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Assessing the Capacity of Construction Consultants to adopt Building Information Modeling in Ghana

By

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DECLARATION

I hereby declare that this submission is my own work towards the MSc Construction Management degree and that, to the best of my knowledge, it contains no material previously published by another person, nor material which has been accepted for the award of any degree of the university, except where due acknowledgement has been made in the text.

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ABSTRACT

The inadequate flow of information within the building construction industry has had serious consequences on the performance of built-environment consultants in Ghana, and this often affects the output of every role player in the industry. Drawing from this the current study seeks to explore the adoption of Building Information Modeling (BIM) among construction consultants in the Greater Accra region. In this exploratory study, 182 questionnaires were administered to construction consultants in the Greater Accra region. However, 100 of the questionnaires were returned given a response rate of 60%. The result of the study showed that notwithstanding the high level of knowledge and awareness of BIM among construction consultants, the level of adoption is still low (7.0%), and lags behind the level of adoption of the technology in the construction sectors in the developed world. The low level of adoption can principally be attributed to the limited capacity of the construction consultants' ability to produce an IT environment that is adaptable to BIM, produce capable system integration, and the absence of capable human resource. The absence of government pressure and consultant's limited experience in BIM usage are also the possible reasons for the low adoption of BIM by the construction consultants in the Greater Accra region. Irrespective of the adoption level, the consultants perceive BIM to accelerate collaboration within project teams, reduce data input and transfer errors, speed up analysis cycle times, improve customer relationship, enhance time management, reduces cost and improves profitability. Based on these findings, the study recommends government policy enforce BIM adoption, training of the human resource in BIM, provide financial and managerial support to BIM adoption.

TABLE OF CONTENTS

LIST OF TABLES

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

Flow of information among consultants in the construction industry has experienced continuous evolution over the years. From the early days of civilization, architects communicated their ideas to the design team by drawing on tree barks, stone tablets and even in the sand (Zeiss, 2013).

According to Vinod Kumar (2009), the beginning of orthographic drawings and perspectives can be traced back as far as during the renaissance era when Filippo Brunelleschi represented the plans in drawing format for Santa Maria del Fiore in Italy in order for the patrons to understand how the building would look like.

Timely flow of information has always been the backbone of achieving smooth execution and maintenance of a project throughout its life cycle. The importance of timely correspondence is buttressed by a study that suggests that project managers spend 75% of their time communicating and handling data (Dawood et al., 2002).

Clients and consultants desire to achieve project goals within the stipulated timeline and budget. Currently, construction consultants are faced with the challenge of exchanging project information on time in order to facilitate work. The consequences are therefore very dire if a consultant does not update other team members with information on changes timely.

However there has been a breakthrough in construction industry that will perhaps drive construction projects to better meet timelines, budget and deliver quality works. This is known as Building Information Modeling (BIM).

BIM can also be referred to as computer-integrated project due to its process and technology application in project delivery (Harris, 2008).

Stakeholders regard BIM as the end results of many years of evolution in graphical representation of buildings which has finally resulted in virtual models that can be through the lifecycle of projects. This model can be useful from the design, construction and facility operation stages to final demolition (Eadie et al., 2013).

BIM uptake is quickly spreading worldwide. The Government of United Kingdom (UK) has the vision to reduce the cost of its construction projects by 20%. The aim of this initiative is to decrease their carbon footprint to meet European Union (EU) carbon footprint directives. To achieve this, the UK government taken several initiatives which includes but not limited to commitment to BIM adoption for government projects over a timeframe of 5 years with specific objective of reaching level 2 BIM from 2016 (Zeiss, 2013).

1.2 PROBLEM STATEMENT

Chris (2009) states that construction projects are characterized by interdependent activities, work packages and project tasks. Over the years, construction projects has endured cost and time overruns, low productivity, high level of waste, disputes and high level of fragmentation. (Xue et al., 2005).

Egan (1998) in "Rethinking Construction" also states that within the construction industry almost 10% of materials are wasted and 30% of construction is rework. This also confirms the need to adopt effective strategies to mitigate the problem.

According to Eastman et al. (2010), more decisions and great effort are needed in the development of a 3D model that supports fabrication and analysis than the existing 2D method of producing construction documents. It has been established most firms that

followed these procedures have realized productivity benefits at the construction documentation level regardless of the initial migration cost.

In order to achieve project goals within stipulated time, project managers must be able to properly monitor and coordinate the activities of both Consultants and Contractors effectively. However, this has become a difficult task as Consultants predominantly work from their various offices with various software packages. This has made it difficult for Project managers and other team members to interpret and integrate information. A solution to this problem is of utmost necessity if the construction industry is to flourish.

1.3 RESEARCH QUESTIONS

1. What is the level of awareness of BIM by construction Consultants.
2. What are the factors influencing adoption of BIM by construction Consultants?
3. What is the state of construction consultancy firms capacity to adopt BIM into practice

1.4 AIM

This research seeks to assess the capacity of Consultants to adopt Building Information Modeling in Ghana

1.5 OBJECTIVES

1. To identify the level of awareness of BIM by construction Consultants
2. To identify the factors influencing the adoption of BIM
3. To determine the state of construction consultancy firms' capacity to adopt B.I.M into practice.

1.6 SCOPE

The scope of this research project is limited to construction consultancy firms in Greater Accra, Ghana. This is because the B.I.M process is widely initiated by Consultants at the design stages. It is important to add that there are many Consultants operating within the Building construction industry. However, this research focuses largely on Architects, Quantity Surveyors, and structural Engineers. Services Engineers, geotechnical Engineers and other allied professionals are not covered by this research due to limited time and resources of the researcher.

1.7 METHODOLOGY

The current study adopts an exploratory design. Source of data used for the study were mainly primary data. Cross-sectional data were collected through a field survey of Construction professionals comprising of Quantity Surveyors, Structural Engineers and Architects. Stratified sampling technique was adopted for this research.

In collecting data for the study, a questionnaire was developed and divided into two parts. The first part, section "A" requested the background information of the respondents. Section "B" was developed to achieve the specific objectives including but not limited to assessing the capacity of consultancy firms to adopt BIM. In this section, respondents were asked rate on a five-point likert scale (where 1= No extent, 2= Very low extent, 3= low extent, 4= high extent, 5= Very high extent), their organisational structure's adaptability to BIM adoption. Section 'B' also sought to find out the factors influencing adoption of BIM among consultancy firms.

1.8 ORGANISATION OF STUDY

The research is organized into five chapters as follows:

- Chapter one is devoted to the general introduction of the study, problem statement, aims and objectives of the research and research methodology adopted.
- Chapter two covers the literature search and touched on areas including but not limited to drivers of BIM adoption, strategies of implementing BIM, influences of BIM adoption
- Chapter three is devoted to the methodology and entails a description of the research method used in this study.
- Chapter four is devoted to analysis of data collected and discussion of results.
- Chapter five is devoted to conclusion of the findings of the research, recommendations and further research.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

The simple theory behind Building information modeling is well defined by Thompson and Miner (2009), in that; if all relevant data associated with a project were stored in a single online framework, the project could be executed in a virtual environment first. When dimensions of time (scheduling) and costs are added to the model this results in easy cost-time benefit.

Building Information Modeling (BIM) is a collaborative method of working, supported by the digital technologies which unravel more efficient methods of designing, creating and maintaining our assets analysis of diverse options almost immediately.

(Government, 2012).

2.2 DRIVERS FOR BIM ADOPTION

2.2.1 Government pressure

During execution of electronic practices, Government sector organizes and makes available necessary documentation to guarantee good practice (Eadie et al., 2013). According to U.K Cabinet office, (2011) the United Kingdom (U.K) Government requires fully collaborated 3 Dimensional BIM (including all project data and necessary documentation in electronic format) as the least requirement by 2016. A phased schedule with required milestones demonstrating quantifiable progress will be published at the end of the year. As of 2016, BIM level 2 is mandatory for all government funded projects (Controller, 2011).

In UK, BIM industry group (2011) classifies BIM levels as follows:

- *Level 0* – Unguided Computer Aided Design information, most likely 2 Dimensional with utilization of paper as most likely mode of information exchange.
- *Level 1* – Managed Computer Aided Design 2D or 3D format using BS1192:2007 with a collaborative software to provide a common data platform. This is conceivably a commercial data managed by standalone cost management software packages without any form of coordination.
- *Level 2* – Controlled 3 Dimensional environment hosted in isolated discipline with accompanying (design and production) information. This system sometimes makes use of 4D schedule information and 5D cost information.
- *Level 3* – This involves a fully integrated and coordinative process whereby information flows freely and is empowered by the use of web services. This synchronization of design information and other data is managed by a central server and known as iBIM or Integrated BIM.

2.2.2 Client/competitive pressure

There has been the emergence of high completion in the Construction Industry. This situation has been worsened by the downward economic recession. Not only are Consultants expected to provide services using BIM, but also to justify their capacity through a reputation of managing BIM projects successfully. Lu and Li (2011) as referred to in Eadie et al., (2013) points out that this is achievable through demonstrating views on the maturity triangle (People, Process and Technology. In instances where demonstration of deep insight into utilization of BIM is required by Clients, strategic managers should take lead in its adoption before the scheduled deadline by the U.K Government. They should endeavor to reach higher levels of adoption in effort to beat competion. Liu et al. (2010) also confirms that pressure from Clients and Competitors are the main influences of BIM adoption.

2.2.3 Improving the capacity to provide whole life value to client

According to Azhar et al. (2011), the most cutting-edge BIM products presently accessible have the capacity to offer energy, cost, environmental, spatial analysis; schedule and all things considered, can be utilised cooperatively by project participants to offer absolute whole life value (WLV) to customers.

The construction industry has been criticized by the report of Latham and Egan for its characteristic inadequacies and ineffectiveness (Latham, 1994; Egan, 1998). Construction inefficiency lessening and enhancement in effectiveness and value were also highlighted ten years after the publication of the Egan study (Wolstenholme et al., 2009). A proposition was made of the outlook change from capital cost to full project life costing. Building designs have high implications on building cost, with upsurges in operational yield delivering considerable savings for the customer (Emmitt, 2007; Deutsch, 2011; Barlish & Sullivan, 2012). The fraction of 1:5:200, linking to the cost

in building: cost in Maintenance and Building Operation: Operating Business Costs, pinpoints the mode through which design value can yield paybacks (Lock, 2007). This involved the thought of how the atmosphere of the building will affect its occupants and cause upsurge working efficiency via improved work quality, out and well-being and these results in minimal heights of time away from work, in the case of a building for commercial purposes (Evans et al., 1998). These strategies, in spite of the fact that evaluated in terms of finance for business issues, employ similarly to public service and non-governmental organisations; with inhabitant living condition been a general occurrence, and savings, as opposed to enhanced profits, the primary issue of improving communication to operators.

