Ayinla, K.O. and Adamu, Z. (2018) "Bridging the digital divide gap in BIM technology adoption", Engineering, Construction and Architectural Management, https://doi.org/10.1108/ECAM-05-2017-0091

Bridging the digital divide gap in BIM technology adoption

Abstract

Purpose – In the architecture, engineering and construction (AEC) industry, a 'digital divide' exists in technology adoption because SMEs (who often form the bulk of AEC organisations in most countries) are thought to be 'Late Majority' and 'Laggards' in the adoption of BIM technology. Larger organisations not saddled with financial and socio-technical constraints might be considered as being among the 'Early Majority' or 'Innovators'. It is crucial to understand how these organisations differ in their speed of BIM technology adoption and the rationale for this difference. This research therefore investigates the potential causes of the digital divide and suggests solutions for bridging the gap.

Design/methodology/approach – Using mixed research method, data was collected through online questionnaire survey of over 240 global respondents as well as a semi-structured interview with nine experts for which statistical and thematic analyses were used respectively.

Findings – Organisations can be zoned into 'layers' and 'levels' of BIM technology adoption and their size is not always significant in terms of the speed at which they adopt BIM. The digital divide is unequal across layers/levels and large organisations utilise technologies across the BIM maturity levels depending on project circumstances. A conceptual model for BIM technology was developed to aid identification of the 'Laggards' and 'Late Majority' from the 'Innovators' through which change agents can customise adoption strategies for each group.

Originality/value – The developed model could serve as a tool for engagement and policy making and it contributes to the body of knowledge in the field of BIM technology adoption.

Keywords - *BIM, Technology Adoption, Large firms, SMEs, Digital Divide, Early Adopters, Laggards*

Paper type - Research Paper

1. Introduction

The overarching benefits of Building Information Modelling (BIM) have been well documented but the pace and extent of BIM adoption by businesses within the Architecture, Engineering and Construction (AEC) sector varies. It is generally slower than what a lot of governments across the globe want the sector to progress in their digital economy strategy. For instance, the UK government has mandated BIM to Level 2 (i.e. the use of fully collaborative 3D BIM as a minimum requirement in simple terms) based on a scale between BIM Level 0-3 for all public sector construction by 2016 but a recent large-scale survey suggests that its enforcement is failed as a third of the sector is still unclear about how to comply with BIM

Level 2 (NBS, 2017). AEC organisations face different kinds of organisational and financial constraints that affect the speed at which they adopt new innovations. BIM is one such innovation being embraced in many countries because of its overarching benefits, requiring different forms of strategies for its diffusion across the construction supply chain. However, although large firms and small firms (SMEs) operate in the same AEC ecosystem, they are very different in their socio-economic categories and live in separate business habitats. This makes them behave in relatively different ways in order to adapt and succeed, and they require different types of technology and knowledge to sustain themselves and perform well (Sexton et al., 2006). The constraints faced by these organisations make a singular approach to adoption of BIM at the same pace unrealistic and therefore some categories of firms are left behind while others proceed swiftly in exploiting new innovations and opportunities.

The 'lag' experienced by some firms because of these constraints is argued to have given rise to a phenomenon known as 'digital divide' (Dainty et al., 2015; van Dijk, 2012). This divide is essentially a technology chasm that separates organizations according to their access and usage of information and communication technologies (van Dijk, 2006; Wielicki and Arendt, 2010). The unfolding digital divide between large and small organisations resulting from lack of access to technological opportunities (Dainty et al., 2015; van Dijk, 2006) is likely to create a technological dichotomy in an industry that has been eager to eliminate fragmentation in its processes. The prolonged effect of this situation could be that large firms and small firms in the same construction industry will operate in different technological worlds (van Dijk, 2012). However, bridging this emerging gap can be very difficult as its complexity is continually increasing (van Dijk, 2012). To conceptualise the digital divide in the context of BIM adoption, the paper develops a BIM adoption model to explain organisation's technology adoption status and identify gaps that hinders them to progress to be early adopters or innovators. With a view to addressing this emerging problem, the objectives of this study seeks to (a) understand the different categories of BIM technology adopters that can be found in the AEC industry (b) investigate the realities of BIM adoption for different categories of AEC organisations and (c) explore the possible cause of the divide and proffer solutions to bridge the emerging digital divide gap in BIM technology adoption.

2. Conceptual BIM Technology Adoption Model Development

This research builds the theory of technology adoption in relation to BIM adoption and diffusion in the AEC industry. It is fundamentally based on two key concepts that are central to BIM adoption which are: Rogers' technology adoption model (Rogers, 1983) and Bew-Richards' BIM maturity model. Both models are abstractions of the layers and levels of technology utilisation from both a general standpoint (Roger's model) and at the AEC industry perspective via BIM (Bew-Richards model). This section deconstructs the aforementioned models by showing their connection in relation to technology and BIM adoption in the AEC industry.

2.1 BIM maturity model

BIM, as a rather new process for construction participants to adopt, faces challenges in getting recognition. Part of the reasons identified include lack of strategic leadership (Yan and Damian, 2008, Alwan et al. 2017), poor understanding of implementation processes (Khosrowshahi and Arayici, 2012) and most importantly lack of clear plan for implementation (Hosseini et al., 2015).

However, BIM being a core element of the UK Government's Digital Built Britain strategy (HM Government, 2015), the UK the government has made clear their intention of improving industry's performance through achieving the goals of 33% reduction in the initial cost of construction and the whole cost of built assets; 50% reduction in overall time from inception to completion; 50% reduction in green house emission; and 50% reduction in trade gap between import and export of construction materials by 2025 ((HM Government, 2013). Arguably, achieving this is on the spine of a digitally driven construction economy in which BIM is one of the catalyst for achieving the targets ((NBS, 2015). Hence, lots of work has been done by researchers on aiding strategic BIM implementation, some of which are through studying (Kassem et al. 2013) or/and developing (Succar 2010; Giel and Issa, 2012; Chen et al., 2012; Mom and Hsieh, 2012) maturity frameworks for BIM.

To give references for adoption, the UK government endorsed a BIM maturity model proposed by Bew and Richards (BIM Industry Working Group, 2011) as shown in Fig. 1. Often known as the BIM wedge diagram, it divides BIM maturity into 4 levels. Level 0 is the pre-BIM stage; referring to a stage where the project participants make use of drawing plans and sections in paper or digital form to exchange information without any common digital exchange standards or processes. Level 1 depicts a stage where 2D and 3D information are created in a digital environment that contains standards and formats to govern the model development. However, the level of information exchange between participants is limited. To progress further, information is managed in a 3D environment at Level 2 in which participants adopt a collaborative approach to deliver assets. Further to Level 3, all data are supposed to be fully integrated into a single model and applications are fully interoperable without data loss. The levels of maturity have been proposed to extend to Level 4 and beyond (Construction Industry Council 2014). It is generally accepted that substantial benefit from BIM adoption can only be drawn through implementation of Level 2 and above.

