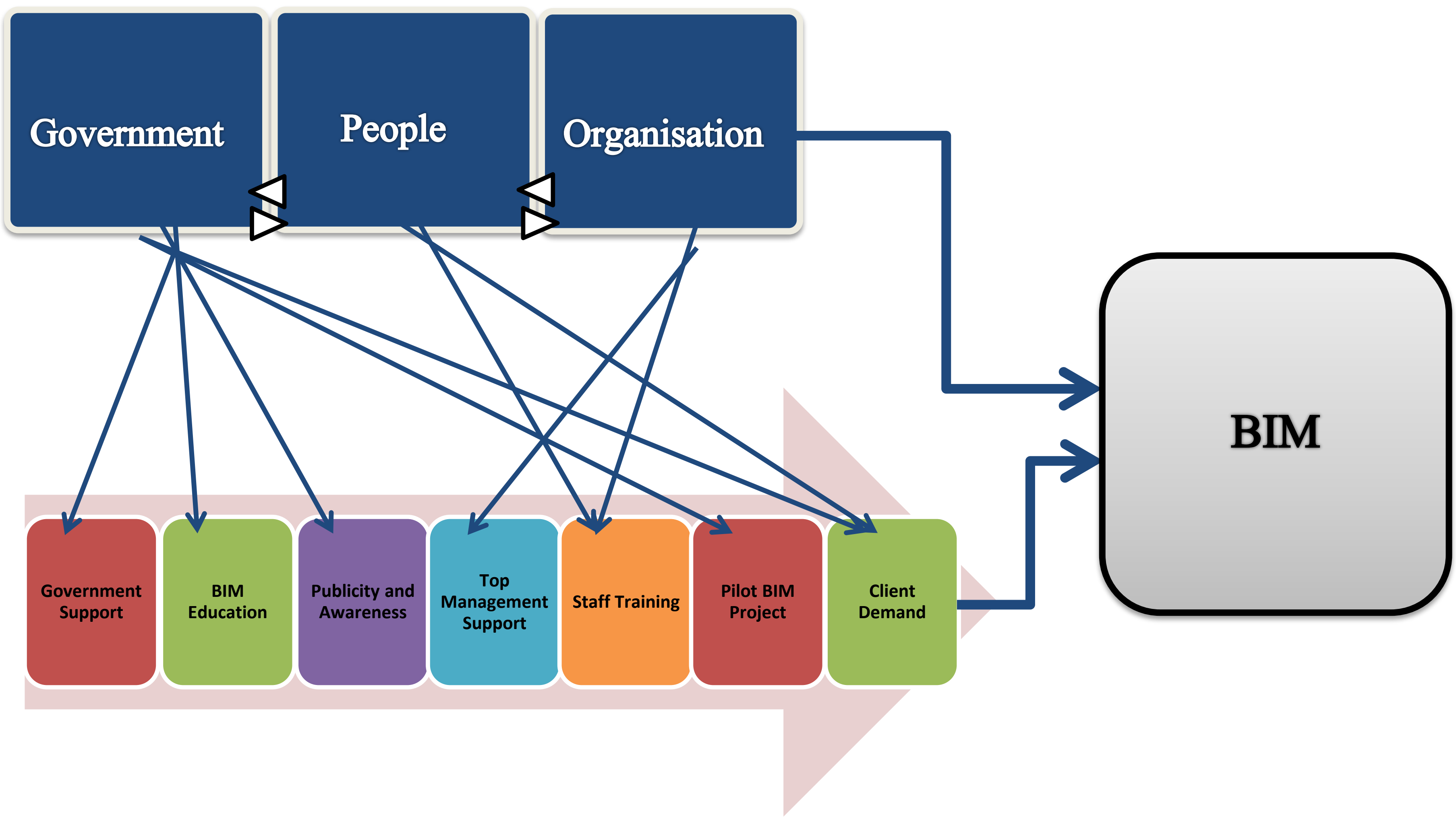

Figure 11: Conceptual Framework for the adoption of BIM in Libya

Chapter 6

CONCLUSION

6.1 Introduction

This chapter is divided into three parts. An overall assessment and conclusion of the questionnaire survey analyses results are summarised in the first two parts whereas, the third part provides recommendations for the Libyan related authorities and AEC industry practitioners, where suggestions are presented for future studies.

6.2 Conclusion

After the completion of this study, the conclusions are given in points as follows:

1. Personal barriers are considered the most effective hurdles for implementing BIM in the Libyan construction industry followed by the market barriers category.

2. The absence of BIM education in colleges and universities is by far the most significant barrier succeeded by the lack of publicity and awareness of BIM, lack of practitioners understanding of BIM and its benefits, lack of insufficient training for employees, and lack of client or government demand and pressure as seen in Table 20.

3. All the above mentioned top five significant barriers have positive relationships between them with a significance level of 0.01.

4. According to the survey analysis more than half of driving factors (15 factors) are affecting the facilitation of BIM adoption.

5. Providing education at university level and top management support are the top significant factors with RII values of 0.864 and 0.859 respectively, followed by the organization desire for innovation with competitive advantages and differentiation in the market then firms collaborating with universities for further researches on BIM as seen in Table 2.

6. The conducted hypotheses concluded that there is no significant interaction between the top driving factors mentioned above in point 5.

