

EFFECTS OF PERCEPTIONS ON BIM ADOPTION IN MALAYSIAN CONSTRUCTION INDUSTRY

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Article history

Received

15 April 2015

Received in revised form

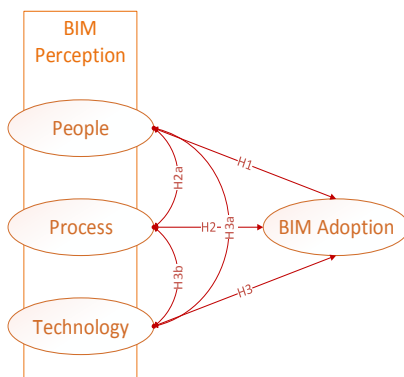
29 September 2015

Accepted

12 November 2015

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Graphical abstract



Abstract

Building information modelling (BIM) continually presents transformation opportunities and strengthening collaboration within the construction industry. People, process and technology are largely discussed factors affecting BIM adoption across the global construction industry. The unsettling precedence envisaged by construction professionals with the onset of BIM in Malaysia has garnered more research focus on this soft issues to technology adoption. Therefore, this paper focuses on the relationship between people, process and technology perception of construction professionals. The overall causal relationship is examined towards effects on BIM adoption in addition to the degree of influence. Quantitative data was derived through a survey of 352 construction professionals (Architects, Quantity Surveyors, Engineers and Contractors) which was further analysed using SPSS and Amos v20. The results revealed a high correlation between people, process and technology (>0.50) while process significantly affected BIM adoption (0.35). Overall, the model explored validated the conceptual framework on the impact of BIM perception of construction industry professionals in Malaysia on the adoption rate of BIM. The results denote grey areas for construction industry stakeholders to direct more efforts towards improving knowledge on BIM technology.

Keywords: Adoption, Building Information Modelling (BIM), construction, Information Technology (IT), Malaysia

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1.0 INTRODUCTION

The growing paradigm in the construction industry is a shift from traditional 3-Dimension (3D) computer aided design (CAD) to building information modelling (BIM) collaborative environment. The McGraw Hill smart market report showed that two-third of BIM users saw positive return on investment (ROI) on their overall investment in BIM while others specified that BIM has placed them in position for better competitive advantage thereby marketing new business ideas to clients. BIM users also saw a productivity increase due

to reduced rework, reduced conflict and variations during construction and clash detection for specialized M&E [1-2]. "BIM is a process of generating and managing building data during its life cycle using three-dimensional, real-time, dynamic building modeling software to increase productivity in building design and construction which encompasses building geometry, spatial relationships, geographic information, and quantities and properties of building components" [3]. Similarly, [4] defined BIM from a project based integration perspective as: "the information management process throughout the lifecycle of a

building (from conception to demolition) which mainly focuses on enabling and facilitating the integrated way of project flow and delivery, by the collaborative use of semantically rich 3D digital building models in all stages of the project and building lifecycle".

The Malaysian construction industry master plan (CIMP) under the critical success factor (CSF) of Knowledge Innovation aimed to improve total Information and technology (IT) spending as a percentage of gross domestic product (GDP), to improve by 50% and also, number of and revenue generated by IT companies supporting the construction industry to improve by 50% [5]. BIM is primarily driven by the private sector in Malaysia. The word BIM was first used in 2009 in Malaysia during a two-day infrastructure and construction asia's building information modelling and sustainable architectue conference in Malaysia [6]. The first government project to fully utilise BIM was launched in 2010 to build the National Cancer Institute (NCI) in Sepang [6]. [7] highlighted the seemingly inadequacy in available literature relating to BIM practices in the Malaysian construction industry. This limitation was further echoed in CIDB Malaysian BIM roadmap which encourages research and development on BIM in the industry [8]. Awareness levels are increasingly raised by seminars/workshops and training on BIM carried out by various bodies (Construction Industry development Board-CIDB, Jabatan Kerja Raya-JKR, Royal Institute Surveyors Malaysia-RISM). Similarly, construction firms which handle large scale projects in-house training is encouraged [9-10]. Cost ranked highest among barrier to BIM implementation among small and medium enterprise contractors in comparison to time, IT components, readiness, knowledge, technology and information [11]. Currently, BIM adoption is affected by the aforementioned challenges bordering around people, process and technology perceptions. This paper aims to assess the effects of people, process and technology on BIM adoption. The subsequent section addresses the hypothesis generation. The methodology, results and discussions are presented including the implications of the research examined.

