PERCEIVED NEGATIVE EFFECTS ON PROJECT STAKEHOLDERS FROM ADOPTING BIM IN SRI LANKA

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ABSTRACT

Many Asian countries have adopted Building Information Modelling (BIM) technology in their projects. But BIM Level 2 has not been adopted by Sri Lankan construction industry yet. While there are number of studies on BIM in and for Sri Lanka, there is no prior research focused on 'Perceived Negative Effects on Project Stakeholders from Adopting BIM'. Among many challenges and barriers in BIM adoption, negative perception is a significant challenge. Understanding the negative perception of each key stakeholder is very important to a successful BIM adoption. Without knowing how significant the perceived negative effects are, formulating effective BIM adoption strategies are impossible. There is a need to develop the understanding, of how these negative perceptions affect BIM adoption in Sri Lankan construction projects and among the key project stakeholders. Therefore, the purpose of this study is to identify the key project stakeholders for BIM adoption and to verify the status of perceived negative effects of BIM among Sri Lankan construction project stakeholders. In order to identify significant negative BIM perception among different disciplines, a deductive research method and quantitative approach was adopted. An online questionnaire survey was conducted among 316 key project stakeholders comprising clients, consultants and contractors, to identify the significant negative effects of BIM. 49 completed the questionnaire. Descriptive statistical analysis using percentiles method was used to rank the significant BIM perceptions. The study finds that the perceptions on BIM among different disciplines are widely different. However, all disciplines firmly agree that BIM will not replace their profession.

Keywords: *BIM; Negative Effects; Perception; Sri Lanka; Stakeholders.*

1. INTRODUCTION

Building Information Modelling is known as BIM or often referred as BIM. Autodesk defines BIM as intelligent process in 3D (3 Dimension) model which helps Architecture, Engineering and Construction (AEC) professionals to plan, design and construct buildings and structures (Autodesk, 2017). The normal misconception about BIM is that individuals think BIM is only about technology and the 3D design but it's more than that. Sri Lanka is far behind on adopting level 2 BIM, compared to the other Asian countries. This is because there are many challenges and barriers, and negative perception is a significant challenge among them. Understanding the negative perception of each key stakeholder is very important to a successful BIM adoption. Without knowing how significant the perceived negative effects are, formulating effective BIM adoption strategies are impossible. There is a need to develop the understanding, of how these negative perceptions affect BIM adoption in Sri Lankan construction projects and among the key project stakeholders. Consequently, this study on "Perceived Negative Effects on Project Stakeholders from Adopting BIM in Sri Lanka" becomes interesting, it yields useful outcomes. Finding of the study is valuable because it will help the professionals, key stakeholders and change agents who want to implement BIM in Sri Lankan construction industry.

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2. BACKGROUND

There are many definitions about BIM, all around the world each individual uses the definition according to their usage. In this study, BIM is defined following National Institute of Building Sciences (2007) as a digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decision throughout the life cycle from inception to its demolition. In 1970s Building Descriptive System (BDS) was introduced by Charles Eastman and that was the foundation for BIM. Then in the 1980s ArchiCAD was developed in Budapest by Gabor Bojar and it was the earliest building specific BIM enable tool. Parametric Technology cooperation (PTC) in the end of 1980s released the technology call Pro/Engineer. Pro/Engineer was used for constraint based parametric modelling. In the year of 1997 the PTC company was split and Charles River software company was created by Irwin Jungreis and Leonid Raiz. Irwin Jungreis and Leonid Raiz started working on Revit. Later, in the year 2002 Revit was bought by Autodesk. There are other many BIM enabled tools which were introduced in the market such as Tekla and Bently at this time. BIM is not only about software it's an integrated system and process related to the information sharing, but there were issues how to interpret from one BIM enabled software to another different BIM enabled software, because different users follow different software according to their easiness. To deal with this issue, International Alliance for Interoperability (IAI) was created in 1994. They found and developed International Foundation Class (IFC) as a solution for the interpret issue. Later IAI developed as buildingSMART and OpenBIM. BuildingSMART has the custodianship of IFC files and OpenBIM represents the universal collaborative process of buildings such as design, construction and operation. Globally at least 150 BIM enabled tools are available which support IFC (Simpson 2013, pp. 7 & 8). Evidently, a significant advancement has occurred for construction information technologies during recent decades.