Table 20: Summary of top significant BIM Barriers in Libya

Ranking	Top Barriers to BIM Implementation
1	Lack of BIM education
2	Lack of publicity and awareness
3	Lack of understanding of BIM and its benefits
4	Lack of insufficient training
5	Lack of client/government demand

Table 21: Summary of top significant BIM Drivers in Libya

Ranking	Top Drivers to BIM Implementation
1	Provide education at university level
2	Top management support
3	Desire for innovation with competitive advantages and differentiation in the market.
4	Collaboration with universities (Research collaboration and curriculum design for students)
5	Clients provide pilot project for BIM

6.3 Suggestions

For further studies the following recommendations are stated:

1. The related authorities of the Libyan construction industry should consider the results of this study to accelerate and assist in establishing a roadmap and a framework for implementing BIM.

2. In order to develop the construction sector in Libya the government should give more attention for projects using BIM.

3. The government should recruit relevant experts and BIM specialist in order to establish BIM guide, standards, rules and regulations for the use in the Libyan construction sector.

4. The Libyan construction companies and clients should collaborate with researchers to seek the benefits of implementing BIM in Libya by providing a pilot project using BIM.

5. In order to spread BIM knowledge in the Libyan construction industry, Building Information Modelling should be taught in the architecture and civil engineering departments in the majority of Libyan universities.

6. Future researches should be carried out for establishing a framework for adoption of BIM in construction industry using the results of this study.

7. Future researches should establish action steps for implementing BIM.

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APPENDIX

Appendix A: Questionnaire Survey Sample

Section 1: Personnel information

1- **Working position:**
   a) Manager
   b) Architect
   c) Engineer
   d) Contractor
   e) research / academic
   f) Owner
   g) Other

2- **What is your qualification level**
   a) BSc
   b) MSc
   c) PhD
   d) other

3- **Years of experience:**
   a) 0-5 yrs
   b) 5-10 yrs
   c) 10-15 yrs
   d) 15+ yrs

4- **what is your organization sector:**
   a) Public
   b) Private

5- **If private is your organisation:**
   a) Consultant
   b) Designing
   c) Construction
   d) Other (please specify)

6- **Which of the following best describes the principal industry of your organisation**
   a) Residential
   b) Industrial
   c) Infrastructure
   d) Commercial
   e) Government
   f) Other

7- **Number of organisation employees:**
   a) 1-15
   b) 16-30
   c) 31-50
   d) 51-100
   e) Over 100 employees

8- **Did you know/hear about Building Information Modelling (BIM)?**
   - YES
   - NO

9- **Which city your organisation located in (please specify):**
   ....

Section 2: Barriers to BIM adoption

To what extent do you agree with the following barriers?

- **Personal barriers:**

Barriers to BIM adoption	1 Strongly disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly agree
1- Lack of insufficient training					
2- Lack of understanding of BIM and its benefits					
3- Lack of skills development (resisting to change)					
4- Lack of BIM education					
5- Lack of BIM knowledge in applying current technologies					
6- Other (please specify)					

- **BIM process barriers:**

Barriers to BIM adoption	1 Strongly disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly agree
1- Legal issues (ownership of data)					
2- Risks and challenges with the use of a single model (BIM)					
3- Changing work processes (Lack of effective collaboration among project participants)					
4- Other (please specify)					

- **Business barriers:**

Barriers to BIM adoption	**1** Strongly disagree	**2** Disagree	**3** Neutral	**4** Agree	**5** Strongly agree
1- High Cost of implementation.					
2- Unclear benefits					
3- Doubts about Return on Investment					
4- The changing roles, responsibilities and payment arrangements					
5- cost of training					
6- Complicated and time-consuming modelling process					
7- Other (please specify)					

- **Technical barriers:**

Barriers to BIM adoption	**1** Strongly disagree	**2** Disagree	**3** Neutral	**4** Agree	**5** Strongly agree
1- Lack of BIM technical experts					
2- Interoperability					
3- Absence of standards and clear guidelines					
4- insufficient technology infrastructure					
5- Current technology is enough					
6- Other (please specify)					

- **Organisation barriers:**

Barriers to BIM adoption	1 Strongly disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly agree
1- Lack of Senior Management support.					
2- Difficulties in managing the impacts of BIM					
3- Absence of Other Competing Initiatives					
4- Unwillingness to change					
5- Magnitude of Change / Staff turnover					
6- Other (please specify)					

- **Market Barriers**

Barriers to BIM adoption	1 Strongly disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly agree
1. Lack of client/government demand.					
2. The market is not ready yet.					
3. Lack of publicity and awareness					

Section 3: Factors influencing BIM implementation

To what extent do you agree with the following influential factors?

- **External Push**

Factors influencing BIM adoption	1 Strongly disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly agree
1. Government support and pressure in the implementation of BIM.					
2. Client pressure and demand the application of BIM in their projects					
3. Provide education at university level					
4. Developing BIM data exchange standards, rules and regulations.					
5. Providing guidance on use of BIM					
6. BIM required by other project parties					
7. competitive pressure					
8. Promotion and awareness of BIM					
9. Clients provide pilot project for BIM					
10. Collaboration with universities (Research collaboration and curriculum design for students)					
11. Perceived benefits from BIM to client					

- **Internal Push**

Factors influencing BIM adoption	1 Strongly disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly agree
1. Top management support					
2. Cultural change					
3. Improving built output quality					
4. Perceived benefits from BIM					
5. Technical competence of staff					
6. Financial resources of organization					
7. Desire for innovation with competitive advantages and differentiation in the market.					
8. Improving the capacity to provide whole life value to client					
9. safety into the construction process (reduce risk of accident)					
10. BIM training program to staff					
11. Requirement for staff to be BIM competent					
12. Continuous investment in BIM					