Additional method is provided by BIM to contractors in terms of corresponding with their employees. Sacks et al., (2009) demonstrate that 4D BIM possess the capacity to show vibrant order of construction on screen and construction project Managers and designers are using this to interconnect the order of operations that various constructors are obliged to execute on site. The prospect of showing even unskilled operators construction methodology, project schedule and location of the project, can solely enhance the on-site procedure. Furthermore, considering the substantial upsurge in the liberalization of the labour market of the construction industry, the number of workers from abroad has upsurge, growing the underpinning the relevance of complementing the needed facility of interpreters with models that are visual nature (Tutt et al., 2011). Besides, communication is a reciprocal procedure. it is possible to have build ability problems with basic, on-site answers for which operators could have proposals and recommendations.

With regard to this, BIM can yield synchronized capacity on a smaller-stage with the employees through visual animation.

2.2.4 Cost savings and monitoring

One of the limitations of 2 dimensional drawings, regardless of CAD programming bundles is that, it is just ready to produce one perspective view of the building (Campbell, 2007). Aside the observable issues as to clarity of configuration data, the ordinary approach of giving areas, rises and plans to temporary workers, has demonstrated to furnish them with lacking information, (BIMhub, 2012); Crotty, 2012). Typically this results in accommodation of "Solicitations for Information" (RFIs) by the contractual worker. RFIs are frequently the reason for deferrals and all the time require re-plan, both of which are a reason for undertaking expense overwhelm (Dickinson, 2010). A focal BIM model with joined task information, if accessible for round of questioning by all venture on-screen characters, can diminish the quantity of RFIs impressively (Azhar et al., 2008; Barlish and Sullivan, 2012; Deutsch, 2011). A report on the Mortenson Group found that the use of BIM diminished RFIs by 32% (Applied Software, 2009). This prompts proficiency and expense reserve funds through BIM. Ventures by their inclination are dynamic, and thusly subject to change influenced by outside and inward powers (Winch, 2010). Consequently, it is frequently the case that disregarding point by point plausibility examination at initiation and comprehensive costing pre-delicate, occasions will happen that will change the anticipated contract whole. It is accordingly imperative to screen these occasions, figure the expense invade, and take moderating activities (Walker, 2007; Lock, 2007). Whilst various issues can build task cost, BIM can have a positive impact, if the issue is that of a required configuration change. Giving the article and the task particular data have been stacked into the application, BIM has the capacity of creating expense gauges for a given configuration varieties (Campbell, 2007). These need not just be founded on the expense of the materials and development charges, rather, they can represent the out-

of-succession work, deferrals to different works bundles, the season of year for climate touchy exercises, and even join possibility aggregates from the danger administration exercise. Further, if the contractual worker is gifted in the utilization of BIM application, they can create quick and worthy level of exactness on appraisals of expense suggestions, to use as a beginning stage for alleviating activities.

2.2.5 Time savings

Time is a crucially essential undertaking project parameters to the accomplishment of a development task (Lock, 2007). The prerequisites to arrange, arrange once more, produce cost-and time estimates as a response to issues that emerges all through the task, or with an end goal to discover funds, are constantly present in development.

Should an outline variation required for any reason, the procedure included would typically incorporate holding a meeting with the configuration group, after which plan modifications would be attracted up and issued to the temporary workers and Quantity Surveyors (QS) for costing; and afterward, the redundancy of the procedure until a tasteful harmony in the middle of outline and cost is accomplished. With a 5-D BIM application, the customer, PM, temporary workers and fashioners can even meet online to talk about outline varieties, and the expense can be changed right away. A study by Azhar et al. (2008) revealed that BIM can deliver up to 80% decrease in the time spent on generating an expense gauge. It can be seen then, that the procedure of adjusting and concurring the configuration change, cost estimation as an aftereffect of these outline modification, and creation and redesigning of registers and calendars, can be lessened from days to hours in length of time (BIMhub, 2012; Eastman et al., 2011).

2.3 STRATEGIES FOR IMPLEMENTING BIM

2.3.1 Training and Deployment

BIM is another IT environment, which requires preparing, framework configuration, framework coordination library and archive format setup, and adjustment of outline audit and endorsement methodology, frequently united with new business rehearses. These should be created incrementally, nearby current generation systems, so learning difficulties don't risk the consummation of current activities. Planning of a definite arrangement for any firm considering rolling out an improvement to BIM is much empowered; appropriation ought not be dealt with as a casual movement. The more grounded the arrangement is in connection to an organization's key objectives, the more fruitful appropriation is liable to be. Preparing starts with one or a little number of IT authorities that both arrangement for framework setups and present a preparation program for whatever remains of the firm. Framework setup incorporates equipment choice (BIM instruments request intense workstation equipment), server setup, plotting and printing configurations, system access, joining with reporting and venture bookkeeping, setup of libraries, and other organization specific framework issues. Early undertakings should focus on the essential abilities required for demonstrating structures and delivering drawings, including incremental definition of article libraries and getting the nuts and bolts down before endeavoring more propelled reconciliation endeavors. After the fundamentals of venture administration have been built up, the entryway is interested in a variety of additional items for exploiting the numerous mix and interoperability benefits that BIM offers (Eastman et al., 2010).

2.3.2 Staffing within Construction Consultancy firms

The best test in actualizing new plan advancements is the scholarly move in getting senior configuration group pioneers to embrace new practices (Ashcraft, 2006). These

ranking staff, regularly accomplices, have many years of involvement with customers, outline advancement strategies, configuration and development arranging and booking, and venture administration that speak to a portion of the center protected innovation inside of any fruitful firm. The test is to draw in them in the move in a way that empowers them to acknowledge both their own particular ability furthermore the new capacities that BIM offers.

Among the few conceivably powerful approaches to address this test:

•Team accomplices with youthful BIM-canny outline staff who can incorporate the accomplice's learning with the new innovation.

•Provide one-on-one preparing one day a week or on a comparative calendar.

•Host a class for outline groups that incorporates preparing for accomplices in a casual offsite area.

•Visit firms that have made a move to BIM, go to live classes and Web-based courses. Comparative move issues exist with other ranking staff, for example, venture administrators and comparable systems may be utilized to encourage their move. No strategy is ensured. The move of a configuration association is to a great extent social. Through their activities, backing, and articulation of qualities, senior partners convey their dispositions toward new innovation to the lesser individuals inside of the association.

A second significant test in any development consultancy firm will be the changed sythesis of staff as for aptitudes. Since BIM most straightforwardly improves profitability for configuration documentation, the extent of hours spent on any undertaking moves far from development documentation. Inside of a run of the mill rehearse, an originator talented in BIM can understand the expectation and itemizing of an undertaking with a great deal less outside drawing or displaying backing than was

beforehand required. Subtle elements, material choices, and designs just should be characterized once and can be spread to all drawings where they will in the end be noticeable. Subsequently, the quantity of junior staff individuals dealing with development documentation will be lessened (Eastman et al., 2010).

A decent illustration of the path in which the workload for a task is moving in development Consultancy firm that has officially embraced BIM can be found in Table 2.1. This information was accounted for by a primary designer in a substantial configuration firm (Birx, 2005). While the aggregate work hours are decreased, the aggregate expense did not change considerably because of a movement toward a more experienced work staff. In spite of the fact that the requirement for section level engineers is diminished, drawing cleanup, model specifying, and incorporation and coordination of numerous building subsystems will proceed as critical and important errands. BIM innovation has new related overhead expenses past that of program.

Table 2.1 Man hours logged by professionals in an Architectural Firm

Professional Grade	Pre-BIM (Man hrs)	Post-BIM (Man hrs)	Change
Principal	32	32	0%
Project manager	128	192	33%
Project architect	192	320	40%
Architect 1	320	192	-67%
Intern Architect	320	96	-233%
Total	992	832	-19%

Source: Birx, 2005

As companies are previously aware, scheme organization, frequently under the administration of the Chief Information Officer (CIO), has developed into a vital aid purpose for the greater proportion of companies.

IT reliance increases as it aids higher yield in a similar manner that power has developed into necessary for many types of activities. BIM certainly augments to that reliance. As

construction consultancy firms embrace BIM, they should allocate responsibility for the two much-expanded roles that will be critical to their success (Eastman et al., 2010).

- ***Systems Integrator***

This role might be in charge of setting up collaborative framework for BIM information with consultants inside and outside the firm. These are corporate- or enterprise-level responsibilities. It also includes setup of libraries and patterns for firms usage. These submissions may be constrained to a solitary set that are employed in all construction schemes or a set of variables that is sampled on the premises of the kind of construction scheme and the consultants who are part.

- ***Model Manager***

While the protocols for version control and managing releases are defined and well understood within the drawing document-based world (whether paper or virtual), alternatives are different and more open-ended with BIM. There may be a single master model or a set of combined ones. Since models are accessible every minute of the day, releases can possibly be made multiple times a day. As a result, the probability for model corruption exists in light of the fact that a construction scheme concept is highly valued commercial merchandise, upholding its information honesty justifies obvious administration. The directives to be adhered to in creating read-and-update liberties is determined by the model manager, for synchronising consultants' work, for coordinating work flows on a project-level basis, and for overseeingmodelconsistency across various versions (Eastman et al., 2010).

2.4 INFLUENCES OF BIM ADOPTION

2.4.1 Version Management

Persistent upgrade of software programmes have been a problem of specialists. Whereas the majority frequently upgraded softwares permit the use of information produced from previous types, numerous times considerable vicissitudes prevent them. This implies that so as to have every cooperating staff operating on compatible versions efficiency has to be often compromised (Hooper, 2010).

In spite of interventions such as IFC standards have abridged the challenges of interoperability (Khemlani 2004) crossways dissimilar software programmes, the changes in the forms of IFC stipulations have also been a problems.