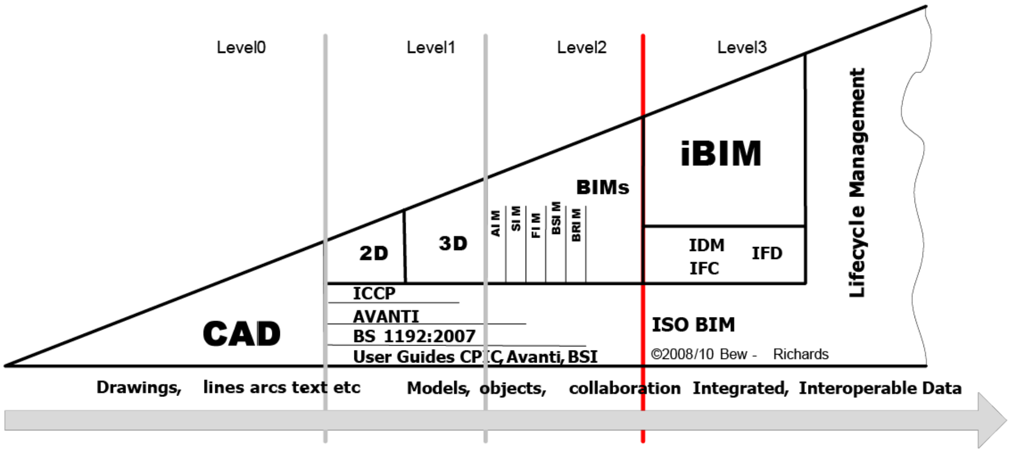

Figure 1: Bew-Richards BIM Maturity model (Source: BIM Industry Working Group, 2011)

Although the UK government through the BIM Task Group (responsible for defining and implementing BIM Level 2) has made attempts to help organisations proceed into higher BIM level, the government arguable expect same pace maturity given the idea of a common deadline regardless of organisational status. However, the realities of a seamless transition seem questionable as previous and recent studies (McGraw-Hill Construction 2014, NBS 2015, NBS 2016, NBS 2017) have shown that the industry is still struggling to meet up the realities of BIM adoption. For instance, the National Building Specification (NBS) BIM report in 2015 revealed that the level of penetration of BIM in the UK construction industry is still in Level 1 as only few firms have started operating in the Level 2 maturity stage while the most recent survey (NBS 2017) reports that although over 60% now use BIM Level 2, BIM adoption is lower among smaller practices despite SMEs make up 90% of UK construction industry (Mellon and Kouider, 2014). Consequently, existing evidences shows backdrops in BIM implementation with regards to adoption and diffusion and following Succar’s (2009) argument of a need for systematic framework for BIM domain knowledge and Alwan et al. (2017) findings that ineffective strategies, policies and leadership have prevented full exploitation of the potential of BIM, perhaps an in-depth understanding of innovation diffusion is essential.

2.2 Model of Innovation Diffusion

Diffusion of innovation has received much interest in the past decades (Kale and Arditi, 2010; Singh and Holmstrom, 2015) because getting people to adopt a new idea (innovation) has proven very difficult even if the benefits are well established (Panuwatwanich and Peansupap, 2013). Some researchers have looked into BIM adoption and diffusion from various perspectives. Succar and Kassem (2015) for example, studied large scale BIM adoption though the generation of macro-adoption models, but those models neglect the pace of adoption among the constituent entities. The speed of adoption is crucial particularly considering the emerging digital divide and the rapid digitisation of construction processes. A widely accepted nomenclature of the key actors in innovation adoption and diffusion which is based on the seminal work of Rogers (1983), the peculiarities of adopting new technologies has already been established (Rogers, 1983) to show that for every new innovation, there are bound to be *laggards*, *late majority*, *early majority*, *early adopters* and *innovators* thus classifying adopters into the five groups (Fig. 2) according to their time of adoption (Kale and Arditi, 2010; Rogers, 1983; Singh and Holmstrom, 2015).

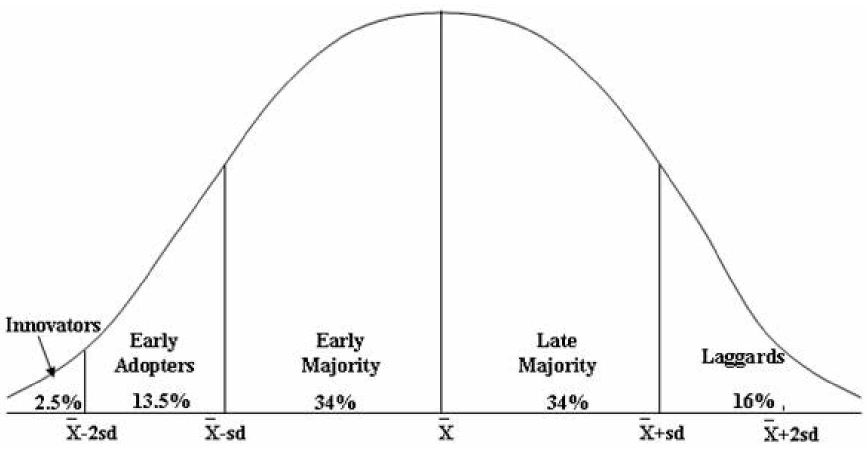

Figure 2: Rogers' technology adopter categorisation on the basis of innovativeness (Source: Rogers, 1983)

Rogers (1983) originally modelled innovation adopters using a normal bell shaped (frequency) curve (Fig. 2) and his model has experienced wide acceptance over the decades (Kale and

Arditi, 2010). The ‘Innovators’ are characterized by their obsession and eagerness to trying new ideas, because of this they typically possess the financial capability to absorb and manage losses due to unprofitable innovations as well as being willing to cope with the high uncertainty degree associated with the new innovations they adopt (Rogers, 1983). Hence, the Innovators are the risk takers of new technologies. The ‘Early Adopters’ are the enthusiastic supporters and accepters of the technologies therefore other ‘potential’ adopters look up to the early adopters for information and advice about the innovation before accepting it. As for the ‘Early Majority’, they are those who adopt technologies after the clear and widely accepted revelation of the positive benefits. This group rarely take leadership position in adopting new innovation (Rogers, 1983). The ‘Late Majority’ are the sceptics who need peer pressure (or perhaps commercial desperation) to motivate their adoption, and would only feel safe to do so after all the uncertainties and risks associated to the innovation have been removed (Rogers, 1983).