2.0 PEOPLE PERCEPTION

IT implementation backbone relies on the perception from people, process and technological knowhow due to inadequate artificial intelligence in software and devices [12]. Human interaction with a new system influences the rate of implementation in an organisation. Drivers such as communication, human activity, system processing, design, specification and trade-offs are necessary considerations. A wider computer scientist community argues towards the effect of work stress, human information processing, sensory motor skills, ergonomics, generic and specific IT training [13-15][12]. Several conflicts and apprehensions arose during BIM usage in Hong Kong, amongst issues noticed were the need for BIM interoperability

significant for the interoperability among the participants. Although BIM is accepted both a new tool and a new process, changes to people, processes, communication and work culture is unavoidable. Other conflicts includes computability of the design data and the information exchange among the BIM components clashes, technical barriers - poor library, low running speed of the system and lack of table customization. Also, early contractor input is still lacking in Hong Kong with most design work done independently by architects or engineers.

At industry level, innovative technology such as BIM requires more efforts and time to implement, thus faces resistance in current project processes and the prevalent fast track culture. at the project level, Design-Bid-Build procurement route in Hong Kong isolates key participants within different project phases, limiting the potential benefits from BIM and finally at the organisational level, clients awareness of BIM benefits is low, architects are resistant to consider extra efforts on creating BIM model while contractors are faced with uncertainty about BIM benefits to decide setting up BIM divisions [16-22]. [23] proposed future expansion of current pedagogy in education of building professionals due to current challenges of building sustainable life cycle buildings. [24] opined that BIM offers an unsettling precedence to an already defragmented construction industry which offers less surety of a total solution but rather a catalyst to change in business processes within the industry. [25] highlighted that BIM is a new processes which promise to enhance the construction process and electronic designs in the construction industry and construction professionals must recognise the immense presence of risk associated with utilising such a new technology. The collaboration of each party to the BIM model will in the long run favour quality, coordination, cost savings, and time leading to better competitive advantage. However, boundaries of professional responsibility and work product are not clearly defined creating uncertainty for liability in a BIM model. Hence it is hypothesized that:

H1: There is a significant relationship between people perception and BIM adoption

3.0 PROCESS PERCEPTION

[26] highlighted that most construction industry early reports such as [27], [28] and [29] except the [30] report, have ignored IT as an integral process in construction. [31] stated that attention should be paid to the organisational and human issues rather than focusing on the technological development alone. Inadequate of Staffs to regularly update BIM models and inadequate human resource training exist in the construction industry [32-33]. Cultural change of modifying the traditional standard process present great challenges [34], where only a selected number of professionals utilize the BIM model [35]. This denotes an

adamant resistance to change towards new systems in the construction industry. The phenomenon known as people managers translates the importance of people in organisations adapting to new IT technologies. Hence, understanding ways to tap into individual creative energy, intelligence, initiative, managing change, alleviates fears to change is critical to implementation success [36-40]. Although fears arise from the perceived reduction in professional fees with BIM, cost savings from energy savings, maintenance, informed decisions, purchasing, clash detection, reduced request for information adds value to the project for clients, hence the onus to demonstrate the level of value added to clients [41]. The IT metamorphosis to becoming an integral part of the construction process at the earlier stage created isolated applications from large IT investments. However, management is constantly faced with the reliance on business pull syndrome, where strong market rarely provide an atmosphere for innovation contrary to a more effective technology push paradigm. Incompatibility in IT applications creates island of automation challenging the normal business processes and computer integrated construction, there also exist limited communication between individual software packages with a growing need for standard in data exchange. Thus it is hypothesised that:

H2: there is a significant relationship between process perception and BIM adoption