2.4.2 Organization and Data Management

As more data is overseen and put away electronically standard practices and systems ought to be set up to oversee information association, stockpiling and security. Managing the distinctive forms of the task, which identifies with perfect arrangement of information from diverse controls at particular stages should be settled. While the capacity to always overhaul the information gives phenomenal adaptability it renders adaptation administration, information blast and ease of use an intricate undertaking. A percentage of the related issues have existed in Database Management Systems (DBMS), yet rather than the mechanical issues, these are a greater amount of administrative issues for the AEC space and expert's and represents another test including vital choice making (Eastman et al., 2010).

2.4.3 Architectural Training In schools

One of the real negatives of the Architectural training in the late years has been the augmenting crevice between procedures taught in construction modeling schools and what is polished in the field (Eastman et al., 2010). As opposed to giving separate

starting sessions on computational methodologies and BIM applications there is a requirement for absorbing the same in configuration studios for the understudies. Such strategies will go far in easing the apprehensions in some segment that trust computational methodologies have a tendency to be hindering outline inventiveness.

2.4.4 Security of Data

Transferring information on a coordinated database in an electronic organization raises some security concerns amongst partners. Related to it are the worries of Intellectual Property (IP) and insurance of copyrights. While a few worries on system security from a specialized perspective may be supported, others may be mitigated by more prominent information and lawful measures. Case in point, the entrance to information on such databases is controlled through secured logins and information check - in and checks - outs are enlisted per each collaboration. Information hosts deal with the information under a contractual concurrence with the information proprietor and the terms and states of information administration and operation are well laid out in the agreement archive. Additionally, the IP issues are lawful Issues, which are the same to this configuration of information stockpiling and outline than what is in Practice.

2.4.5 Readiness of the tools

Occasions of the utilization of BIM methodology by and by suggest that in the present state also devices can impressively enhance the work process in the AEC business. Be that as it may, nonattendance of devices supporting and consolidating applied outline movement has been a foremost concern (Khemlani, Holzer, 2004 as refered to in (Eastman et al., 2010)). As more particular BIM applications are being created that spotlights on particular parts of outline process and permit joining with one another, the specialized backing is sure to make strides.

2.4.6 Seamless Integration and standards

In the course of the most recent couple of years different sorts of instruments have come up for particular parts of BIM application. BIM methodology includes a joint effort stage, and with that there are particular instruments giving item libraries (standard items), coordinated route and representation, conflict location, natural and execution examination, development and task administration, creation etc (Khemlani, 2007 a). These advancements propose the requirement for more noteworthy institutionalization of procedures, phrasings and items, early data trade between the distinctive players to keep away from re-work, capacity to direct preparatory investigation of venture ideas, more prominent insight in apparatuses to help processability.

2.5 POLICIES OF COUNTRIES FOR BIM ADOPTION

2.5.1 Australia

As indicated by the National Building Data Modeling Initiative Policy report a definite timeframe being July 2016 has been set for implementation of an open-standard grounded 3D cooperative BIM data interchange for all procurement buildings of the Government of Australia. The initiatives are also backed the proposed in the ‘in the Construction Network Productivity’ document to concentrate on mounting Procurement methods, BIM Strategies, Product Data, Tutoring creek and BIM Archives, Procedure and Information Interchange strategies, Monitoring Outline and Experimental Schemes. (Brewer et al., 2012).

According to Brewer, Gajendran and Goff (2012), BIM is beginning to start, nonetheless industry and Government institutions are now being commended to facilitate in speeding up its uptake. A superb instance of how BIM has been used in the management of existing buildings is the Sydney Opera House.

Learning and drill is rapidly being established to propel implementation of BIM at every phase from architectural specialist uphill, with the acknowledgement that fresh BIMpeculiar role definition are being produced: BIM modeler and BIM designing director are two precise instance. Professional organizations, TAFEs and colleges are all quickly replying to the difficulties that BIM establishes for conventional job roles. (Australian Institute of Architects, 2010).

2.5.2 Iceland

As per Kjartansdóttir (2011), BIM is certainly being received in Iceland; with forty percent of participants report their assimilation of BIM, predominantly by Engineers and Architects. The BIM prime of life phase is placed in between maturity phase 1 and 2, as a result of the detail that no servicer indicated employing BIM.

BIM users did not base their choice as to use BIM due to customers„ needs. They indicated that the key factors for embracing BIM was due to BIM abilities. This shows that the main force propelling BIM usage has not been a customer motivated procedure, in spite of GCCA strategies and the BIM-Iceland construction scheme. Customers necessitating BIM on a scheme proximately upsurge the worth of BIM to adopters.

These outcomes showed that BIM adopters and non-adopters relying on clients to take the initiative.

2.5.3 Singapore

In 2010 the Building and Construction Authority of Singapore also implemented the BIM adoption roadmap with the aim of achieving 80% adoption rate by 2015 (Zeiss, 2013). This is part of the government's plan to improve the level of productivity within the construction industry by up to 25% over the next ten years (Zeiss, 2013). They established a mandatory engineering BIM e-submission for all new building projects of

20,000 m² by 2014 (Construction Industry Council, 2013). The CORENET e-PLAN Check system (Construction Real Estate Network), instituted by Singapore's Ministry of National Development delivers automated compliance checking against building codes for BIM designed.

2.5.4 Finland

Koppinen and Tomi (2011) said new National BIM prerequisites as per Senate Properties guidelines were released early 2012. Construction companies and other clients are developing their own guidelines. They further state that the overall adoption in projects falls between 20-30%. However, among public sector clients the adoption is rather high with current execution falling between 20% and 30% of the volume. Private sector clients are far behind, only a handful are showing interest. Adoption is below 10%. Private sector and investors haven't recognized the paybacks of BIM so far, and this is one of the future challenges to get them into the same boat.

2.5.5 China

China appears to be well positioned to adopt BIM quickly. It has a fast moving construction sector and there is significant investment in infrastructure, combined with solid government backing and a trust-based and pragmatic culture which are good foundations for rapid BIM execution.

BIM has been incorporated as part of the National 12th Five Year Plan (2011–2015) and a BIM framework is being drawn up.

2.6 BENEFITS OF BIM

A few studies have made conclusions as to the favorable circumstances and likely advantages with this new innovation in examination to conventional 2D CAD. Laid out underneath are illustrations.

"BIM is unquestionably possible and offers numerous achievable points of interest over CAD" (Howell and Batcheler, 2005).

"As the utilization of BIM quickens, cooperation inside of undertaking groups ought to build, which will bring about enhanced benefit, cost decrease, enhanced time administration and advanced client/customer connections" Azhar et al. (2008)

"BIM bolsters the trading of undertaking information between different programming bundles to accelerate investigation process durations in this way diminishing information data and exchange mistakes" Fischer and Kunz (2006). BIM can convey brilliant advantages, yet doing as such requires a complete move from conventional methods for working. Arayici et al. (2009). Eastman et al. (2010), builds up the accompanying as advantages of using BIM as an apparatus

2.6.1 Earlier and more accurate visualizations of a design

The 3D model created utilizing the BIM programming is outlined straightforwardly into the product stage instead of being delivered from various 2D sees. It can be utilized to picture the configuration at any phase of the procedure with the suspicion that it will be dimensionally steady in all perspectives.

2.6.2 Automatic low-level adjustments when changes are made to plan

On the off chance that the items in the outline are controlled by parametric standards and imperatives that guarantee appropriate arrangement, then the 3D model will be

bereft of geometry, arrangement, and spatial coordination blunders. This diminishes the client's have to oversee configuration changes.

2.6.3 Improved coordinated effort utilizing incorporated venture conveyance

At the point when a customer uses Integrated Project Delivery (IPD) for task acquisition, BIM can be utilized by the venture group from the onset of configuration to enhance comprehension of undertaking necessities and in addition concentrate expense gauges as improvement of the outline advances. This permits outline and cost to be better comprehended furthermore stays away from the utilization of superfluous paper trade and its related postponements.

2.6.4 Generation of exact and reliable 2d drawings at any phase of the configuration

Exact and reliable drawings can be extricated for any arrangement of articles or specified perspective of the undertaking. This abatements the measure of time and number of blunders connected with producing development drawings for all configuration disciplines. At the point when varieties to the configuration are required, dependable drawings can be produced when the outline modifications are affec

2.6.5 Use of design model as basis for fabricated components

On the off chance that the configuration model is exchanged to a BIM creation instrument and point by point to the level of manufacture items (shop model), it will contain an exact representation of the building articles for creation and development. Since segments are as of now defined in 3D, their robotized creation utilizing numerical control apparatus is encouraged. Such computerization is standard practice today in steel manufacture and some sheet metal work. It has been utilized effectively as a part of precast segments, fenestration, and glass manufacture. This permits sellers worldwide to expound on the model, to create subtle elements required for manufacture,

and to keep up connections that reflect the configuration plan. This encourages offsite manufacture and decreases expense and development time. The exactness of BIM additionally permits bigger parts of the outline to be created offsite than would typically be endeavored utilizing 2D drawings, because of the probable requirement for on location changes and the powerlessness to anticipate accurate measurements until different things are developed in the field. It additionally permits littler establishment teams, quicker establishment time, and less on location storage

2.7 BARRIERS TO BIM ADOPTION BY CONSTRUCTION CONSULTANCY FIRMS

The efficiency and monetary advantages of BIM to the AEC business are broadly recognized and progressively surely known. Further, the innovation to execute BIM is promptly accessible and quickly developing. Yet, BIM selection is much slower than expected (Fischer and Kunz, 2006). The accompanying examination addresses obstructions to successful BIM reception in development consultancy firms.

2.7.1 Transactional business process evolution

With the variety of advances accessible to today's architect, possiblities are made that far surpass typical practice and surely knew business conventions.

Gu and London (2010) contend that a standout amongst the most basic procedure issues should have been be tended to is, that activities won't succeed if the requirement for change in plans of action are not fathomed in an approach to suit the fluctuated business needs. Contingent upon how the BIM model is overseen and kept up extra lawful assentions may be expected to guarantee information security and client certainty (Gu and London, 2010)

BIM facilitates the stream of data and associate procedures, yet does not settle the business challenges. The characteristic mix of configuration information in a modelbased outline to-fabricate procedure wiped out various potential clashes, however addresses none of the hidden absence of essential business process intergration. Without such intergration, the procedures themselves will neglect to legitimately develop as they need unmistakably characterized work process and information interactions.Ironically paper-based conventions gave clear lines of business process that are presently obscured by liquid computerized information. Eastman et al. (2010) focuses out that few government organizations and privately owned businesses have beat the obstruction of relocating to advanced data trade and are progressing in the direction of agreement dialect that not just changes the way of how data is traded inside of the undertaking group yet the obligation and dangers connected with a more community exertion.