The final actors in his classification are the ‘Laggards’, they are ‘traditional’ and always the last in the system to adopt new innovation such that by the time Laggards adopt an innovation, it would most likely have been superseded by a more recent technology that is already used by others higher up in the innovation hierarchy (Rogers, 1983). The resistance to innovation of the Laggards may seem rational or justifiable from the laggard’s viewpoint owing to the limited resources at their disposal thus making them cautious of innovations until they are certain that the new idea will not fail if they adopt it. It can be deduced that if such Laggards happen to be SMEs (who typically comprise 90% of the AEC industry) then their slow pace of BIM adoption constitutes a risk to the entire industry, regardless of the existence of a mandate.

Based on the established characteristics of technology and innovation adopters, the classification of BIM adopters in the AEC industry as done by Singh and Holmstrom (2015) can be used as default presumption, i.e. that SMEs occupy the bottom strata and large organisations dominate the upper layers (Fig. 3).

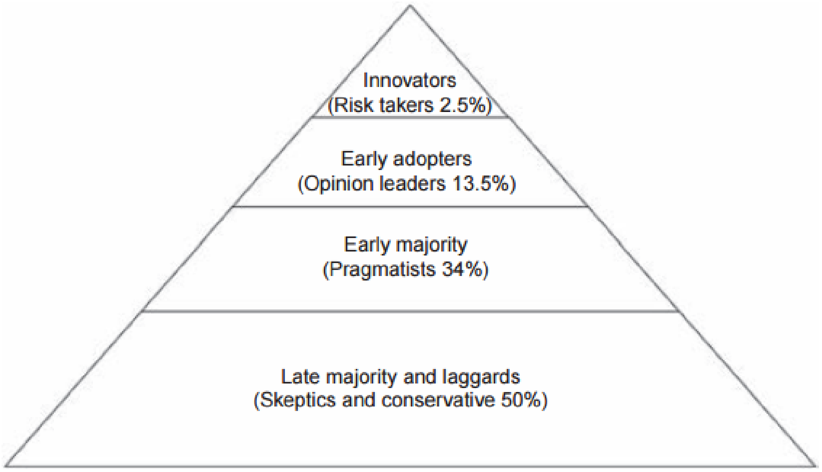

Figure 3: Singh and Holmstrom representation of innovation diffusion categories (Source: Singh and Holmstrom, 2015)

2.3 Theoretical explanation of relationships between models

Considering that the Bew-Richards BIM maturity model comprises of four maturity Levels: i.e. from Level 0 to Level 3, then the Singh and Holmstrom (2015) proposition requires a logical and theoretical presumption that for each Level of BIM maturity all the five categories from Rogers' innovation adopters model can be found. Consequently, the speed at which organisations adopt any specific BIM Level cannot be same, i.e. some may adopt BIM Level 2 at Late Majority or Laggard speed, while others have done so at Innovator speed. Given the established patterns of technology adoption in general and the characteristics of each category of adopters, it is tempting to postulate that in the construction industry the few large organization fall under the Innovator's category while many SMEs fall under the Late Majority and Laggards categories. This argument is strengthened by Rogers' bell shaped model (Fig. 2) and the pyramid version (Fig. 3) by Singh and Holmstrom (2015) whereby the proportion of Innovators is a small fraction of the Laggards who form the bulk.

It is also rational to theorise that between one Rogers' category and the other, a digital divide exists due to the constraints that have defined these categories in the first place and by extension, there is also a digital divide between one BIM Level and another (Fig. 4). This inequality (gap) which manifests as a digital divide is considered difficult to bridge and is 'continually shifting'; mainly due to lack of access (i.e. usage access, skill access, physical and material access, and motivational access) to technology opportunities (van Dijk, 2006). In addition, because differences in social categories reinforce the divide (van Dijk, 2006, 2012) it will be justified from the AEC perspective to view this social categorization in terms of large organisations and SMEs relative to BIM context as already implied by Dainty et al. (2015).

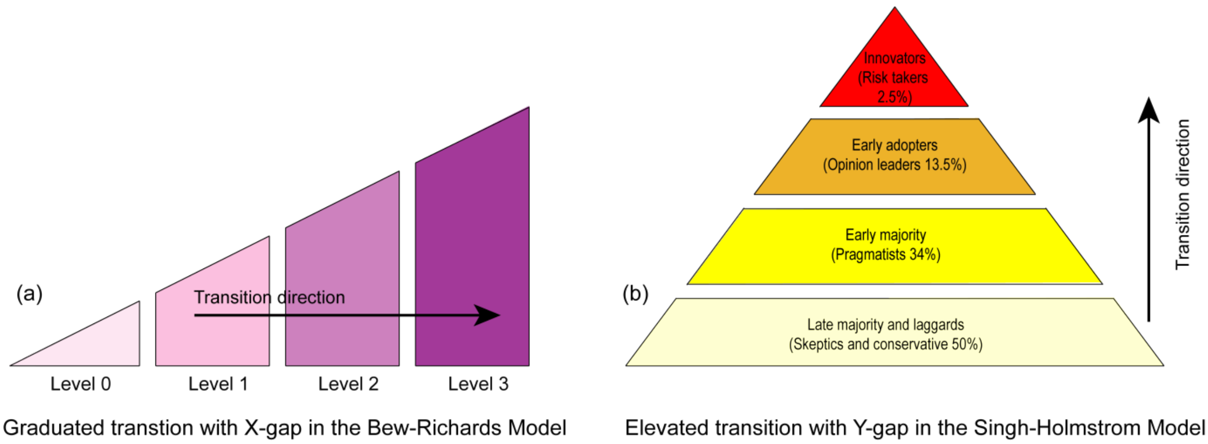

Figure 4: Conceptual view of the digital divide in (a) Bew-Richards BIM maturity model and (b) Singh-Holmstrom technology adoption model

In summary, there is sufficient evidence to conclude that the five categories of technology adopters (and the four BIM Levels) do not exist side by side as a continuum where organisations can transition effortlessly from a lower category/level to a higher one. Based on this, the digital divide gap can be integrated into both models (Fig 4). The first type of gap (which we can call the X-gap) is one that is encountered during the transition along the horizontal direction from one BIM Level to another (Fig. 4a). This gap has to be crossed in order for actors to advance their adoption Level (e.g. from Level 2 to Level 3 BIM). The second type of gap (which we can call the Y-gap) is characterised by time/speed of adoption and represents the barriers that organisations have to overcome in order to elevate their adoption status, e.g. from Early Majority to Early Adopters (Fig. 4b).

2.4 Towards an integrated BIM technology adoption model

Based on the literatures reviewed, this study conceptually merges Rogers' technology adoption model with Bew-Richards BIM maturity model, a preliminary integrated BIM adoption model is proposed as shown in Fig. 5. Organisation progresses in adoption are indicated by arrows showing the moves horizontally, vertically or diagonally as illustrated in Fig. 6.