2.1. BIM CHALLENGES AND BARRIERS

Deutsch (2011) overheard that the General Services Administration's (GSA) Office of Project Delivery, director Charles Hardy saying "BIM is about 10 percent technology and 90 percent sociology". From this statement it is understandable that, BIM is not only about technology. That is the key reason why there are many challenges/barriers in BIM adoption.

Lindbald (2013) has mentioned some barriers to BIM adoption such as interoperability; perceptions of BIM from different stakeholders; poor match with user's need; changing of work process; risks and challenges using a single BIM model; legal issues arise from it; disinterest and lack of demand of BIM; fear of new roles and new working collaboration; cost spend for training of individuals and the time spent for it. Puolitaival and Forsythe (2016) have identified some BIM adoption challenges from their research study as:

1. Finding the balance between
   - Technology and process
   - Practice and theories
   - Traditional and emerging Construction Project Management[CPM]
2. Smoothing professional development of staff
3. Availability and appropriate resources for BIM

Because of these problems BIM adoption become troublesome. People response to BIM has caused hindrance to BIM adoption but people also have overcome some of these challenges and these challenges and barriers are related to people and their perception, so it has a significant impact towards successful BIM adoption.

3. PEOPLE'S PERCEPTION ON CAD AND BIM

The human factor plays a vital role when new technologies are introduced, especially in the case of BIM. Technology, software and file sizes become more easy to use and manage but people are influential elements, who will determine the success of BIM (Deutsch, 2011).

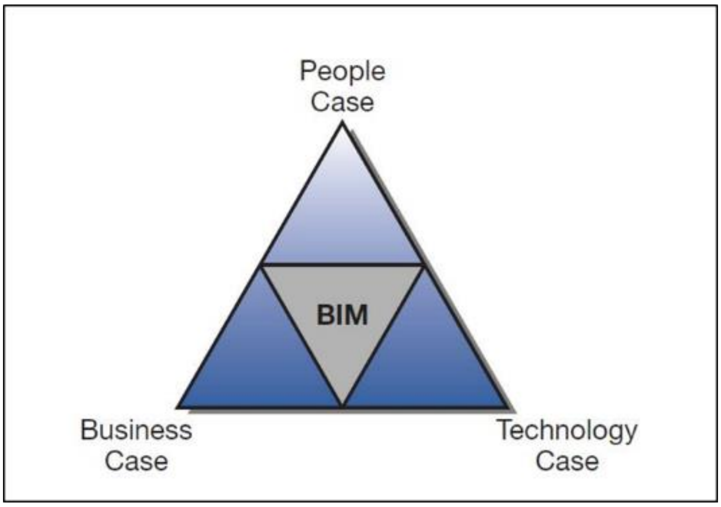

Figure 1: Peoples Influence on BIM

Source: Deutsch (2011)

Figure 1 shows that BIM is incomplete without people. Perception comes in to this heading since perception is interrelated with people's culture, attitude and practice.

Also computer aided design (CAD) and BIM are interrelated with each other. CAD was introduced in the late 1980's and some perceived that introduction of CAD can substitute Quantity surveyor profession (Sanders et al., 2007). But this perception was not true. Also some perceived that, the introduction of CAD will be a good opportunity for quantity surveyors to use it as a tool in design stage, but if those opportunities are missed, CAD can demise quantity surveyors' profession (Atkin et al., 1987). People may also have perceived variously for BIM as well.

3.1. KEY PROJECT STAKEHOLDERS FOR BIM ADOPTION

Project stakeholders are defined according to the Project Management Body of Knowledge (PMBOK, 2013) as "Individuals and organizations who are actively involved in the project, or whose interests may be positively or negatively affected as a result of project execution or successful project completion".

Some previous studies have identified the key project stakeholders for BIM adoption in the following Table 1.

