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The impact of BIM application on construction delays and cost overrun in developing countries

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Abstract. Delays and cost overruns are generally acknowledged in the construction industry as serious issues that require the use of advanced technologies. However, the adoption of new technologies has not kept pace with the growth of the industry. This is due to low studies on the impact of these technologies in the industry. Building Information Modelling (BIM) as an alternative technology for management of construction is still in its early stage of adoption in many countries. This research tends to determine the relationship between the use of BIM and the causes of delay and cost overrun in construction industry. Data were obtained through admininstered questionnaires to Contractors, which was analysed using Pearson's product-moment correlation to determine their relationships at 0.05 level of significance. The results from the analysis of the causes of delay and the causes of cost overrun shows that there is a positive correlation between the two (r =0.737, n = 69, p = 0.000). More also, the result of the analysis shows that there is a significant negative relationship between the application of BIM and the causes of delay and cost overrun (r = -0.246, n = 69, p = 0.041) and (r = -0.313, n = 69, p = 0.009). The result of this research shows that an increase in the use of BIM in the management of construction projects reduces the occurrence of delay and cost overrun.

1.0 Introduction

Time, cost, and quality remain vital measures' for the success of any project in the construction industry (Torp et al., 2016). Nevertheless, the construction industry seldomly complete projects within there time schedule because of issues arising from cost and time controls that are ineffective (Forbes and Ahmed, 2010). The construction industry projects are now multifaceted as they involve participants from different specialization. The rising issues of delay and cost overrun differ together with the project scope, sizes, type, and location. Moreoften, construction projects are charecterised according to there sizes and scope which defines it complexity and capital demand. These complexity in constructions are as a result of limited accurate information which most time results into inaccurate evaluation of projects (Zavadskas, 2010). As such, construction industries globally are plagued with high profiled projects with significant delays and cost overrun (Smith, 2014).

It is vital to note that most developing countries are increasingly trailing in the direction of industrialization of there Nations, and the role of the construction industry cannot be overemphasized as they are enhanced to meet global standards with the intention of actualizing the aspirations of its population (Alaghbari et al., 2007). Conversely, the aspiration of meeting the needs of people is in most cases hindered by the consistent occurrence of delays and cost overrun in construction industries. Hence, the emergence of alternative technology is believed to minimize the delay and cost overrun related issues in the industry. Building Information Model (BIM) as an alternative technology that is gaining acceptance globally is anticipated to solve most of the issues being faced in the industry. This is possible as the model increases collaboration between different professionals in the construction industry (Zhang and Gao, 2013).

Furthermore, BIM is not limited to digital representation of designs but it also comes up with all the necessary information for any project before it is constructed (Eadie et al., 2013). Similarly, BIM as an innovative design tool has the potential to positively impact on the way construction projects are procured, constructed, managed and maintained (Xiao and Noble, 2014). This is because, the information in BIM models are useful in analysis that can optimize the design, planning and construction processes (Azhar, 2011).

According to Bryde et al. (2013), "BIM is an appropriate tool for project managers and should be considered by the project management profession as a way to help manage construction projects". Similarly, BIM has so far has been proven to be a useful technique in the construction industry, because it has helped its users in the reduction of uncertainties as well as the attainment of successful completion of a project (Enegbuma et al., 2014). Consequently, BIM is used as an alternative means of interdisciplinary information sharing (Isikdag, 2015), this allows the detection of clashes in designs that can cause delays during construction. Similarly, the constructability analysis of the building is possible using BIM, thereby mitigating potential risk and design error which saves cost and time (Azhar et al., 2008, Ding et al., 2014, Mohandes et al., 2015). Some of the merits of BIM are enhanced scheduling, enhanced drawings, single detailed model, controlling time and cost (Memon et al., 2014).

More also, Farnsworth et al. (2015), stated that the top five applications of BIM are: detecting clashes, team collaboration, 3D modelling, sales, and constructability issues of design. Lahdou and Zetterman (2011) further stated that, "clash detection, constructability, analysis, time & cost estimation (4D & 5D), quantity take-off, element based models, collaboration, team building, and communication are the key applications of BIM in project management which are continuously developed". It therefore means that, BIM can be applied at all stages of construction processes starting from planning to operation and maintenance. Evidently, the construction industry plays vital role simultaneously in the development and economic growth of most developing countries. The industry often suffers from cost overrun and delays which hinders projects that should have been successful to become projects involving litigation, disagreement, incurring additional costs and in some cases abandonment (Kaming et al., 1997, Ofori, 1991, Ofori, 1993, Ramanathan et al., 2012, Shehu et al., 2014, Ting et al., 2009). For example, a study on 359 projects estimated to cost billions of Ringgit was conducted in Malaysia in 2009, it was revealed that only 42 percent out of the total number of the projects were completed within the budget (Endut et al., 2009). As such there is the need to improve on this phenomenon that shows 58 percent of projects going beyound the budget.