The composite model generated inspires further investigation of the digital divide gap phenomenon and how it relates to BIM adoption in the AEC industry. The model represents the horizontal and vertical dynamics of change across BIM Levels and across adoption layers. The most obvious gap is the X-gap, where an organization in the UK seeks to adopt for instance Level 2 BIM (which was mandated for public sector projects starting in 2016 onwards). However, the time taken to adopt Level 2 BIM cannot be overlooked because this could be at the Laggard/Late Majority speed, whereas the Innovators and Early Majority may concurrently be adopting Level 3 BIM. Such a scenario could leave the SMEs hanging onto the relics of outdated technologies. Hence, it would be desirable (ideal) for an organization to not only adopt a BIM Level but to do so 'quickly' (i.e. moving to Level 2 at and Early Majority status), regardless of whether the organisation is currently operating as a BIM Level 1 Laggard. This scenario is more pertinent given the relatively short deadline imposed by most government e.g. UK, China, Hong Kong etc. (Tahrani et al., 2015). This model could assist governments with a tool that provides an understanding of 'how' and to 'whom' to diffuse BIM technology based on the classification of actors in each category or Level.

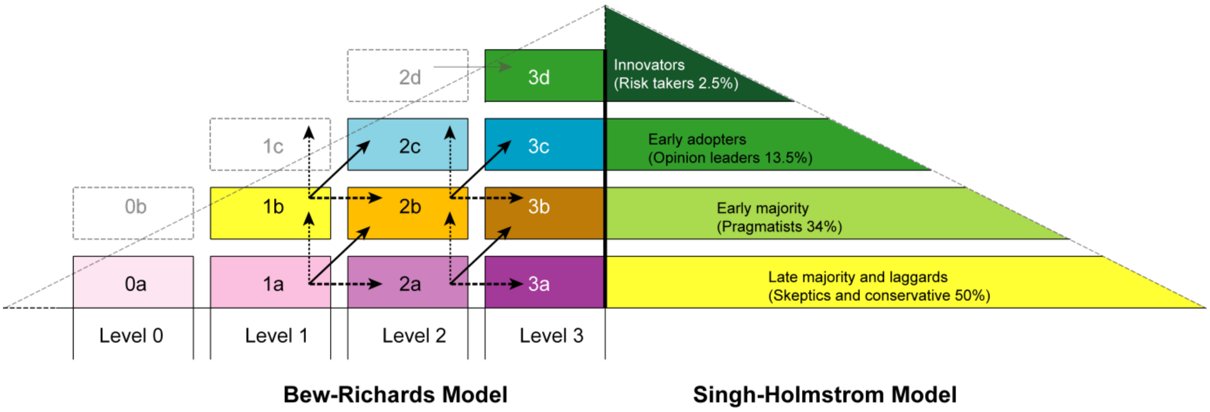

Figure 5: Composite model with digital divide

Using the 2016 UK government mandate as a reference point, this study assumes that due to constraints such as organisational diversity, size and manpower or technical and financial resilience, many organizations will likely expend the minimum resources required to move from one BIM Level to another. This transition is referred to as the 'probable move' which is the X-move along the BIM Maturity timeline (Fig. 6). Similarly, some organizations with the requisite capacity would (without waiting for a mandate) choose to adopt BIM quickly and seek new innovations/advantages from it because innovation has always been part of their modus operandi and they appreciate the benefits of BIM. Such organisations would swiftly make 'voluntary moves' (i.e. Y-move) along the Singh-Holmstrom's pyramid (Fig. 6). Making either an X-move or Y-move requires overcoming the digital divide gaps that separates the constituent layers. However, the ideal BIM adoption transition should be a combination of the

X-move (horizontal) and the Y-move (vertical) leading to an XY-move (vector) that is a resultant of X-move and Y-move, and which exploits the best of both scenarios but which must overcome two gaps at the same time (Fig. 6).

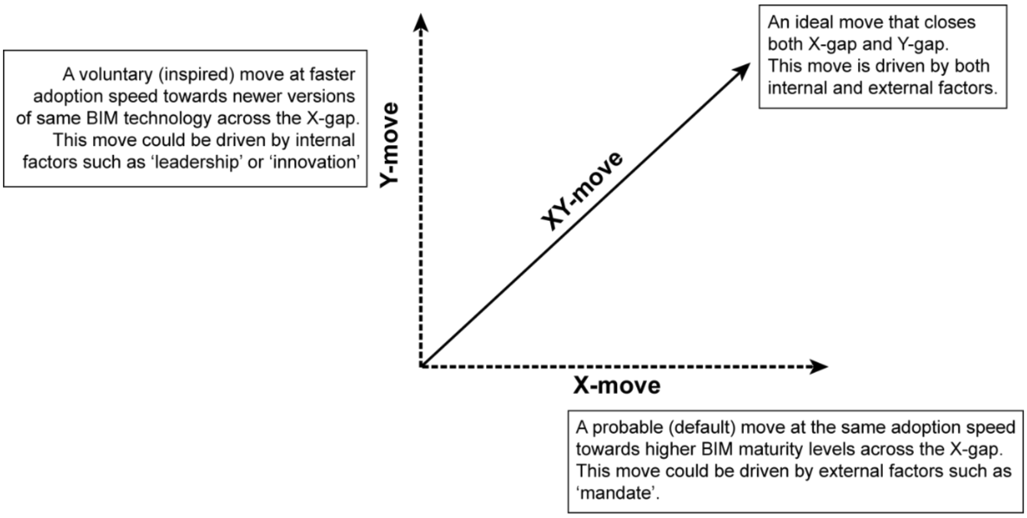

Figure 6: Transition vectors for closing the digital divide gaps in BIM adoption

The digital divide gaps encountered while making the X-move, Y-move or XY-move are basically the direct consequences of the constraints which prevent organisations from either moving to a new BIM level or adopt new BIM technologies quickly as implied by (Wielicki and Arendt, 2010). If the composite model is decomposed to a finer granularity so that these gaps are represented, then it can be deduced that an organisation on zone 2a is a 'Late Majority' or 'Laggard' operating at Level 2 BIM while at zone 2d an organisation is 'Innovating' at Level 2 BIM. This is applicable to all other Levels and categories as presented.

The horizontal arrow (X-move) in the vectors (Fig. 5) represent a 'maintained status' for entities such that a Late Majority in Level 2 BIM would still be a Late Majority even in Level 3 BIM (i.e. they moved from 2a to 3a) BIM adoption. Also, the vertical arrow (Y-move) in the vectors represents an *elevated status in same technology* such that a Late Majority in Level 2 BIM can transition to become an Early Majority when for example; there is a new release of Level 2 BIM technology (i.e. they moved from 2a to 2b). Finally, the resultant arrow (XY-move) represents an *elevated status in advance technology* such that a Late Majority in Level 2 can transition to become an Early Majority in Level 3 (i.e. they moved from 2a to 3b)[1]. Ideally, the XY-move would be most desirable but seem difficult due to the gap explained previously. The model developed thus helps explain the realities of BIM adoption faced today

[1] [Moving from 2a to 3c would require significant disruption in adopting radically new technology at a very fast pace or short time].