Every relationsship in the building inventory network is characterized by an arrangement of commitments, dangers and prizes. Before the advanced future can be completely acknowledged and genuine procedure reconciliation accomplished, these business terms must be characterized over the undertaking.

2.7.2 Obligations

This deals with the task to be performed by each participant, deliverables required to accomplish those assignments and data to be produced and particularly traded with a specific end goal to meet those obligations.

Characterizing particular information trades will both encircle obligations and lessen the huge undertaking of permitting all members in the configuration to interoperate with all information.

2.7.3 Risks

As information connections are built up, the discrete limits of obligation are additionally going to obscure, and this will require better approaches to dispense work. At the point when the originator of a given bit of configuration data can't be absolutely decided, how is danger doled out? What's more, all the more imperatively, how is it genuinely shared? Should plan choices followed to their exact originators keeping in mind the end goal to dole out danger, or does an open data venture infer just as shared obligation?

Eastman et al. (2010) recognizes that the lawful calling perceives these hindrances and the vital danger portion changes that need to happen. They further add this will keep on continuing and will rely on upon expert associations, for example, the AIA and AGC to reconsider standard contracts and/or proprietors to change their own agreement terms.

BIM usage unifies data that is "comprehensively available," relies on upon consistent upgrading, and subjects architects to expanded potential obligation (Ashcraft, 2006).

2.7.4 Rewards

There is likewise an absence of created guidelines for who will be in charge of errors in the model. Obligation regarding overhauling the model and guaranteeing that it is exact accompanies a lot of danger. (Thompson and Miner, 2009)

With shared dangers, shared prizes must take after. On the off chance that a BIM-based development process in characteristically more effective and gainful, the motivations for coordinating information and danger must be driven by pay. A portion of the reserve funds acknowledged by the proprietor must be spent amid outline and development to accomplish the more financially savvy end.

In the end, business sector powers will set up new baselines of pay, and likely new models of installment. Until then, how are computerized deliverables to be esteemed as instruments of administration that hold on through the building lifecycle. A prize is, in our perspective, the essential driver in the appropriation of any innovation as adequacy, all by itself does not drive business conduct.

Each of these business issues, characterized in parallel, must be joined with the recommendation of BIM before far reaching selection will happen.

Early adopters of BIM methodologies propose how some, however not all, of the inquiries postured above will be replied. Model-based advances today are as often as possible conveyed in ventures that are profoundly community oriented, and where the configuration group has consented to completely coordinate data from all sources amid outline including the constructor who is much of the time at the table from the onset of the undertaking. In such circumstances, danger is by definition dispersed over the whole plan group. What's more, that group every now and again incorporates the proprietor, who joins the fight by utilizing the model as a configuration choice making device. As the estimation of such methodologies gets to be evident by more organized outline and activities developed on timetable and beneath spending plan, planners who offer BIMbased configuration systems will charge bigger expenses and comparable danger appropriation in their agreements.

2.7.5 Computability of computerized data

As indicated by Bernstein and Pittman (2004), computerized plan information exist in an assortment of structures, a considerable lot of which are not calculable. The building business, generally, has embraced the word processor way to deal with recording building outlines in the course of the last 20years. PC supported configuration devices

has been utilized to make electronic drawings of structures. In these drawings, structures are portrayed by theoretical graphical representations, for example, lines, circular segments, circles and polygons. These representations are significant when perused by people. In the greater part of these applications the PC has no understood learning of building components, for example, entryways, dividers, windows, rooftops, HVAC hardware, decorations and sections. Plan data that moves through the building procedure for most structures today is recorded utilizing pictorial information, not processable data. Modern building data demonstrating frameworks; the building business' variant of the spreadsheet was uncommon. In any case, now innovation is no more the issue. Complex building data displaying frameworks are accessible; however their reception has been moderate.

One simple clarification is basically dormancy and imperviousness to evolving procedure. With more profound investigation, it comes to exposed that creators and leaders don't completely get a handle on this idea of processable information and impediments of the information made by their present frameworks and methodologies.

The condition of practice in many firms is to make pictorial, non-calculable information. In any case, the assumption is that the information is processable. It is entirely normal to endeavor to utilize plan information for examination, expense evaluating, or even representation and find that in spite of the fact that the information looks calculable, is really a gathering of pictorial components. Generally, people take a gander at the information, translate it, and exchange it to new applications for extra investigation. This procedure is both inefficient and mistake inclined.

This marvel is not interesting to the building business. For the greater part of its archived efficiency increases, just around 10% of the assembling business has moved from pictorial to calculable models of items (Bernstein and Pittman, 2004).

Prior to the business can move to important BIM selection, the requirement for calculable data must be comprehended and the business' attitude must move from pictures to data models.

2.8 REQUIREMENTS FOR SUCCESSFUL BIM IMPLEMENTATION

Hooper and Anders (2010) contends that numerous experts are exhibiting an in number enthusiasm for BIM.There is a conceivable absence of functional information in applying current innovation and utilizing the highly gloated about advantages of BIM. Other examination (Gu & London 2010) has uncovered that Design Construction and Operating (DCO) member concerns basically concentrate on practice, procedure and specialized related issues.

Giel and Issa (2012) states that regardless of the current financial emergency, BIM execution still keeps on creating broad. In a review led by McGraw Hill Construction (2009), 48% of the AECO business reacted to utilizing BIM at some level, speaking to a 75% expansion from a past study they directed in 2007.

Presenting and actualizing BIM can be speedy and effortless, if went before with the perfect measure of arranging and arrangement. This 'appropriate sum' will be chosen altogether in light of every individual company's working and targets. Much the same as each draftsman, firm and outline are remarkable and diverse, BIM execution for every firm; modeler and creator would likewise be interesting and distinctive. (Gilmour, 2013)

Littler firms face greater difficulties their bigger partners as they would think that its hard to move their creation staff to different studios. In this way, drafters and colleagues must be agreeable to work process changes. For little firms BIM usage requires basic arranging and committed execution of these arrangements. Additionally, they must know about techniques to quantify the achievement and disappointment of this execution arranging and system. This arranging requires understanding into the short terms venture plans. Measuring the achievement or disappointment of the execution can be judged by reproducing a past outline utilizing new innovation and methodology.

Financial plan prerequisites are additionally a prevention for littler firms. While executing new programming, equipment, for example, work stations and server may likewise ring for degree. Moreover, the billable hours lost amid framework rollout are dependably a worry, especially for littler firms with shorter undertaking courses of events (Gilmour, 2013).

Littler firms can consequently, hope to influence seaward skill and framework speculations with respect to BIM usage. As these organizations are experts in BIM innovation, they wield completely prepared studios and proficient group of experts to handle each necessity.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter examines the research methodology adopted in this thesis. The chapter discusses the research design, the population and the sample and sampling technique of the study. The chapter then outlines the reasons for the adoption of the case study method. It also provides an overview of the data collection methods used for the thesis, as well as the means used to analyse the data. The last section of the chapter discusses the validity and reliability issues that enhance the quality standard of the research.

3.2 RESEARCH DESIGN

Polit et al. (2001) states that research design is a generic plan which is adopted for the study so as to answer the research questions. The research design outlines step by step procedure to be used in conducting the research. Burns and Grove (2001) refers to research as policies for the research process so as to accomplish realistic results. Polit and Hungler (1999) states that significant decisions in methodology of research are contained in the research design. The current study adopts an exploratory design. To find out what is happening in a given situation, an exploratory study is most appropriate and especially where the nature of the problem is unclear, exploration helps gain an understanding of issues (Saunders et al., 2009). The main advantage of conducting an exploratory study is that it is flexible and adaptable to change. It allows for the researcher to change the direction of the study when new insights or information is discovered in the course of study. The study employed both descriptive and inferential method of analyses and a case study approach to study.

3.3 POPULATION OF THE STUDY

A population is a group of individuals, persons, objects, or items from which samples are taken for measurement (Saunders et al., 2009). Target population is the entire group of individuals about whom you want to gather information. To design a useful research project, there is the need to be specific about the size and location of your target population. The current study was limited to some professionals in the construction industry in the Greater Accra region. The selection of professionals was limited only to Architectural Consultancy Firms, Quantity Surveying Firms, and Structural Engineering Firms. In Ghana, 140 architectural firms are registered with the Architectural Registration Council. However 70 architectural firms are in the Greater Accra region (Architectural Registration Council, 2013). Further, out of the 302 quantity surveying firms registered in Ghana, 62 are located in Greater Accra region (Ghana Institute of Surveyors, 2014); and out of the 271 structural engineering firms registered in Ghana, 60 are also in the Greater Accra region (Ghana Institute of Engineers, 2014). Construction consulting professionals of the study comprised of Quantity Surveyors, Structural Engineers and Architects. The decision to focus on Greater Accra region was due to the concentration of the majority of the consulting firms in Ghana in the region. Furthermore, limited time available for the study and financial constraints did not allow the researcher to travel to the other regions.

3.4 SAMPLE AND SAMPLE SIZE OF THE STUDY

It has been argued that a sample is a sub-group of the population which is an ideal representative of the entire population (Kumar, 2008). It is practically difficult for researchers to make direct observation of everybody within the subset of population under study. Instead, a subset of these people forming larger population is identified and data is therefore collected. Observations and information gathered are used to

represent the whole population (Zickmund, 2003). Therefore, there is the need for determination of appropriate number of respondents to be sampled from the entire target population of the study.