H2a: there is a significant relationship between people and process perceptions

database as challenges to BIM education in Hong Kong Polytechnic University (PolyU) while, [43] stated that the Malaysian construction industry also lags behind in advanced IT and project management techniques which forms an essential part to high-tech and capital intensive construction and inadequate push for more open standards in software development noted by AIA. [44] argued that construction industry lacks consistency in the way it represents, communicates and interprets information about its product, materials and systems. [45] in analysing the affordance of building information modelling utilised sequential analysis technique to study design routine changes due to building information usage by professionals in a building case study located in Norway. The study found that effective work sharing was not achieved in actual practice, the system also did not include a support functionality to direct users on the context of production and coordination technology application. The infrastructure functionality to allow users to transfer knowledge, skills or methods to other projects or planning situations was not identified. The systems applied were void of user storage or housing information within a device. Also, actors at early project stages had a greater degree of freedom when it came to making use of their design tool affordances than actors working at later project stages. It is thus hypothesised that:

H3: there is a significant relationship between technology perception and BIM adoption

H3a: there is a significant relationship between people and technology perceptions

H3b: there is a significant relationship between process and technology perceptions

4.0 TECHNOLOGY PERCEPTION

[42] highlighted that the knowledge of BIM software, inadequate reference material and component

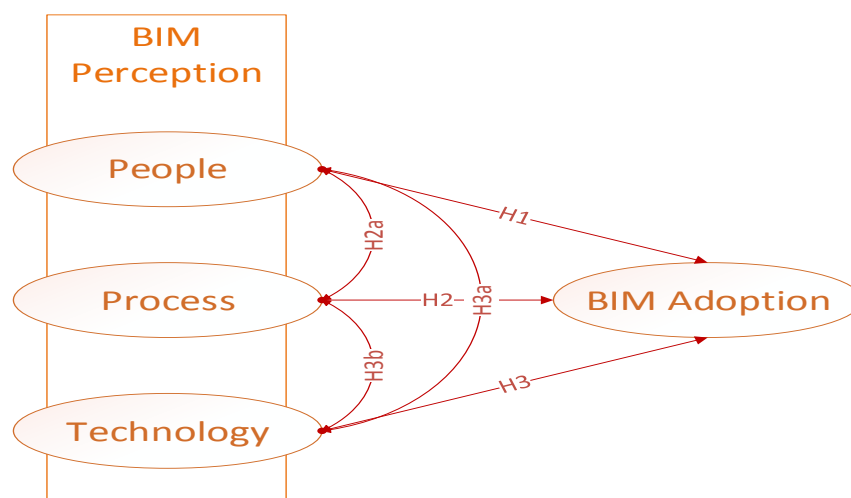


Figure 1 BIM perception model

5.0 METHODOLOGY

Stemming from a quantitative approach, the research epistemology is driven by the positivist view [46]. Positivism targets examining and deriving an explanation for BIM adoption in Malaysian construction industry. The primary respondents were construction professionals (Architects, Quantity Surveyors, Engineers and Contractors). Hence, survey analysis aids in tapping in-depth views related to the perception of the aforementioned professionals [47]. The deduced research constructs were derived from extensive literature while the hypotheses are quantified are measured through the survey instrument. The survey was done through an online survey [48-49]. Participants were invited via email to fill up responses through the survey monkey platform for a period of three months. Sample selection was screened to within medium to large construction organisations including CIDB Class-A contractors. The target sample size according to previous SEM analysis and research [50-55] recommends a minimum of 200 samples. 352 responses were screened following the steps for structural equation modelling (SEM) outlined by [52][56]. A total of 292 were usable and fell within the minimum threshold for SEM multivariate analysis [52][55-56]. The research instrument contained four section measuring People, Process, technology and BIM Adoption respectively. The measure of reliability for all items were first carried out before the test for congruent and discriminant validity. The measurement model was tested to meet the required model indices and subsequently the structural model was assessed.