Table 1: List of Key Project Stakeholders Influenced BIM Adoption from Previous Studies

No	Author(s)	Country	Project owner/ client	Architects	Quantit Surveyors	Contractors	Engineers	Some of them/ all
1	Kymmel (2008)	USA						x
2	Gu and London (2010)	Australia						x
3	Eastman *et al*. (2011)	USA	x					
4	Reddy (2011)		x					
5	Arayici *et al*. (2011)	UK		x				
6	Khosrowshahi and Arayici (2012)	UK						x
7	Keat (2012)	Malaysia			x			
8	Wijayakumar and Jayasena (2013)	Sri Lanka			x			
9	Eadie *et al*. (2013)	UK				x		

According to the Table 1, the key project stakeholders for BIM adoption as follows:

1. Project owners/client
2. Architects
3. Quantity Surveyors
4. Contractors
5. Engineers

3.2. NEGATIVE IMPACTS OF BIM ADOPTION AND IMPLEMENTATION IN PREVIOUS STUDIES

There are many previous studies on BIM and several authors have mentioned negative effects of BIM adoption in their relevant journals and books. These studies are ranging from 2011 to 2017 but not all books and journals related to the negative perceptions on BIM were referred but most of the negative perception has been identified through these journals and book. Most of the findings were through questionnaires, expert interviews and literature reviews. Those negative impacts are given in the following Table 2.

Table 2: Negative Effects of BIM Stated in Previous Studies with Relevant Authors

Author & Year	Identified Negative Effects of BIM
Deutsch (2011)	▪ BIM is extremely complicated and difficult to follow. ▪ BIM will overtake traditional way of designing. ▪ Working in BIM is not easy, have to learn lot of new skills and practices. ▪ Working in BIM may cause many technical difficulties. ▪ BIM will not give the expected Return on Investment (ROI). ▪ Allowing others to use BIM model and to edit it increase design liability risk. ▪ Difficult to learn BM applications. ▪ BIM change the way of workflow. ▪ Designers don't benefit from BIM like owners and contractors. ▪ BIM blurs the boundaries between design and construction. ▪ Can't rely on the dimensions obtained from BIM models for practical purposes
Azhar (2011)	▪ When using BIM model, it is not possible to identify who is responsible for if anything goes wrong. ▪ Data Ownership of BIM model is an unsolved issue.
Aibinu and Venkatesh (2012)	▪ Working with a BIM version would need to upgrade software, it is a huge cost to upgrade when new versions are released. ▪ Sometimes project documentation in old BIM files can't be imported into new BIM version. ▪ Upgrading to new version and even have to subscribe them may add additional cost to the firms. ▪ Information included in BIM models are not appropriate to allow automation of QS tasks. ▪ Lack of skilled employee who can work with BIM. ▪ If information assigned in BIM model is insufficient QS will have to return to manual quantity take-off. ▪ The end goals of the BIM models are different so the information are not easily reconciled to QS measurement. ▪ When insufficient and incorrect information input into BIM, QS may end up spending more time taking off and correcting quantities manually. ▪ Only a marginal or no time savings with BIM because significant portion of time will be spent on checking the accuracy of the model prior to quantity automation. ▪ When the models are erroneous the accuracy of estimate still remains the responsibility of the QS. ▪ BIM systems do not provide accuracy in measurement ▪ BIM can't communicate information in a level the subcontractors can interpret appropriately for pricing. ▪ Time need to learn the new way of working in BIM would affect the business. ▪ Designers are reluctant to share their model with QS.

Author & Year	Identified Negative Effects of BIM
Rogers et al (2015)	▪ Clients may not keen on paying design fees when shared BIM model is accessible to him. ▪ Government is not supporting its adoption.
Liu et al (2017)	▪ Unequal rewards of BIM among the other stakeholders. ▪ Restructure of the workflow. ▪ It is not worthy to pay for additional software and hardware cost, compared to benefits it brings. ▪ It is not worthwhile to invest as much time in design complicated 3D BIM models ▪ Various levels of project stakeholders may not have direct access to the BIM. ▪ Young staff with little experience will soon become skilled with BIM tools while experience veterans will have to rely on young staffs to operate BIM functions.
Herr and Fischer (2017)	▪ Practical standards and guidelines for BIM are not well developed

4. RESEARCH METHODOLOGY

4.1. *DEDUCTIVE RESEARCH APPROACH*

The deduction process always looks for ideas in text and through communication with others. The text can be journal articles, books and etc. Communicating with others such as colleagues and experts (Fellows & Liu, 2015). Usually a deductive research approach starts with a theory or generalised assumptions related to a hypothesis which will be tested through empirical observation which helps to decide whether to accept or reject that theory (Saunders et al., 2007; Bryman, 2012). In deductive approach, the theories or hypotheses will be tested using quantitative method. The deductive approach has been adopted for this study because the findings of negative effects of BIM has been identified in literature survey and based on that generalise theory was created. Then it will be tested among project stakeholders related to the construction industry using questionnaire survey.