(Fig. 5) and will be tested through the research methodology so as to confirm its validity in explaining the phenomenon of BIM technology adoption.

3. Research methods and data collection

The research methodology for the study was designed to investigate the theoretical concepts represented in the conceptual model developed earlier. The main aim of using a model is to generate a research focus in order to specify who and what to be studied and predict relationships between variables (Miles and Huberman, 1994). The composite model proposed (Fig. 5) was developed through critical thinking and exploitation of knowledge gaps in literature but it is still in principle, a reflection of the Bew-Richards and Rogers models. A mixed research method was considered suitable for this study and so the research methodology consists of a mixture of both quantitative and qualitative methods. The data collection process was carried out in two phases: an online questionnaire survey was administered in the first phase aimed at construction professionals who use BIM around the world while in the second phase; a semi-structured telephone interview was carried out with systematically selected experts from the survey. The interview phase also involved validation of the conceptual model ensuring that the final model retained its theoretical underpinnings as well as having a practical reflection of the phenomenon under investigation.

Three key inter-related concepts have a hidden but crucial connection on BIM adoption and served as the basis of the data collection. The first concept is based on the ‘vertical’ layers or categories in the technology adoption model as depicted by Singh-Holmstrom model (with its Early Majority, Late Majority, Laggards, etc.). The second concept is based on the ‘horizontal’ levels of BIM maturity model as depicted by the Bew-Richards model (with its BIM Level 1, BIM Level 2 and BIM Level 3). The third concept that feeds into the proposed model is the ‘digital divide’ gap that exists between different layers/Levels of technology users, i.e. the gaps that separate vertical layers and horizontal levels. The research methodology adopted hence, is channelled towards testing the inter-relationships between the three concepts that are represented in the model. Based on precedent studies, a hypothesis was developed for testing as follows:

- **Research hypothesis H_1 –** Most large AEC firms are Innovators/Early Adopters and most SMEs are Late Majority/Laggards in BIM technology adoption.
- **Null hypothesis H_0 –** Most large AEC firms are ‘not’ Innovators/Early Adopters and most SMEs are ‘not’ Late Majority/Laggards in BIM technology adoption.

The methodical approach to data collection, which includes a validation exercise during the qualitative phase of the study, was deemed key to the successful acceptance and further development of the model by stakeholders. The questionnaire survey involved 241 respondents consisting of different construction professionals using BIM (Table 1) as well as different geographical locations globally with the UK having the largest number of respondents (Table 2).

[Table 1: Breakdown of Survey Respondents Job Title]

[Table 2: Breakdown of Survey Respondents Company Location]

The web based questionnaire was distributed to ensure random responses from AEC professionals who are experienced in BIM[2]. Large organisations with over 250 people employed were in the majority (59.3%), followed by SMEs between 10-250 employees (25.3%) and Micro Enterprises between 0-10 employees (15.4%).

The semi-structured telephone interview involved nine participants out of the 66 that showed interest during the questionnaire survey. The selection process for the interviews was done through purposive sampling based on criteria such as years of experience in using BIM, geographical location, organisational size and job role (see Table 3). To ensure a smooth discussion and avoid misconceptions, participants were sent a brief/guide consisting of some basic definition of terms, as well as the original figures that were used to generate the integrated model and the final model itself. This allowed familiarisation with the themes and the model itself but the specific interview questions were not sent to participants to avoid bias from the preparation of ready-made answers. Results obtained from the quantitative and qualitative data analysis carried out through SPSS and NVIVO software respectively.

[Table 3: Profile Information of Interviewees]

[2] [There was supporting explanation for those respondents outside the UK to make them aware of the mechanics of Level 2 BIM even if they do not recognise the terminology].

4. Results and Observations

4.1. Classification of AEC organisations based on Rogers' model of technology adoption

Efforts were made to determine how organisations can be categorised based on Rogers' technology adoption model with regards to BIM technology adoption in the AEC industry. Series of questions were asked in both the quantitative and qualitative stages of the study to determine how organisations display characteristics (or fall into any) of Rogers' categories of adopters. For example, to examine their level of innovativeness, respondents in the interview phase were asked about the technology they wish to adopt soon. Their responses were analysed using cross-tabulation in SPSS in order to differentiate the large firms from the small firms (Fig. 7).