Several approaches are available for determining the sample size of a study population (Israel, 1992). These include but not limited to the utilization of census for small population, making use of published tables, adopting sample size of similar studies and calculating sample size using formulas. The first and last method was applied in the determination of sample size. The total number of the three groups of consultants working in the Greater Accra area is 192 and according to their associations; each employs a minimum of three project professionals. Therefore, the population of the professionals working with these consulting firms in the Greater Accra region is five hundred and seventy six (576) consultants. However, only one consultant was sampled from each selected firm. The sample size of the consulting firms was determined using the formula (Kish, 1965).

$$n = \frac{N}{1 + N(e)^2}$$

$n = \frac{70}{1 + 70(0.05)^2}$; $n = 60$ Architectural Firms

$n = \frac{70}{1 + 70(0.05)^2}$; $n = 1.175$

62 62 ; $n = 54$ Quantity Surveying Firms

$n = 1 + 62(0.05)^2$; $n = 1.155$

$n = \frac{60}{1 + 60(0.05)^2}$; $n = 601.15$; $n = 52$ Structural Engineering Firms

n = *Sample size* N = *Population* e = *Confidence Level*

Equation 1 Shows calculation of sample size

The sample size formula employed for the calculation of the sample size of the consulting firms give information on the lowest number of responses to be collected.

From the available literature in this area, 10% is often added to the sample size by researchers such as Cochran (1963) and Israel (1963) to compensate for people that the researcher for one reason or the other is unable to survey Therefore an approximation of 16.6 representing 17% is added to the sample size. Therefore 182 questionnaires were sent by the researcher to consultants working in consultancy firms within Greater Accra region. However, only 100 questionnaires were retrieved from the surveyed respondents. This therefore gave a response rate of 60.2%. The structure of the sample size and the total surveyed respondents is shown in Table 3.1.

Table 3.1: Sample Size of the Study

Consulting firms	Population	Sample size	10% of sample size	Questionnaires	Response
Architectural	70	60	6.0	66	31
Quantity surveying	62	54	5.4	59	40
Structural engineering	60	52	5.2	57	29
Total	**192**	**166**	**16.6**	**182**	**100**

3.5 SAMPLING TECHNIQUES

The study employed a multi-stage sampling procedure to select 166 consultants for the study. A multistage sampling procedure is appropriate in an attempt to avoid the use of all sample units in all selected clusters (Pedhazur & Schmelkin, 1991). Furthermore, multistage sampling avoids unnecessary and perhaps high cost associated with traditional cluster sampling. In the initial stage, the target consulting firms were stratified into Architectural Firms, Quantity Surveying Firms, and Structural Engineering Firms through stratified sampling procedure. Stratification was used because of the following reasons: it ensures that the sample is representative of the characteristic used to form the strata. It produces a lower standard error or variability, and thus standard error or estimates, may be reduced. It can also give higher precision

with the same sample size, and thus simplifies data collection (Saunders et al., 2007). The stratum was based on type of consulting firm (architectural firm, quantity surveying firm, and structural engineering firm). Stratified sampling procedure is embraced where the population has distinct categories, and the frame can be organized by these categories into separate 'strata' (Pedhazur & Schmelkin, 1991). Each stratum is therefore sampled as an independent sub-population, out of which individual elements can be randomly selected (Pedhazur & Schmelkin, 1991). In the second stage of the multi-stage sampling process, 60 Architectural firms, 54 quantity surveying firms, and 52 structural engineering firms were sampled from each strata through a simple random sampling by balloting procedure.

3.6 SOURCE AND TYPE OF DATA

The data used for the study were mainly primary data. Cross-sectional data were collected through a field survey of Construction professionals comprising of Quantity Surveyors, Structural Engineers and Architects. Data was collected on the adoption of building information modeling (BIM) in the construction industry, construction firm's professional's level of awareness of BIM, BIM contribution to improving professional practice of building construction, factors influencing BIM adoption, and the challenges of the adoption of BIM. The data was principally obtained from 100 construction consulting professionals in the construction industry in the Greater Accra region with the aid of a structured questionnaire.

3.7 DATA COLLECTION INSTRUMENTS

The research principally depended on structured questionnaire for collecting data. Several methods can be utilized in the collection of reliable data for research works. These include, archives, interviews, observations, questionnaires and (Eisenhardt,

1989; Yin, 1994). However, structured questionnaire was adopted as the principal tool of collecting data. This is mainly because it has the track record of the most reliable technique that helps collect important and valid data (Easterby-Smith et al., 2002). Thus, this section describes the structure of the structured questionnaire and the administration of the questionnaire to 182 professionals in the construction consultancy industry in the Greater Accra region.

3.7.1 Structured Questionnaire

A structured questionnaire was split as the primary method of collecting information. The questionnaire was developed and built on closed questions. This form of questionnaire was particularly employed in the sense of capturing all the objectives of the study. The questionnaire was self-administered to the professionals and consultants in the construction industry and government agencies in the Greater Accra region.

The questionnaire was divided into five parts: (1) the first section had to do with the respondent's demographic characteristics such as the professional background of respondent, respondent's academic qualification, nature of projects undertaking by respondents, and the respondent's years of experience in the construction industry, (2) the section of the questionnaire aimed at assessing the construction professionals awareness of BIM, (3) the third section of the questionnaire provides items to determine BIM contributions to improving professional practice of building construction, (4) the fourth section identifies the factors influencing BIM adoption in the construction industry, and the (5) the fifth section identifies the challenges hindering the smooth adoption of BIM. All items or statements were measured through a five-point Likerttype scale ranging from 1 (strongly disagree) to 5 (strongly agree).

3.8 PRE-TEST

To maximize the reliability and validity of the questionnaire, questions generated from the interview was pretested on a sample of 25 professionals in the construction industry in the Kumasi metropolis. This sample is consistent with a study by Patton (2002) that suggests that the sample size for a pilot study should be at least 20 respondents. The participants were asked to fill out the initial surveys based on their awareness, adoption and the factors influencing BIM adoption in the construction industry. The initial survey took about ten to fifteen minutes to complete. The aim of this pre-test was to ensure that quantitative measurements corresponded with expected results from interaction with construction consultants. Results from the pre-test analysis showed that professionals in the construction industry viewed some of the items as measuring the same constructs, which resulted in some minor changes in both the questions and the

(wording of) items. The input of two lecturers with in-depth academic knowledge in BIM was sought in the re-structuring of the designed questionnaire. Finally, a decision was made to maintain all parameters in the research to test inputs on a broader spectrum in order to check and ensure its conformity to same constructs from respondents' point of view.

3.9 METHOD OF DATA ANALYSIS

As stated by Miles and Huberman (1994), separating and putting data together and then thinking through this data is termed as "the stuff of analysis". Descriptive and inferential codes usually typifies this state of quantitative research process (Bryman & Bell, 2007; Flick, 2002). Moving forward, data analysis for this research began with initial set of codes based on the research aims, research questions and important data extracted from the literature review. Following advice from Robson and Hedges (1993), the practice

of re-testing and evaluating the collected data was adopted. This enabled the researcher to audit and improve the codes in the course of running data analysis.

Decayed codes were dropped whiles relevant ones were maintained in the study. Statistical package for social sciences (SPSS) version 17 was used to analyze coded data on responses. The results of data analysis were displayed in the form of percentages, tables, frequencies and generated figures. However, the inferential analysis employed was a binary logistic analytical tool to assess the factors influencing

Construction consultancy firm's adoption of BIM in the construction industry. The contribution of BIM to improving professional practices of building construction were ranked with the aid of the Relative Importance Index (RII) formula, whereas the challenges of the consultancy firms in the adoption of BIM were ranked with the aid of Kendall Rank Test. Relative Importance Index (RII) method was used to determine the relative importance of each of the factors and impacts identified. The five-point scale ranged from 1(strongly disagree) to 5 (strongly agree) was adopted and transformed to relative importance indices (RII). Relative Importance Index, RII was calculated from the formula given below:

$$RII = \frac{\sum W}{A * N}$$

Where

RII = Relative Importance Index

W = is the weighting given to each factor by respondents ranging from (1 to 5)

A = highest weight (i.e. 5 in this case)

N = Total no. of respondents

3.9.1 Model Estimation

To examine the factors influencing BIM adoption in the construction industry, the binary logistic regression analytical method was employed. In examining the model, a consultancy firm was classified and regarded as an adopter of BIM if certain elements was evident. 1 was assigned as adoption variable indicating consultancy firms' adoption of BIM and 0 if otherwise. Logistic regression was used to evaluate the factors that determine BIM adoption status. These standalone variables were both discrete as well as continuous in nature. The justification for adopting logit was based on its simplicity of calculation with its probability lying between 0 and 1, and its popularity in the empirical literature. The probability scale moves towards zero at a slower pace as its explanatory "unknowns" reduces with its probability reaching 1 at a slower rate as explanatory unknowns increases continuously (Gujarati, 1995). It is by far the most widely used analytical method for applied adoption research or studies.

According to Hosmer and Lemeshew (2000), logistics results from analysis of differential outcome variable has less advantage over that of logistic distribution (logit) as the latter is comparatively flexible and can be easily utilised in mathematical analysis to produce results worthy of interpretation. The model approximation are asymptotically orderly and reliable. The homogeneous co-efficient match up to the beta-coefficients in the least square regression models. According to Doss (2003), theories are not formulated with binary logistic model in the linearity between reliant and autonomous variables and do not assume homoskedasticity. Other notable benefit of adopting logit model includes its independence on normally distributed variables. Logit mode, can also be easily understood and calculated. This therefore justifies the adoption of logistic model for this study. The possibility of a consultancy firm's adoption of BIM was assumed as a dependent internal and external parameters.

Based on all these, the collective logistic probability model is expressed as follows:

$$P F Z_i \square (_i) \square F(\square \square_0 \square \square \ _i x_i) \square 1 \_\_\_\_\_ \square e^{\square z_i}$$

If the disturbance term (ε_i) is taken into account, the logit model becomes:

$$Z_i \square \square \square \square \square \square \ _i x_i \square \ _i$$

The second econometric model was estimated by maximum likelihood method. This procedure does not require assumptions of normality or homoscedasticity of errors in predictor variables. This analysis was carried out using STATA version 11.0. the other major diagnostic test employed to examine the appropriateness of the estimated model was the Pseudo R-square that shows how the explanatory variables well explain the estimated dependent variable.