4.2. *QUANTITATIVE METHOD*

Like, the nature of qualitative methods are 'subjective', the nature of quantitative methods are 'objective' (Naoum, 2006). Quantitative method are based on testing a hypothesis or a theory based on natural phenomena (Bryman & Bell, 2007). The process is based on studying the relationship between facts and theories and findings from previous research (Fellows & Liu, 2015). In construction management research studies, quantitative research method has been the dominant methodology (Knight & Ruddock, 2008). In quantitative studies the theory becomes a framework for the entire study and it helps to research questions or hypothesis and data collection procedure in the form of organizing a model (Creswell, 1994). The general quantitative strategies are: experimental and survey approaches such as questionnaire surveys. The negative impacts from previous studies as shown in Table 2 were converted in to questions and shared among 125 architects 30 quantity surveyors, 50 engineers and 111 participants of a recent BIM seminar which included a mix of professionals via email online. Among three different disciplines 17 architects, 25 quantity surveyors and 7 engineers responded to the questionnaire survey.

4.3. *DATA ANALYSIS AND FINDINGS*

Descriptive statistical analysis using percentiles has been used to rank the perceived negative effects statements from the respondents. All the perceived negative statements were ranked according to the following process. In order to rank the perceived negative statements: the minimum, 10th percentile, first quartile (25th percentile), median (50th percentile), third quartile (75th percentile), 90th percentile and maximum were identified individually for each statement. Then for the ranking process the statements were sorted out as in the first round the median which is 50th percentile was sorted within ties second round using 3rd quartile (75th percentile) sorted and within the ties 1st quartile (25th percentile) was sorted in third round, and further rounds sorting's were followed according to 90th percentile, 10th percentile, maximum and finally minimum respectively.

The equation to calculate the percentile is given below. This method is used to calculate PERCENTILE.INC in Microsoft Excel application. The Excel function was preferred over manual method in dealing with large amount of data.

$X = f(p,N) = p(N-1) + 1, p \in [0,1]$

$\therefore p = \frac{x-1}{N-1}, x \in [1, N].$

Note that $x \leftrightarrow p$ *relationship is one to one for* $p \in [0,1]$

Where, P= Percentile and N= Number in List

(Wikipedia, 2018)

Additionally, interquartile range (IQR) also calculated to understand how typical the median value is.

IQR = 3rd Quartile (75th percentile) – 1st Quartile (25th percentile)

5. BIM PERCEPTIONS

5.1. BIM PERCEPTION AMONG STAKEHOLDERS – GENERAL CATEGORY

The list of negative perceptions was ranked using descriptive statistical analysis using percentile. The stakeholders who participated in the questionnaire survey (architects, quantity surveyors and engineers) were asked to rate their level of agreement for a given statement in relation to each variable. The main purpose of the survey is not to identify the list of negative perception but to rank the significant negative perception that can influence the BIM adoption in Sri Lanka. Level of agreement included in the questionnaire as strongly disagree, agree, undecided, agree and strongly agree. In order to do the data analysis, level of agreement has been scaled -2, -1,1 and 2, where strongly disagree is -2, disagree is -1, undecided no scale, agree is 1 and strongly agree is 2. Ranking of the perceived negative effects of BIM relevant to all are given in Table 3.

The greatest significant negative perception of BIM among key stakeholders in general category are "Various levels of project stakeholders may not have direct access to the BIM"; "Practical standards and guidelines for BIM are not well developed"; "BIM is not possible because Sri Lankan government is not supporting its adoption"; "Young staff with little experience will soon become skilled with BIM tools while experience veterans will have to rely on young staffs to operate BIM functions" and all four of them has been ranked 1st. the fifth highest significant negative perception is "Time need to learn the new way of working in BIM would affect the business", The most least significant negative perceptions are "BIM software applications are difficult to learn"; "BIM will not give the expected Return on Investment (ROI)" and "BIM technology and process is complicated and difficult to follow". All three of them has been ranked 12th. However, analysis of the above for each profession showed quite different levels between them.