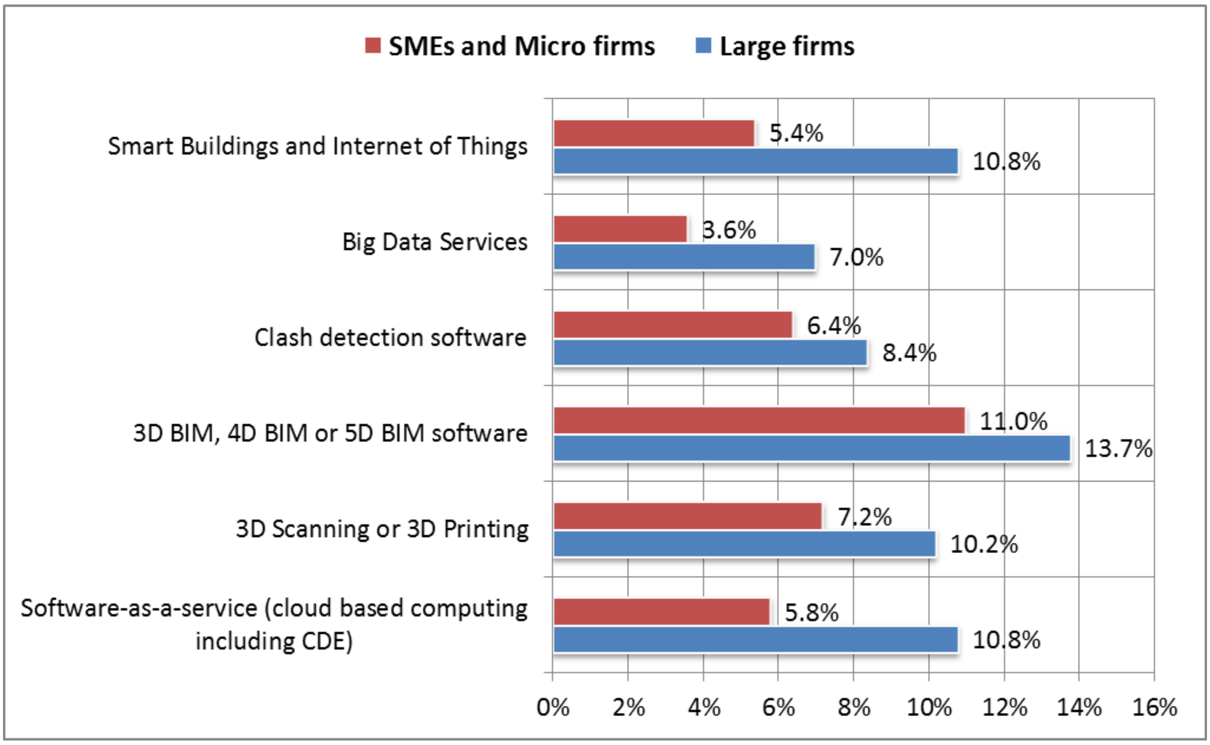

Figure 7: BIM technology wished to be adopted soon by respondents

It was necessary to ascertain how soon the respondents felt their organisations were going to make innovative changes. From the data collected, a total of 24.7% of the respondents in both sizes of firms were "looking forward" to adopting 3D, 4D or 5D BIM software which has the highest percentage value. Similarly, a total of 31.2% of the respondents were "looking forward" to adopting cloud-based shared workspaces or common data environments in addition to clash detection software. These technologies are however already commonly used with or without Level 2 BIM and a total of 55.9% of respondents were "looking forward" to adopting these technologies, suggesting, that they were not currently operating at Level 2 BIM (or equivalent). This finding was further reinforced in the qualitative phase of the study where although most participants firms claimed to be in Level 2 BIM (based on their own understanding of the provided definition) but upon further probing, they accepted to be between Level 0 and 2 and sometimes at all three levels concurrently.

The reason for the concurrent use of multiple BIM technologies was that some organisations were executing projects using different sophistications of BIM technology based on unique project requirement (including clients' requirements, supply chain capability and project type). Hence, some projects were carried out in level 2 BIM while others were procured using older or more traditional methods. This divergence goes as far as some firms operating at Level 0 (i.e. using drawing boards and draftsmen) on some particular projects and it was unexpected to find that large companies are "technologically inclusive or diverse" in this regard. Since organisations depend on project types to dictate their operation at any particular BIM maturity level, it was not possible or logical to classify some of them as being fully at Level 2 maturity. Similarly, statistical analysis carried out on the most frequent BIM technology used by responding organisations for the survey showed that both large firms and small firms are similar in the types of technology they use for their projects. In summary, 2D CAD and 3D BIM technologies are the most frequently used design and construction technologies accounting for 62.7% for both small and large firms. On the other hand, 3D, 4D and 5D BIM technologies were only collectively used by 13.7% of respondents' organisations while a combination 3D, 4D and 5D BIM with cloud-based CDEs were used by 23.7% of the respondents (Fig. 8). This is further confirmed from Chi-Square test results (Table 4) which showed a probability of 0.718 (*p value* = 0.718) which is greater than 0.05 (at the 5% confidence interval). This *p value* is statistically significant and indicates that there is no association between the two variables tested. As a result of this, we fail to reject the null hypothesis which states "most large AEC firms are not Innovators/Early Adopters and most SMEs are not Late Majority/Laggards in BIM technology adoption". In other words, there was lack of sufficient evidence to accept the alternative hypothesis which seeks to ascertain that large firms are Innovators/Early Majority while small firms are Late Majority and Laggard.

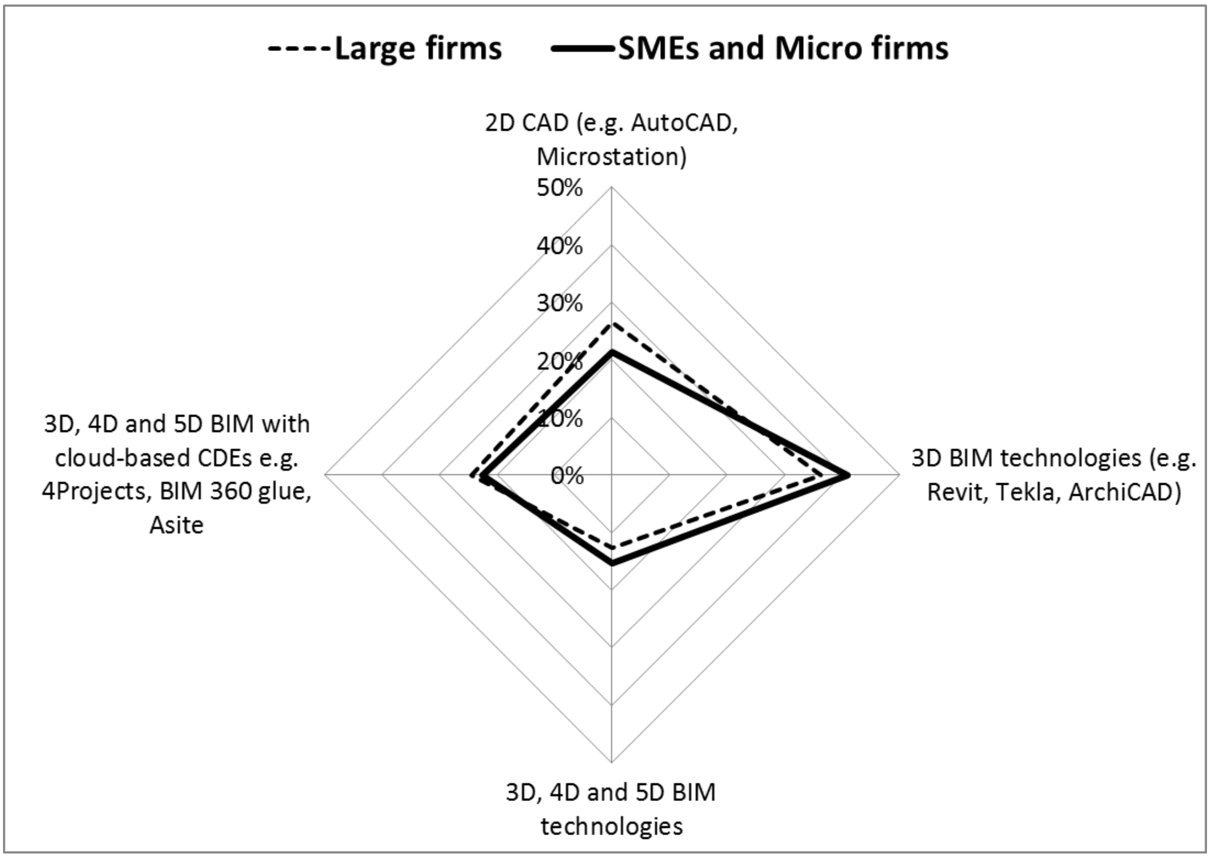

Figure 8: Most frequent technology used by organisations.