6.0 RESULTS AND DISCUSSION

The research demographic result revealed that the designation of respondents as Architects (37.9%), Quantity Surveyors (17.5%), Engineers (32.2%) and Contractors (12.3%). The major age bracket fell within 25-35 years (55.1%). Private sector accounted for 65.5% of the construction professionals. A total of 52.6% held a position of junior management in their respective firms while 59.4% possess a bachelor degree. 54.6% of the professionals were equipped with a minimum of 6-10 years working experience in the construction industry and subsequently registered with various professional affiliations. 45.1% of the professionals expressed the opinion that they fell into the beginners' category of experienced BIM users. The adoption of BIM in the industry continues to see an upwards shift in the adoption of BIM. The Instrument pool generate for all the constructs were measured for internal consistency and showed that all constructs were above threshold of >0.60. Items which failed to meet the criteria were screened at the instrument cleaning stage. In the one

factor congeneric model, all constructs showed discriminant validity and convergent validity [56]. The measurement model examined by covariance of all constructs a prelude to the attributes of the structural model showed that all Fit indices were within the acceptable thresholds as shown in Table 1.

Table 1 Goodness-of-fit Indices for measurement model

Fit Index	Acceptable Fit	Indices for data
χ^2		288.97
df		128
ρ	<0.05	0.00
χ^2/df	$\leq 2-5$	2.26
RMR	<0.06	0.02
CFI	≥ 0.90	0.91
GFI	≥ 0.90	0.90
RMSEA	$\leq 0.05-0.80$	0.06

The next step after measurement model examination for fit indices was the assessment of the structural model. The major aim is to examine the validity of the relationship within the structural model. The hypotheses of the structural model was exhibited previously in Figure 1 indicating the direction of impact and relationship between all constructs. The examination of the goodness of fit indices in Figure 2 indicates a mode fit in accordance with the data from respondents and aligns with BIM theory. The indices showed that χ^2/df is 2.3 which fell within the acceptable threshold of $\leq 2-5$ [56]. The CFI and GFI are 0.91 and 0.90 respectively which also fell with the acceptable threshold [56].

The next step assesses the strength of the relationships to denote the overriding hypothetical standpoint on this research. The path coefficient is determined by the regression weights shown in Table 2. Constructs with critical ratio (C.R) above 1.96 are considered to be statistically significant in the model [56]. Out of the three hypotheses generated, one was found to be statistically significant while two others on the impact of people and technology on BIM adoption were found to be statistically insignificant in this model. In BIM model formulation, previous research of [48] infused the constructs of unified technology acceptance and use theory (UTAUT) into technology acceptance models (TAM) with two insignificant scales. [57] extend TAM to include computer self-efficacy, top management support, technical support, training and compatibility with two out of nine hypotheses significant. [49] combined TAM and innovation diffusion theory (IDT) with all 13 hypotheses significant. This paper however, retains the constructs of people, process and technology perception and translates subjective norm from technology acceptance models in terms of the perceived pressure from the changes in the industry with a mediating construct on collaborative processes.