3.10 Validity and Reliability

There are three different divisions of validity. These are content validity, criterion validity and constructs validity. Content validity involves the determination of the validity of evident variable for measurement purposes in the study. An in-depth research into literature of the subject matter to be measured is an option towards achieving content validity. Criterion validity also shares some similarity with the theory and are required to forecast some predefined outcomes. criterion validity can be established by two ways; relevant theoretical knowledge regarding subject matter and undertaking statistical analysis to determine the relationship between dependent variable and standalone variables. Constructs validity presents a more complex case with respect to the internal structure of a measurements scale and the data being measured. Cronbach alpha was of the major constructs of the study were tested to check the internal validity

of the study. The internal validity of the constructs was also tested with the test values of the binary logistic model.

CHAPTER FOUR

DISCUSSION AND ANALYSES

4.1 INTRODUCTION

This chapter presents the collated data, and analyses the data to address the specific objectives in Chapter One of the study. The major areas the chapter discusses include respondent's background; construction consultants awareness and knowledge of BIM in the construction industry; BIMs contribution to improving professional practices of consultants; the factors affecting the adoption of BIM in the construction industry; and the challenges of BIM adoption in the construction industry.

4.2 SOCIO DEMOGRAPHIC CHARACTERISTICS

This section of the study elaborates on the major socio demographic characteristics of the surveyed consultants. The section discusses the working experience of the consultants, the professional background of the consultants, the academic qualification of the consultants, and the nature of the projects undertaking by the firms of the consultants. The result is presented in Table 4.1.

Table 4.1: Socio Demographic Data

Socio Demographic Information	Respondents	Percent
Type of consulting firm		
Architectural firm	31	31.0
Quantity surveying firm	40	40.0
Structural engineering firm	29	29.0
Professional background		
Quantity surveyor	31	31.0
Architect	40	40.0
Structural engineer	29	29.0

Academic qualification		
HND	13	13.0
PDG	28	28.0
BSc/B. Tech	40	40.0
MSc/MPhil	19	19.0
Nature of project undertaking		
Office buildings	1	1.0
Residential building	2	2.0
Industrial building	4	4.0
Civil engineering project	5	5.0
Combination above	88	88.0
Years of experience 0-5 years	2	2.0
6-10 years	2	2.0
11-15 years	8	8.0
16-20 years	77	77.0
21+ years	11	11.0

Source: Field Survey, 2014

From Table 4.1, out of the total 100 consultants surveyed, 31.0% were architects from architectural firms, 40.0% were quantity surveyors from quantity surveying firms, and 29.0% were also structural engineers from structural engineering firms. The majority (40.0%) of the surveyed consultants have academic qualification of BSc or B-Tech, whereas 19.0% have MSc or MPhil. However, 13.0% and 28.0% of the surveyed consultants also have qualifications in High National Diploma (HND) and Post Diploma Degree (PDG) respectively. The majority (88.0%) of the surveyed consultants work with consultancy firms engaged in combination of construction projects including office buildings, residential buildings, industrial buildings, and civil engineering projects. The working experiences of the majority (77.0%) of the surveyed consultants were between 16 to 20 years, and so were in the appropriate position to provide the needed information for the study.

4.3 RELIABILITY ANALYSIS

The aim of this reliability analysis is to ensure that constructs of the study are dependable. To achieve this, Cronbach's alpha (α) analysis was used to measure how dependable a group of two or more data is. Cronbach alpha is usually in situations where alpha coefficient outputs fall between 0 and 1. The higher values show high reliability levels among the indicators (Hair et al., 1992). Thus the reliability for this study falls between 0.790 and 0.928 showing high reliability levels.

Table 4.2: Reliability Analysis

Constructs	**Cronbach alpha (α)**
Awareness of BIM	0.792
Contribution of BIM	0.831
Factors influencing BIM Adoption	0.863
Consultant's capacity constructs	0.928
Challenges of BIM	0.890
Overall	**0.790**

Source: Field Survey, 2014

4.4 CONSTRUCTION CONSULTANT'S AWARENESS AND KNOWLEDGE OF BIM

This section of the study assesses the surveyed consultant's awareness and knowledge of Building Information Modeling (BIM) in the construction industry. The section's results are presented by Table 4.3 and 4.4.

4.4.1 Consultants Knowledge of BIM

This sub-section of the study discusses the surveyed consultant's knowledge level of Building Information Modeling (BIM). The result is presented in Table 4.3.

Table 4.3: Knowledge of Consultant in BIM

Variables	Respondent	Percent
Know of BIM		
Yes	94	94.0
No	6	6.0
Total	100	100.0
Level of knowledge of BIM Very well	72	72
Well	20	20.0
Not well	2	2.0
Not at all	6	6.0
Total	100	100.0
Adopter of BIM		
Adopter	7	7.0
Non-adopter **Total**	93	93.0

Source: Field Survey, 2014

From Table 4.3, out of the total surveyed consultants, the majority (94.0%) have knowledge of Building Information Modeling (BIM). The majority (72.0%) of the surveyed consultants have 'very well' knowledge of Building Information Modeling (BIM), whereas 20.0% have 'well' knowledge of Building Information Modeling (BIM). However, 8.0% of the surveyed consultants have no knowledge or very limited knowledge of Building Information Modeling (BIM).

Irrespective of in-depth of knowledge of the surveyed consultants in the adoption of BIM, only insignificant percentage (7.0%) of consultancy firms have adopted the technology. From Table 4.2, 6.5% of the surveyed consultants perceived their consultancy firms to be using BIM. This is therefore not surprising since a study by Fischer and Kunz (2006) assert that BIM adoption is even much slower than anticipated in the developed world.

4.4.2 Consultant's awareness of BIM

The surveyed respondent's awareness of Building Information Modeling (BIM) usage in the construction industry is presented and discussed in this section of the study. Table 4.4 presents the result of the surveyed consultant's awareness level of Building Information Modeling (BIM). The awareness of the surveyed consultants of BIM were ranked on the 'likert-scale' of 1 to 4 as highly aware, aware, fairly aware and not aware. For each party, the RII was calculated by summing up the scores given to it by the respondents, and the relative importance index was calculated. The calculated Relative Importance Index was used as a proxy to awareness index of the consultants about Building Information Modeling (BIM). Awareness index of more than 0.7000 would be accepted as respondent's awareness of a particular measuring variable.

Table 4.4: Consultant's Awareness of BIM

Awareness of BIM	**Responses**				**RII**	
	1	**2**	**3**	**4**	**weight**	**AI**
Accelerates collaboration within project teams	0	3	27	70	367	0.9175
Produce more accurate visualizations of a design	0	1	24	75	374	0.9350
Generates accurate and consistent 2D drawings at any stage of the design	0	4	21	75	371	0.9275
Improved profitability	0	4	29	67	363	0.9075
Ensures the use of design model as basis for fabricated components	2	18	26	53	328	0.8283
Reduces costs	1	4	20	75	369	0.9225
Better time management	1	8	16	75	365	0.9125
Improved customer/client relationships	2	10	19	69	355	0.8875
Speed up analysis cycle times	0	7	20	73	366	0.9150
Reduce data input and transfer errors	4	21	22	53	324	0.8100

Rank: [1 =Highly Aware, 2 = Aware, 3 = Fairly Aware, 4 = Not Aware]

AI: Awareness Index

Source: Field Survey, 2014

From Table 4.4, the Awareness Index (AI) of 0.9175 indicates that the surveyed consultants were aware of the ability of Building Information Modeling (BIM) to accelerate collaboration within project teams. The awareness index of 0.9350 indicates that the surveyed consultants were aware of Building Information Modeling (BIMs) ability to produce more accurate visualizations of a design. The awareness index of 0.9275 and 0.9075 also show that the surveyed consultants were aware of Building Information Modeling (BIMs) ability to generate accurate and consistent 2D drawings at any stage of the design and improves profitability of consultancy firms respectively. Furthermore, the result of the Table 4.4 showed that the surveyed consultants were aware that Building Information Modeling (BIM) adoption by consultancy firms ensures the use of design model as basis for fabricated components, reduction of cost of production, better time management, improvement of customer or client relationship, speeding up the analysis of cycle time and reduction of data input and transfer errors as the awareness indexes of these variables are greater than 0.7000.

4.5 BIMs CONTRIBUTION TO IMPROVING PROFESSIONAL PRACTICE

This section of the study assesses the various contributions of Building Information Modeling (BIM) to improving the professional practices of consultants in the construction industry. to achieve this objective, the respondents were presented with several potential contributions of BIM identified in literature to indicate their level of agreement to them as contributions of BIM adoption to the improvement to the professional practices of consultants in the construction industry by choosing from options of 'Strongly Disagree' [1] to 'Strongly Agree' [5]. For each factor or variable, the RII was calculated by summing up the scores given by the respondents, and by extension their rank. The result of the frequency responses of the surveyed respondents and the weight, RII and ranks of the factors are presented in Table 4.5.

Table 4.5: Contribution of BIM to Professional Practices

Contribution of BIM	Responses					RII		
	1	**2**	**3**	**4**	**5**	**weight**	**RII**	**Rank**
Accelerates collaboration within project teams	0	0	0	3	97	497	0.9940	1
Reduce data input and transfer errors	0	0	0	6	94	494	0.9880	2
Speed up analysis cycle times	0	0	3	6	91	488	0.9760	3
Improved customer/client relationships	0	0	7	8	86	483	0.9564	4
Better time management	0	1	7	10	82	473	0.9460	5
Reduces costs	0	1	7	12	80	471	0.9420	6
Improved profitability	0	2	6	14	78	468	0.9360	7
Produce more accurate visualizations of a design	0	2	7	16	75	464	0.9280	8
Ensures the use of design model as basis for fabricated components	0	2	7	17	74	463	0.9260	9
Generates accurate and consistent 2D drawings at any stage of the design	3	2	2	21	73	462	0.9149	10

Rank: [1 = Strongly Disagree, 2 = Disagree, 3 = Fairly Agree, 4 = Agree, 5 = Strongly Agree]

Source: Field Survey, 2014

From Table 4.5, the relative importance index calculated indicates that the surveyed respondents' ranks the acceleration of the collaboration within project teams as the greatest contribution of Building Information Modeling (BIM) to improving the professional practices of consultants as shown by the highest RII of 0.9940. Reduction of data input and transfer errors was also deemed a major contribution of BIM to the professional practices of consultants in the construction industry as shown by the second highest RII of 0.9880. The third and fourth ranked contributions of BIM to professional practices of consultants in the construction industry were speeding up of analysis cycle time and improvement of customer or client relationship with RII of 0.9760 and 0.9564 respectively. The Latham (1994) and Egan (1998) reports slated the construction industry for its intrinsic inefficiencies and waste (Egan, 1998; Latham, 1994) and hence the need for BIM.