[Table 4: Chi-Square Test for Hypothesis]

Some interesting responses were obtained from the interviewees about their motivations for adopting BIM. Three major reasons (subthemes) were derived from their responses which include: *BIM mandates*; *Peer pressure* and *Intrinsic benefits of BIM*. Firstly, some organisations were adopting BIM mainly because of the pressure of government mandate. This reason applies to both large and small firms that were represented in the interview and with strong statements like "*push from the government*". Secondly, some participants identified gaining competitive advantage and following the crowd (peer organisations) as their company's motivation to adopt BIM. This was evident from responses where phrases like '*the competition*' and '*everyone else is doing it*' emerged. The last major motivation for using BIM was linked to cost and time savings in addition to other benefits associated with it like '*collaboration*'. Majority of respondents identified this reason as a driver for their organisation's adoption of BIM but only a few stated this as the 'only' motivation. So although most organisations appreciate the intrinsic benefits of BIM, they still required other external factors like mandate and peer pressure to further motivate or force them to adopt BIM.

Collectively, these observations suggest that most participating organisations are comfortable being in the lower levels of BIM maturity as well as being in the bottom layers of technology adopters. It is also deduced that small and large organisations are somewhat similar based on sophistication of BIM technology used and their speed of adoption.

4.2. The digital divide in BIM technology adoption

Further to classifying representatives of AEC organisations according to Rogers' model, a section of the data was used to explore reasons that could explain how the categories emerged. That is, why Laggards would 'choose' or are constrained to remain in their current status in BIM adoption while their peers were advancing quickly to more sophisticated technologies. Questions were asked about what was required to make them transition from Level 2 BIM to Level 3 BIM as well as act quickly to move from being Late Majority to Early Majority status. In this regards, three subthemes emerged inductively from the interview data coding process including: (i) *the complexity and widening of the digital divide gap between various levels/layers*, (ii) *nature of the gap constraints* and (iii) *requirements for closing the gap*.

4.2.1. Extent of difficulty of closing the digital divide gap

The interview participants were asked about how difficult it would be for an SME to upgrade its BIM practices and technology from Level 1 to Level 2 and from Level 2 to Level 3. In addition to oral explanations, they were required to use a rating scale of 1 to 10 with 10 being the highest level of difficulty. Responses obtained signified that generally, it would be very difficult with answers ranging between 6 and 9. Most interviewees affirmed that in future BIM maturity levels would be tougher for smaller organisations largely because of the increasing sophistication of the technologies associated with each maturity level in addition to the extra financial commitments and acquisition of new skills / talents required to operate successfully at each level. Consequently the gaps between the BIM maturity levels were said to be unequal since the challenges encountered from moving from Level 0 to Level 1 will be different from those associated with moving from Level 1 to Level 2. With respect to design technology for example, respondents pointed out that: switching from Level 0 BIM (manual drawing) to Level 1 BIM (2D CAD) is not as difficult as switching from Level 1 BIM (e.g. 2D CAD) to Level 2 BIM (3D BIM, CDEs and the implementation of various standards/protocols)". The constraining factors and increasing difficulty of adopting new technologies were thought to contribute to the industry's reputation for (and culture of) change resistance. This leads to questions about the nature of constraints encountered in moving between BIM levels as presented in the next section.

4.2.2. Nature of constraints in the digital divide gap

Data from the interview participants revealed seven subthemes that represented constraints or barriers to BIM technology adoption for organisations irrespective of their size. The subthemes include: cost, culture, expertise, training, lack of client demand, legal requirements as well as technology/interoperability (Table 5). These constraints were thought to be primarily responsible for the existence and persistence of the digital divide. In summary, these constraints must be overcome by an organisation regardless of whether an X-move, Y-move or XY-move is to be made. Crossing a digital divide boundary between BIM levels or technology adoption layers was therefore perceived to be 'very difficult' due to the complex nature of these constraints often acting in synergy. The respondents thought that as long as these constraints remained, there was a low probability of an organisation (especially an SME) making an XY move.

[Table 5: Summary of seven constraints that make up the digital divide gap]

4.2.3. Requirements for closing the digital divide gap

The constraints to be overcome in closing the digital divide gap have led to new insights on the necessities and pre-requisites of BIM technology adoption. Up to ten pre-requisites were identified as explained in Table 6.

[Table 6: Pre-requisites for closing the digital divide gap]

5. Discussion: Bridging the digital divide in BIM technology adoption

With respect to Roger's (1983) classical model, organisations in the construction industry are displaying unexpected characteristics in technology adoption. Unexpectedly, among the 'opinion leaders' (i.e. large firms) who might be thought of as 'Innovators', there are many that are lagging behind in BIM technology adoption, while among the supposed Late Majorities/ Laggards (i.e. small firms) many are catching up with state-of-the-art technologies. As advised by Rogers (1983), change agents hoping to diffuse a technology through a social system should make an attempt to identify the Innovators and Laggards in their audience so as to determine the appropriate strategies to use for these critical and extreme categories. Based on this, data was collected about organisations in the construction industry in order to understand their needs and attitude towards BIM technology diffusion in accordance with the peculiarities of their presumed categories.

The hypothesis tested indicated that there was no clear difference between large firms and small firms in the types and sophistications of BIM technology used which is somewhat contrary to Sexton et al. (2006) who argued that these two contrasting organisations require different types of technology and knowledge to sustain themselves and perform well. For instance, most large firms surveyed were still using 2D CAD (a Level 1 BIM technology) for their projects while many small firms were found to be using 3D BIM and some of its peripheral technologies (like 4D BIM and CDEs). In addition, a significant number of organisations, including those based in the UK and who occasionally enjoy government patronage were still “looking forward” to adopting 3D BIM, 4D or 5D BIM, CDEs and clash detection technologies. This was unexpected as at least two of these technologies (3D BIM and CDEs) are central to Level 2 BIM, thus suggesting that these organisations were not presently operating at Level 2 BIM maturity (as at the time of the survey). This finding makes it difficult to place such organisations at Early Majority category or above. Some organisations (large and small) were often found executing different projects using Level 0, Level 1 or Level 2 BIM and the inference drawn was that government mandates on BIM was a key driver to their use of the more mature Level 2 BIM. By extension, many organisations were considered as being in the lower layers of the adoption pyramid (Late Majority and below). In regions where BIM mandates were not in place, client demand was a major driver for using BIM Level 2 technologies.

Some organisations adopted BIM either because everyone else was using it (i.e. peer pressure) or because they did not want to lose patronage in the ‘BIM market’. It was difficult to identify organisations adopting BIM solely because of its intrinsic benefits. The digital divide gap was thought to be increasingly widening between the lower and higher levels/layers of BIM technology adoption. Identification of the constraints which manifest into the digital divide gap as well as the requirements for closing this gap was carried out revealing constraints such as cost, culture, expertise, training, technology, lack of client demand and legal issues. These constraints relate to the findings of van Dijk (2006) and are responsible for the presence and persistence of the digital divide. To address them, requirements like mandate, nudges (through incentives, subsidies, tax breaks, and other supports), expertise, technology and legal aspects are necessary. However, the same strategy may not work for everyone type of organisations because Innovators would hardly require or wait for BIM mandates while Laggards probably need enforcement (mandates) as well as incentives (nudges) in order to adopt BIM Level 2 for example.