However, BIM as a technology that is improved need to be studied in developing countries to provide proof that it can satisfy the industry's need to improve on cost and time control. The BIM maturity level appreciation in developing countries with regard to increasing demand for efficiency and competitive advantages is being hindered by several factors (binti Ali and Boon, 2013) which include low research on applications of BIM in the management of construction projects. It is also important to further find out the impact of BIM application on delays and cost overrun. Consequently, this serves as a rationale for this research.

2.0 Methodology

A quantitative study was conducted for this research in other to rank the different causes of cost overrun and delays in Malaysian construction industry and correlated with the applications of BIM in the industry. The strategy of enquiry used for the research was questionnaire survey for achieving the objective of the research. A draft questionnaire was developed based on the causes of cost overrun and delays and the applications of BIM in the industry for a pilot study with 20 respondents. This is to ensure that the respondents for the main questionnaire understand the questions. The research sampling frame comprised of the G7 rating registered Construction Industry Development Board (CIDB Malaysia) construction companies in Selangor and Wilayah Persekutuan (Klang Valley) that make use of BIM in the management of their construction projects. There are 3105 construction and civil engineering (CE21) registered construction companies according to CIDB Malaysia (CIDB, 2016) in Selangor and Wilayah Persekutuan (Klang Valley). A sample size of 66 was obtained at 90% Confidence Interval and 10% margin error with z-score 1.65 using the formula:

$$\frac{z^2 * p(1-p)/e^2}{1 + [z^2 * p(1-p)]/e^2N} = \frac{1.65^2 * 90(1-90)/0.1^2}{1 + [1.65^2 * 90(1-90)]/0.1^2 * 3105} = 66$$

Where;
z = z-score (standard deviation).
p = confidence level
e = margin error
N = total population.

The research sampling was narrowed to some indentified group of companies that could give the anticipated information expected by the researcher team. Questionnaires were used for data collection, while data analysis was carried out using frequency distribution and descriptive analysis. Pearson's product-moment correlation was used to relate the causes of delay and cost overrun with the application of BIM to determine the correlation between the two using SPSS version 23 software. Cronbach's alpha test was also conducted on the items to test the reliability of the responses.

3.0 Results and Discussion

The questionnaire consisted of four sections which are the respondent's demographic characteristics, causes of delay, causes of cost overrun, and the applications of BIM in the management of construction projects. This allows the respondents to rank the causes of delay, causes of cost overrun, and to know how often they make use of the different applications of BIM in the management of construction projects on a five-point Likert scale. A total of (187) questionnaires were sent, and (69) of the contractors responded to the questionnaires sent out.

The representatives of the indentified G7 rated companies who responded to the questionnaire survey had different backgrounds in terms of working experience with BIM, industry working experience, levelof education, and job positions. Descriptive analysis was used to analyse the distribution of there backgrounds. The summary of the background information of the respondents can be seen in Table 1 below.

Table 1: Frequency distribution of respondent's demographic characteristics.

Variable	Level	Frequency	Percentage
Job position	Director	5	7.2
	Project manager	14	20.2
	Technical officer	7	10.1
	Engineer	23	33.3
	Architect	7	10.1
	Others	13	18.8
Level of education	BS c.	28	40.6
	MS c.	34	49.3
	PhD	2	2.9
	Other:	5	7.2
Industry working Experience	Less than five years	21	30.4
	Between five and ten years	12	17.4
	More than ten years	36	52.2

Work experience with BIM	Less than 2 years	30	43.5
	Between 2 to 5 years	26	37.7
	More than five years	6	8.7
	Never	7	10.1

The result from the investigation of the respondent's job position, engineers had (33.3%) been the highest percentage of respondents, while (20.2%) were project managers, and (7.2%) were directors of the companies. For the respondent's level of education, (49.3%) had masters' degree (MSc), while (40.6%) of the respondents had bachelor degree. Similarly, the frequency distribution in Table 2 showed (52.2%) of the respondents had more than 10 years working experience, (30.4%) of the respondents had less than five years working experience, while (17.4%) of the respondents had five years and above working experience in the industry.

The frequency distribution with respect to working experience with BIM showed that (43.5%) had less than two years working experience using BIM while (37.7%) had between two to five years working experience using BIM, (10.1%) had no experience using BIM, and (8.7%) of the respondents had more than 5 years working experience with BIM. The four characteristics of the respondents are evidence that revealed the respondents are qualified to answer the questionnaires of this research.

In the same light, the respondents were asked if BIM is used in the management of construction projects in their various companies and (85.5%) of the respondents said BIM was used in their companies, while only (14.5%) of the respondents said that their companies do not make use of BIM.