Furthermore, the fifth and sixth ranked contributions of BIM to the professional practices of the surveyed consultants were better time management and reduction of production cost with RII of 0.9460 and 0.9420 respectively. The seventh and the eighth ranked contributions of BIM to the professional practices of consultants in the construction industry were improvement of profitability and production of more accurate visualization of a design with RII of 0.9360 and 0.9280 respectively. Building design can be a great contributing factor to the construction and operational cost of a business as increase in operational productivity provides significant savings to the prospective client (Barlish & Sullivan, 2012; Deutsch, 2011; Emmitt, 2007). However, the least two ranked contributions of BIM adoption to the professional practices of consultants were ensuring the use of design model as basis for fabricated components and generation of accurate and consistent 2D drawings at any stage of the design with RII of 0.9260 and 0.9149 respectively.

4.6 FACTORS INFLUENCING BIM ADOPTION

The result from the logit model has been presented in Table 4.6. The Pseudo R^2 of the estimated model was 26.0%, which means that 26% of the variation in the dependent variable (adoption of BIM) is explained by the model or the explanatory variables. To further study the explanatory power of the model, a statistic based on likelihood ratio (LR) is appropriate. The significance of the likelihood ratio statistic indicates that the model follows a chi-square distribution (χ^2) with 24 degrees of freedom. The HosmerLemeshow statistics (df = 8, p = 0.2656) for the Logit model is insignificant. This is

because, the observed probability did not reach significance at $\alpha = 0.05$ on χ^2 distribution with 8 degrees of freedom. Hosmer and Lemeshow (2000: 145-147)

suggests that insignificant statistics indicates a goodness of fit of a model. Thus, it can be concluded that the Logit model sufficiently explains the data. That is, there is enough evidence to suggest that the goodness of fit of the overall model is very good.

Table 4.6: Factors influencing the Adoption of BIM

BIM-Adoption	**Odds Ratio**	**Std. Err.**	**Z**	**P>|Z|**
Government pressure	9.8176	12.8252	1.75	0.080
Client/competitive pressure	6.7207	6.0651	2.11	0.035
capacity to provide whole life value to client	6.1657	3.9699	2.83	0.005
Need to improve communication to operatives	14.7910	1.1013	2.45	0.014
Cost savings	2.8789	1.2919	2.36	0.018
Ensure proper monitoring	3.0250	2.2021	1.52	0.128
Time savings	1.4350	0.1220	2.96	0.003
Experience BIM usage	6.1218	6.1102	1.82	0.069
Knowledge of BIM	1.7110	5.1443	2.79	0.005
Capital capacity	2.3602	1.1148	1.82	0.069
Human resource capacity	3.7254	4.5712	3.31	0.001
Goodness Of Fit Of The Model				
Number Of Observations				100
LR Chi^2 (24)				75.77
Prob > Chi^2				0.000
Pseudo R^2				0.2608
Log likelihood				-107.396
Number Of Groups				10
Hosmer-Lemeshow $chi^2(8)$				9.99
Prob > chi^2				0.2656

Source: Output from STATA 11

From the logistic regression model, government pressures positively influences the adoption of Building Information Modeling (BIM) at statistical significance level of 10%. This implies that any greater pressure from government for consultancy firms to

adopt BIM will positively influence the adoption of BIM in the construction industry. For instance, the requirement of the United Kingdom Government to fully collaborate 3D BIM by 2016 would serve as an impulse for greater adoption by the end of 2016 (Cabinet office, 2011). The positive relationship between competitive pressure and the adoption of BIM indicates that consultancy firms operating in a competitive environment would search for better methods of improving production including the adoption of BIM and so would have a greater odds or probability (6.7207) of adopting BIM all other things being equal. These days clients only require consultants to exhibit high competence level in BIM, but also to convince them with an in-depth portfolio of successfully managed BIM (Lu and Li, 2011). Coates et al. (2010) clearly states this as primary justification for BIM adoption in architectural practice.

The positive relationship between company's wish to improve is capacity to provide whole life value to client and the adoption of BIM indicates that companies with whole life value to client would have greater odds or probability (6.1657) of adopting BIM in the construction industry. Sophisticated BIM products on the market presently provide spatial, energy, cost, environmental and schedule analysis. This data can be collectively used by project stakeholders in a collaborative way to provide whole life value to clients (Azhar et al., 2011). The study revealed positive relationship between the need to improve communication to operatives and the adoption of BIM at a statistical significance level of 5%. This therefore implies that when consultancy firms wish to improve their communication levels to clients then they would have greater probability or odds (14.7910) of adopting Building Information Modeling (BIM). BIM provides extra medium of communication at the labour front. Sacks et al. (2009) demonstrates the capability of 4D BIM to animate the construction sequence on a computer. This is currently being used by designers and construction managers to communicate the

sequence of operations that are required for execution of projects. The study of Sacks et al. (2009) therefore revealed findings consistent with the current study.

There is also positive relationship between the need to save cost and the adoption of BIM at a statistical significance level of 5%. This therefore implies that the greater consultancy firm wishes to save cost in production, the greater the probability or odds (2.8789) of adopting BIM. Besides the obvious issues concerning easy interpretation of design information, the conventional method does not furnish contractors with adequate information (BIMhub, 2012; Crotty, 2012) and hence the need for BIM. With availability of information attached to a central model, all project stake holders can decrease the number of RFIs significantly (Azhar et al, 2008; Barlish & Sullivan, 2012; Deutsch, 2011). The need to ensure proper time management also positively influences the adoption of BIM at a statistical significance level of 1%. This therefore implies that the greater a consultancy firm desires to save time in production the greater the probability or odds (1.4350) of adopting BIM. Consistent with this study was a study by Azhar et al. (2008) reports that BIM can minimize time spent on generating cost estimate by up to 80%.

It is evident that the process involved in modifying and confirming design variation, its cost implications and update of drawings, specifications and schedules can be reduced to the utmost minimum.

Experience in BIM adoption positively influences the adoption of BIM at a statistical significance level of 10.0%. This therefore implies that the greater consultancy firms have experience in the adoption of BIM, the greater the probability or the odds (6.1218) of adopting BIM in the construction industry. Construction professional's knowledge in BIM positively influences the adoption of BIM at a statistical significance level of

1%. This therefore implies that the greater consultancy firms have professionals with in-depth knowledge in BIM, the greater the probability or the odds (1.7110) of the company adopting BIM. Capital capacity or adequacy of consultancy firms positively influences their adoption of BIM at a statistical significance level of 10%. This therefore implies that any increase in consultancy firm's financial capacity would increase their probability or odds (2.3602) of adopting BIM. Finally, availability of human resource positively influences the adoption of BIM at a statistical significance level of 1%. This therefore implies that the greater consultancy firms possess the available human resource capacity to handle BIM the greater the odds or the probability (3.7254) of the adoption of BIM in the consultancy firm.

4.7 STATE OF CONSTRUCTION CONSULTANTS' CAPACITY TO ADOPT BIM

This section of the study assesses the resource capacity of consultancy firms in the Greater Accra region to manage and adopt Building Information Modeling (BIM). The major resources looked at include human resources, IT environment capacity, financial resources and the integration capacity of the available IT system. The result is presented by Table 4.7.

Table 4.7: Consultancy Firms' Capacity to Adopt BIM

	Response					RII		
	1	**2**	**3**	**4**	**5**	**Weight**	**RII**	**Rank**
Organisational structure adaptability	3	6	17	61	13	375	0.7500	1
Financial capacity	9	6	15	60	10	356	0.7120	2
IT environment's adaptability	7	10	53	21	9	315	0.6300	3
System integration capacity	6	14	64	10	6	296	0.5920	4
Human resource capacity	6	16	73	3	2	279	0.5580	5

Rank: [1= No extent, 2= Very low extent, 3= low extent, 4= high extent, 5= Very high extent]

Source: Field Survey, 2014

From Table 4.7, the result of the RII indicates that the Consultancy firms have greater capacity with regards to their organisational structure's adaptability to BIM adoption shown by the RII value of 0.7500. The firms also have the financial capacity to adopt BIM as shown by the RII value of 0.7120 which therefore ranks financial capacity second. However, the consultancy firms have relatively less capacity with regards to IT environment, system integration and human resource shown by their RII of less than

0.7000. The surveyed consultancy firm's difficulty is significantly recognized in human resource technical know-how that is ranked last with RII value of 0.5580.

4.8 CHALLENGES HINDERING ADOPTION OF BIM

This section of the study identifies the major challenges or obstacles to the adoption of Building Information Modeling (BIM) in the construction industry. To achieve this objective, the respondents were presented with numerous challenges of the adoption of Building Information Modeling (BIM) identified in literature to indicate their agreement by choosing from [1] 'strongly agree' to [5] 'strongly disagree'. The considered factors or variables were weighted and then ranked based on their calculated Relative Importance Index (RII). The result of the section is presented in Table 4.8.

Table 4.8: Challenges of Adoption of BIM

Firm's Capacity in Adopting BIM	**Responses**					**RII**		
	1	**2**	**3**	**4**	**5**	**Weight**	**RII**	**Rank**
Capital adequacy	0	0	0	1	99	499	0.9980	1
Organisational structure fits adoption of BIM	0	0	0	3	97	497	0.9940	2
Human resource capacity	0	0	0	6	94	494	0.9880	3
System configuration	0	0	4	8	88	484	0.9680	4
IT environment	0	1	9	10	80	469	0.9380	5
Adaptation of design review	0	2	6	14	78	468	0.9360	6

Approval procedures and new business practices	1	1	7	15	76	464	0.9280	7
Library and document template setup	1	2	7	17	73	459	0.9180	8

Rank: [1 = Strongly Disagree, 2 = Disagree, 3 = Fairly Agree, 4 = Agree, 5 = Strongly Agree]
Source: Field Survey, 2014

From the result of Table 4.8, it can be reported that all the factors are rated as challenges of the adoption of Building Information Modeling (BIM) as their RII are all greater than 0.7000. The Relative Importance Index of 0.9980 indicates that the surveyed respondents regard as the most pressing problem of the adoption of Building Information Modeling (BIM) capital adequacy ranked first. The second and third ranked challenges of the adoption of Building Information Modeling (BIM) in the construction industry were the ability of the organizational structure to fit adoption of BIM and the availability of human resources with RII of 0.9940 and 0.9880 respectively. Gu and London (2010) argue that one of the most critical process issues needed to be addressed is, that projects will not succeed if the need for change in business models are not solved in a way to suit the varied industry needs. The fourth and fifth ranked challenges of the adoption of Building Information Modeling (BIM) in the construction industry as shown by the result of Table 4.6 were system configuration and IT environment suitability for the adoption of BIM. The least two ranked challenges to the adoption of Building Information Modeling (BIM) in the construction industry were getting approval for new procedures and new business practices and the availability of library and document template setup with RII of 0.9280 and 0.9180 respectively.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter mainly focused on summarizing key finding of the research problem analysis, measures to be taken in order to improve the sector and conclusion of the study. The recommendations constitute both governmental and managerial level policies.