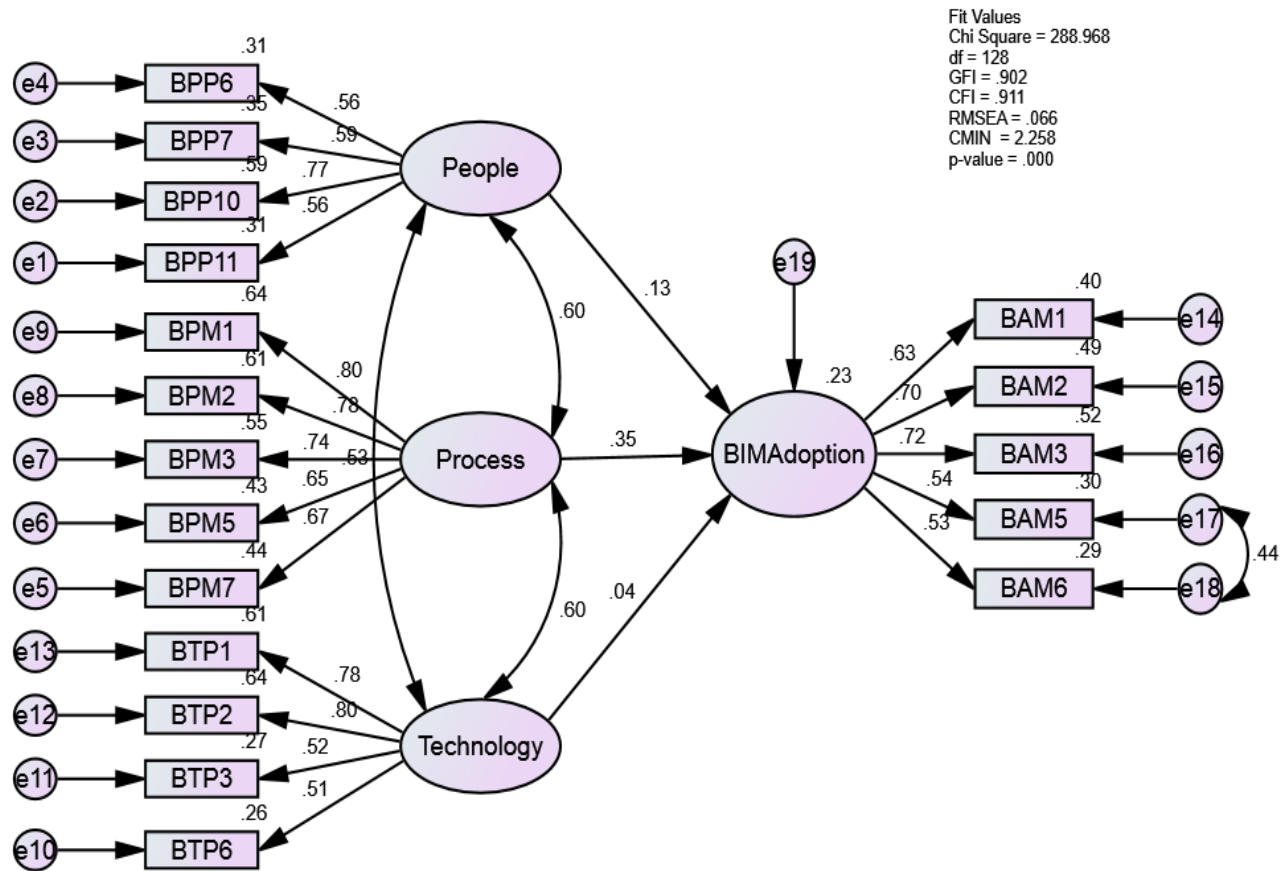


Figure 2 Structural model

Table 2 Structural model estimates and hypothesis testing

			Estimate	S.E.	C.R.	P	Label	Hypotheses
BIMAdoption	<---	People	0.202	0.155	1.301	0.193	par_15	Insignificant
BIMAdoption	<---	Process	0.427	0.132	3.243	0.001	par_16	Significant
BIMAdoption	<---	Technology	0.064	0.158	0.407	0.684	par_17	Insignificant

The implication of the research model shows that the results derived varied from previous research which argued on the effects of people perception on BIM adoption [12][16-20][22-23]. People showed an effect of 0.13 on BIM adoption which suggest that although the statistic presented a relatively insignificant result, the direct impact on BIM adoption will be improved with future drive in awareness and productivity gains by construction professionals. Process perception presented that highest impact on BIM adoption with 0.35 which suggests that the perception towards process change was in line with the aspiration of construction professionals, which was statistically significant and similar to those argued in previous research [26][31][32-35][40-41]. Technology perception presented the lowest effect of 0.04 which varied from previous research [42-43][45] and suggests an improvement in training and knowledge on BIM. Three

construct correlation argued in research model all showed relatively high scores of 0.60, 0.60 and 0.53 respectively which confirms the authors standpoint on the relevance of this constructs to BIM adoption. Overall the variance extracted (0.23) accounted for the explanation of the feature of BIM adoption in Malaysia.

7.0 CONCLUSION

This research aimed at examining the relationship between several constructs affecting BIM adoption in Malaysia. This was achieved through an assessment of the SEM model fit indices and strength of relationship within the constructs. The argument for correlation and mediation of constructs to determine the rate adoption of BIM informed the model formation. The goodness of fit of the structural model preceded by the

measurement model further strengthened the hypotheses developed. The significant relationships were established with one statistically significant relationships. From the findings, it is recommended to improve grey areas such as awareness, collaboration amongst construction professionals, evidence of returns on investment and training. Continual formulation of BIM favorable policy is encouraged. The model for future research can be utilized in assessing the perception from other key stakeholder in the construction industry.

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