Table 3: Negative Perceptions Ranking of General Category

BIM perception statements	Min	10th Per	Q1	Median	Q3	90th Per	Max	**Rank**
General [Various levels of project stakeholders may not have direct access to the BIM]	-2	-1	1	1	1	2	2	**1**
General [Practical standards and guidelines for BIM are not well developed]	-2	-1	1	1	1	2	2	**1**
General [BIM is not possible because Sri Lankan government is not supporting its adoption]	-2	-1	1	1	1	2	2	**1**
General [Young staff with little experience will soon become skilled with BIM tools while experience veterans will have to rely on young staffs to operate BIM functions]	-2	-1	1	1	1	2	2	**1**
General [Time need to learn the new way of working in BIM would affect the business]	-2	-1	1	1	1	1.7	2	**5**
General [BIM will disrupt the present established workflow and therefore is difficult to adopt]	-2	-1	-1	1	1	1.3	2	**6**
General [Working in BIM is not easy, I have to learn lot of new skills and practices]	-2	-1	-1	1	1	1	2	**7**
General [Working in BIM may cause many technical difficulties]	-2	-1	-1	1	1	1	2	**7**
General [BIM blurs the boundaries between design and construction]	-2	-1	-1	1	1	1	2	**7**
General [When using BIM model, it is not possible to identify who is responsible for if anything goes wrong]	-2	-1	-1	-1	1	1	2	**10**
General [We can't rely on the dimensions obtained from BIM models for practical purposes]	-2	-1	-1	-1	1	1	2	**10**
General [BIM technology and process is complicated and difficult to follow]	-2	-1	-1	-1	1	1	1	**12**
General [BIM will not give the expected Return on Investment (ROI)]	-2	-1	-1	-1	1	1	1	**12**
General [BIM software applications are difficult to learn]	-2	-1	-1	-1	1	1	1	**12**

Min= Minimum, 10^{th} Per= 10^{th} Percentile, Q1= 1^{st} Quartile, Q3= 3^{rd} Quartile, 90^{th} Per =90^{th} Percentile, Max = Maximum

6. CONCLUSIONS AND RECOMMENDATIONS

The top most significant perceived negative effects common to all three professions are:

- Various levels of project stakeholders may not have direct access to the BIM
- Practical standards and guidelines for BIM are not well developed
- BIM is not possible because Sri Lankan government is not supporting its adoption
- Young staff with little experience will soon become skilled with BIM tools while experience veterans will have to rely on young staffs to operate BIM functions

However, ranking for these also varies among three professions.

6.1. RECOMMENDATION - GENERAL

"Practical standards and guidelines for BIM are not well developed" and "BIM is not possible because Sri Lankan government is not supporting its adoption" has been ranked as 1st most significant perceived negative effects of BIM in general category by different disciplines. This kind of similar findings were identified in several overseas studies. UK has already mandated the level 2 of BIM in 2016 and there has been improvements in BIM based projects. Countries like Singapore and Hong Kong are leading in BIM based projects in Asia. Somehow Sri Lank will adopt BIM but the government should drive the adoption within five years, because BIM is the future of construction. If the government can make BIM compulsory, the demand for BIM will increase but in order to do that construction bodies, industry associations and the government should make a joint effort to create and modify guidelines and practical standards for BIM and also should amend better laws and regulation on BIM.

In addition, the universities should add BIM to their curricula and provide more BIM courses to students which will help students to become familiar with BIM before they work in BIM based projects. So it will reduce the training cost and time which different disciplines perceived it as a significant negative effect of BIM adoption. The brainstorming sessions, Symposium and seminars must be conducted regularly all over the Sri Lanka to understand about BIM, rather than to think that BIM is just a 3D based CAD service, but BIM is not only about 3D it has other 'nD' capabilities which would help the stakeholders throughout the project lifecycle.

6.2. LIMITATIONS OF THE STUDY

Only the identified negative effects of BIM from literature survey has been used to conduct the research but there could have been other various negative effects of BIM not clearly identifiable from the previous studies which were not included in this this research. 14 negative perceptions discussed in this paper are the common effects identified as relevant to all. Unique effects to each profession are not discussed in this paper though they were studied in original study.

6.3. FURTHER STUDY RECOMMENDATION

To overcome this identified limitation of this study it is recommend to identify the negative effects from other previous literature and to be continued further.

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