5.2 SUMMARY OF FINDINGS

This research was set to find answers to the following: 1) What is the level of awareness of BIM by construction Consultants, and 2) what are the requirements for effective uptake of BIM into the practice of construction Consultants; 3) what is the state of construction consultants' capacity to adopt BIM into their practice. Rigorous field works was conducted and below are the main findings:

5.2.1 Construction Consultants Level of Awareness of BIM

The construction consultants surveyed perceive to have high level of knowledge of Building Information Modeling (BIM). However, the surveyed consultants perceive less adoption of the technology among the various consulting firms in the Greater Accra region. The consultants were aware of the ability of BIM to accelerate collaboration within project teams, produce more accurate visualizations of a design, generates accurate and consistent 2D drawings at any stage of the design, improve profitability, ensure the use of design model as basis for fabricated components, reduce cost, ensure better time management, improve customer/client relationships, speed up analysis cycle times and reduce data input and transfer errors.

5.2.2 Effective Uptake of BIM into the Practice of Construction Consultants

The consultants perceive BIM adoption to contribute to the professional practices of consultants. The major eight contributions of BIM to the professional practices of consultants revealed by the study include acceleration of the collaboration within project teams, reduction in data input and transfer errors, speeding up of analysis cycle times, improvement of customer/client relationships, betterment of time management, reduction of cost, improvement of profitability, and production of more accurate visualizations of a design.

5.2.3 Construction Consultants' Capacity to adopt BIM into their Practice

The construction consultants believe in their organizational structure adaptability and their financial capacity to adopt Building Information Modeling (BIM). However, the consultants perceived to have limited capacity in their IT environment's adaptability, System integration capacity, and Human resource capacity to adopt Building Information Modeling (BIM).

5.2.4 Factors influencing the Adoption of BIM

The factors revealed by the study to influence BIM adoption positively included government pressure, client/competitive pressure, need to provide whole life value to client, need to improve communication to operatives, cost savings, time savings, experience in BIM usage, knowledge of BIM, capital capacity, and human resource capacity.

5.2.5 Challenges of Consultants in BIM Adoption

The major five challenges of consultants to the adoption of BIM revealed by the study included capital adequacy, organisational structure adaptability to the adoption of BIM, human resource capacity, software system configuration and IT environment

adaptability.

5.3 CONCLUSION

Irrespective of the high level of knowledge and awareness of BIM among construction consultants, the level of adoption still far lags behind the level of adoption of the technology in the construction sector in the developed world. The low level of adoption can principally be attributed to the limited capacity of the construction consultants to produce an IT environment that is adaptable to BIM, produce capable system integration, and the absence of capable human resource. The absence of government pressure and consultant's limited experience in BIM usage are also the possible reasons for the low adoption of BIM by the construction consultants in the Greater Accra region. Based on these conclusions, the study therefore subsequently make both managerial and policy recommendations.

5.4 RECOMMENDATIONS

Based on the findings of the study, the adoption level of Building Information Modeling (BIM) among construction consultants could improve if the enumerated managerial and government policy recommendations made below are taken into consideration:

5.4.1 Government Policy to Enforce BIM Adoption

Since the study revealed positive relationship between BIM adoption and government pressure, BIM adoption can be increased in the country through government enforcement measures. Policy instruments of government can ensure as requirement for all construction consultants to adopt Building Information Modeling (BIM) in their operations.

5.4.2 Training of the human resources in BIM

The experience and knowledge capacity of consultants were found to positively influence BIM adoption and hence the need to enhance the knowledge capacity of construction consultants in Building Information Modeling (BIM). Such training can be organized by outsourcing a resource person in the area of BIM adoption to give training programmes on the technology or consultants could be send abroad to acquire the knowledge. Any of the methods could be adopted depending on the relative cost components.

5.4.3 Provide both the financial support and managerial support to BIM adoption

To ensure the adoption of Building Information Modeling (BIM), financial and managerial support should be provided. The success of the adoption every technology begins with managerial support and hence devotion of certain amount of company budget to the adoption of the technology.

5.5 LIMITATIONS AND AREAS FOR FURTHER STUDIES

The current study was limited to providing insight into the adoption of BIM by construction consultants in the Greater Accra region. Therefore, any further study could be widened to capture other stakeholders in the construction industry. Furthermore, the current study was limited to a small sample size of 182 construction consultant in the Greater Accra region which limits the generalizability of the study. Therefore further studies in this area could enhance the validity, reliability and generalizability of the study by increasing the sample size.

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APPENDIX

Questionnaire

Dear Respondent,

I am a Post-Graduate Planning Student of KNUST undertaking a study to assess construction professionals awareness of BIM and hence BIM adoption in the construction industry. This study forms part of the requirement for the program of Master of Science (MSc) in the College of Architecting and Planning, KNUST. Please, read each question carefully before responding, and then circle or tick the appropriate answer in the designated space. Please answer to the best of your ability. You are rest assured that the study is for only academic purposes; all and every information provided will therefore be treated with the utmost confidentiality. Thank you for your help.

Demographic Background of Respondents

Type of consulting firm
Architectural firm [ ]
Quantity surveying firms [ ]
Structural Engineering firms [ ]

Professional background of respondent
Quantity surveyor [ ]

Architect [ ] Structural engineer [ ]
Others (Please specify) …….

Respondent's Academic Qualification
HND [ ]
PDG [ ]
BSc/B. Tech [ ]
MSc/MPhil [ ]
Others (Please specify) …….

Nature of projects undertaking by respondents
Office buildings [ ]
Residential buildings [ ]
Industrial buildings [ ]
Civil engineering projects [ ]
Combination of above [ ]

Respondent's years of experience in the construction industry
0-5 years [ ]
6-10 years [ ]
11-15 years [ ]
16-20 years [ ]
Over 20 years [ ]

Construction Firms professionals Level of Awareness of BIM Do you know of BIM?
Yes [ ] No [ ]

How well do you know BIM?
Very well [ ] well [ ] not well [ ] not at all [ ]

Please indicate the extent of your awareness of the following or the underlisted about BIM by choosing from a four pointer scale of 1 to 4 where 1 = highly aware and 4 = Not aware. (1 =highly aware, 2 = aware, 3 = fairly aware, 4 = not aware)

Awareness of construction professionals about BIM	**1**	**2**	**3**	**4**
Accelerates collaboration within project teams				
Produce more accurate visualizations of a design				
Generates accurate and consistent 2D drawings at any stage of the design				
Improved profitability				
Ensures the use of design model as basis for fabricated components				
Reduces costs				
Better time management				
Improved customer/client relationships				

Speed up analysis cycle times					
Reduce data input and transfer errors					

BIM Contribution to Improving Professional Practice of Building Construction

Please indicate the extent to which the underlisted factors serve as contributions of BIM to professional practices of building construction by choosing from a five pointer scale of 1 to 5 where 1 = Strongly Disagree and 5 = Strongly Agree. (1 = Strongly Disagree, 2 = Disagree, 3 = Fairly Agree, 4 = Agree, 5 = Strongly Agree)

Contributions of BIM	**1**	**2**	**3**	**4**	**5**
Accelerates collaboration within project teams					
Produce more accurate visualizations of a design					
Generates accurate and consistent 2D drawings at any stage of the design					
Improved profitability					
Ensures the use of design model as basis for fabricated components					
Reduces costs					
Better time management					
Improved customer/client relationships					
Speed up analysis cycle times					
Reduce data input and transfer errors					

Factors Influencing BIM Adoption

Do you use BIM?
Yes [ ] No [ ]

Please indicate the extent to which the underlisted factors influences your outfits choice to use BIM by choosing from a five pointer scale of 1 to 5 where 1 = Strongly Disagree and 5 = Strongly Agree. (1 = Strongly Disagree, 2 = Disagree, 3 = Fairly Agree, 4 = Agree, 5 = Strongly Agree)

Factors	**1**	**2**	**3**	**4**	**5**
Government pressure					
Client/competitive pressure					
Desire to improve capacity to provide whole life value to client					
Need to improve communication to operatives					
Cost savings					
Ensure proper monitoring					
Time savings					
Experience BIM usage					
Knowledge of BIM					
Capital capacity					
Human resource capacity					

To what extent do you think your construction firm's capacity can adapt to BIM adoption 1= No extent, 2= Very low extent, 3= low extent, 4= high extent, 5= Very high extent					
Factors	1	2	3	4	5
Financial capacity					
Human resource capacity					
IT environment's adaptability					
System integration capacity					
Organisational structure adaptability					

Challenges Hindering the Smooth Adoption of BIM

Please indicate the extent to which the underlisted factors impedes your company's adoption of BIM by choosing from a five pointer scale of 1 to 5 where 1 = Strongly Disagree and 5 = Strongly Agree. (1 = Strongly Disagree, 2 = Disagree, 3 = Fairly Agree, 4 = Agree, 5 = Strongly Agree)

Barriers to BIM adoption	**1**	**2**	**3**	**4**	**5**
Responsibility for updating the model and ensuring accuracy comes with a great deal of risk					
Database management difficulty and complexity					
Difficulty with the computability of some digital information					
Gap between Architectural training in schools and field practices					
Data security issues					
Lack of tools supporting and integrating conceptual design activity					
Seamless Integration of procedures and standards					
Defining specific data exchanges circumscribe responsibilities					
Difficulty in risk allocation					