Pilot study was conducted to measure the reliability and internal consistency of research instruments used for the research. The Cronbach's alpha minimum value was set at (0.7) to establish a coefficient of internal consistency since it is the most common technique of measuring internal consistency reliability (Cochran, 2007). The scale reliability and internal consistency of data for the enquries made were 0.805, 0.867, and 0.966 which shows that the internal consistency of the items are relatively high as shown in Table 2 below.

Table 2: Reliability Statistics (Cronbach's Alpha)

Item	Cronbach's Alpha Value	Number of Items
Causes of delay	0.805	10
Causes of cost overrun	0.867	10
Applications of BIM	0.966	12

Pearson's product-moment correlation were carried out on the constructs to determine their relationships and how significantly they affect one another. Pearson product-moment correlation is a measure of strength and direction of relationship which exists between two variables (Norman, 2010). The Pearson's correlation coefficient (r), ranges from -1 to +1. A negative coefficient indicates a negative correlation, while a positive value indicates a positive correlation, and 0 indicating that there is no correlation between the two variables.

Several methods of conducting correlation analysis were used. First, the variables for the causes of delay, cost overrun and applications of BIM were merged together using data reduction method by conducting Factor Analysis (FA) using principle component on each of the constructs. The factors to be extracted for each of the construct was set at one (1) using principal component analysis. After the data reduction of each of the construct (causes of delay, causes of cost overrun, and application of BIM) by extraction using EFA, the extracted components were then correlated with one another to show the strength and significance of their relationships as shown in Table 3.

Table 3: Correlations of the constructs

		FA causes of delay	FA causes of cost overrun	FA applications of BIM
EFA causes of delay	Pearson Correlation	1	.737	-.246
	Sig. (2-tailed)		.000	.041
	N	69	69	69
EFA causes of cost overrun	Pearson Correlation	.737	1	-.313
	Sig. (2-tailed)	.000		.009
	N	69	69	69
EFA applications of BIM	Pearson Correlation	-.246	-.313	1
	Sig. (2-tailed)	.041	.009	
	N	69	69	69

Correlation is significant at the 0.05 level (2-tailed).

From Table 3, the Pearson's product-moment correlation analysis was conducted between the causes of delay and causes of cost overrun, causes of delay and the applications of BIM, and the causes of cost overrun and applications of BIM to determine their relationships. The correlation significance level was set at 0.05 using 2-tailed significance level.

The results of the analysis on causes of delay and causes of cost overrun showed a positive correlation between them (r =0.737, n = 69, p = 0.000). The (p) value was 0.000 that indicate there is a statistically significant relationship between them. Any decrease or increase in either of the two, increases the other one and same applies in the later. The (r) value was (0.737), this shows a strong relationship between the two constructs.

More also, the result from the analysis of the causes of delay and the applications of BIM shows that there is a negative correlation between the two (r = -0.246, n = 69, p = 0.041). The (p) value is 0.041 which is less than 0.05, this means that there is statistically significant relationship between the causes of delay and applications of BIM. The (r) value is negative (-0.246), this means that there is a negative relationship between the two constructs. An increase in the use of BIM leads to a decrease in the causes of delay.

In the same light, the result of the analysis of the causes of cost overrun and the applications of BIM shows that there is a negative correlation between the two (r = -0.313, n = 69, p = 0.009). The (p) value is 0.009 which is less than 0.05, this means that there is statistically significant relationship between the causes of cost overrun and applications of BIM. The (r) value is negative (-0.313), this means that there is a negative relationship between the two constructs. An increase in the use of BIM leads to a decrease in the causes of cost overrun.

4.0 Conclusion

Delays and cost overrun are prominent in many construction projects globally, resulting to additional cost for the projects. BIM has been used in developed countries of the world for managing construction projects which have proven successful. A large percentage (91.3%) of the respondents have 0-5years of working experience using BIM, out of which only few percentage of the population might have had real life scenerios using BIM to manage construction projects apart from trainings and workshops. This is an indication that the use of BIM is yet to be embraced by a large number of stakeholders in the industry. It also shows a gap in the industry in terms of use of advanced technologies in construction projects in the industry. The zeal for development in the industry is not inline with the current development in the modern world with regards to the use of advanced technologies. This makes it important for stakeholders to look into the learning curve and actual use of BIM in the industry in order to mitigate the causes of delays and cost overrun in projects. Thus, the result of this research shows that BIM can be used to control time and cost in construction industry in developing countries such as Malaysia. The consistent use of BIM in managing construction projects is believed to eliminate the incidence of cost overruns and delays in the industry through the participation and cooperation of the stakeholders involved. More also, stakeholders have vital roles to play in making sure that BIM is consistently used by including it in the contract terms and conditions for contractors.

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