The final model underwent a validation and refinement process during the interview particularly with respect to addressing the digital divide in BIM technology adoption. It was necessary to understand the underlying factors that influenced the existence of the gaps as well as the appropriate strategies to tackle the categories of stakeholders separated by the divides (Fig 5). This study revealed the complex and varying nature of the digital divide gap in the construction industry and the difficulties associated with bridging the divide/gap. The gaps were also considered to be unequal between the BIM maturity levels and between the technology adoption layers (Fig. 9). The gaps (constraints) continue to increase[3] in complexity or difficulty from the lower to higher levels/layers as illustrated in the final validated model in Figure 9. This is consistent with existing literature where it has been argued that the digital divide is ‘difficult to bridge and observed to be continually shifting’ (van Dijk, 2006) and frames the challenges to be encountered in digitising the construction industry.

[3] [The gaps increase from: x to x^{n+1} to x^{n+2} (along X-axis) and from: y to y^{n+1} to y^{n+2} (along Y-axis)].

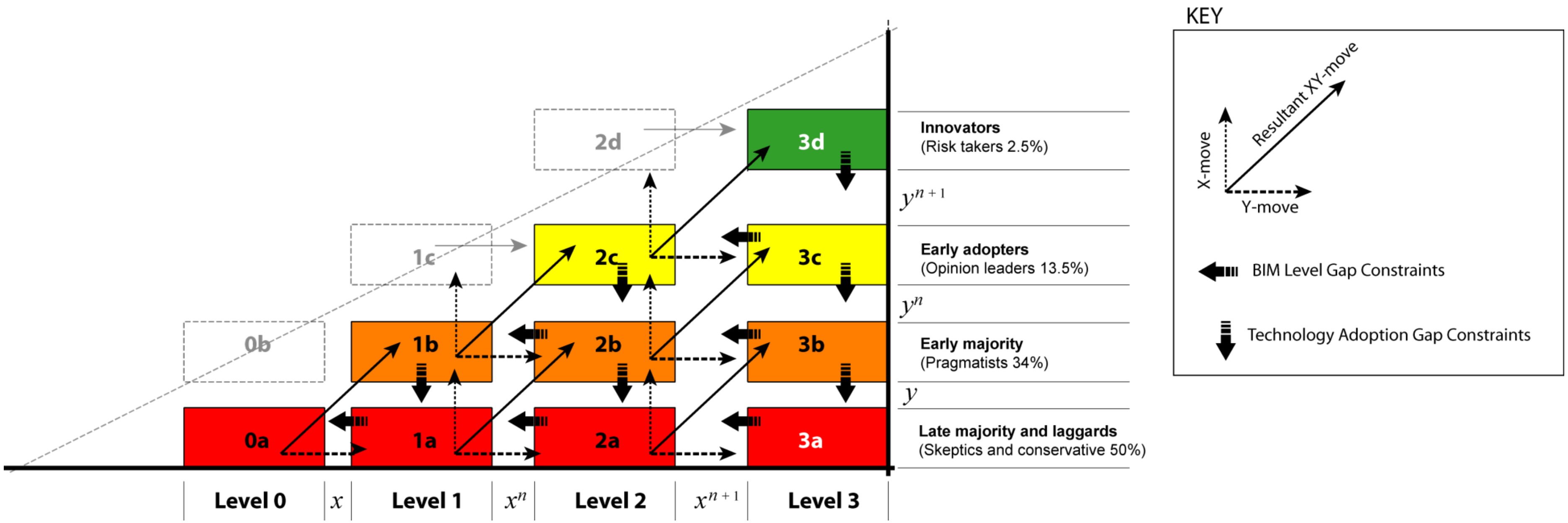

Figure 9: Final validated BIM technology adoption model showing the digital divides [4]

[4] [The BIM maturity gap and technology adoption gap constraints arrows in the illustration represent the constraints that tend to pull organisations down and stop them from moving forward in BIM adoption].

This study identifies three possible kinds of transitions involved in moving from one level of BIM maturity to another. An organisation can either take an X-move (maintaining status quo across BIM levels), a Y-move (elevating in status but remain on the same BIM level) or an XY-move (elevate in status between levels). In the first type of transition (X-move), a Late Majority in Level 2 BIM adoption would still be a Late Majority in adopting Level 3 BIM (i.e. their transition is from 2a to 3a in Figure 9). In the second (Y-move) transition, a Late Majority in Level 2 BIM can elevate to be an Early Majority (in the same Level 2 BIM) if or when a newer version of Level 2 BIM technology is released and they adopt it quickly (i.e. transition from 2a to 2b in Figure 9). The third kind of transition requires an organisation to make an XY-move such that a Late Majority in Level 2 BIM adoption elevates to become an Early Majority in Level 3 BIM (i.e. from 2a to 3b in Figure 9).

The pyramid/wedge in the final validated model narrows to the top implying that majority of construction organisations will be at the bottom category while only a few will be at the top in conformance with Singh and Holmstrom (2015) . Organisations in the Late majority/Laggards category are those that mostly affected by the ‘gap’ constraints (e.g. cost). These constraints are illustrated in Figure 9 and tends to exert a force threatening to push them into lower categories, a ‘forceful push’ through a mandate is probably an effective tool avoid that. However, since their limited resources fuels their change resistance, a nudge (through incentives, subsidies, tax breaks) will also be required to motivate them. Organisations in the Early majority category although better than the Late majority, will only adopt BIM when the market is at its peak (Rogers, 1983) and by so doing, the BIM adoption process might be slowed down. Therefore, they also require a combination of mandate and all forms of nudges to make them adopt quickly. Lastly, the Innovators and Early adopters are the risk takers and opinion leaders who are enthusiastic about trying out new technology and are capable of pouring the resources into it (supposedly large firms). It can be purported that the few construction organisations in this category do not need government intervention to use BIM as they will by themselves adopt even without any BIM mandate hence, they might only be nudged with industry recognition and leadership roles. It is thought that new start-up companies developing bespoke or game-changing technologies can belong to this category

Nevertheless, in the process of being innovative, there could be situations where Innovators might deviate from the standards (supposedly because they are ahead of everyone else) and a mandate will encourage them to comply with government protocols.

7. Conclusion

This study looked into BIM technology adoption using the Rogers theoretical model of technology adopters and the Bew-Richards model for BIM maturity levels. AEC organisations represented in the study were classified into layers (Rogers' model) and levels (Bew-Richards' model) with explanations about why they belong to their respective categories. The digital divide which exists as a result of some constraints was found to be increasingly wider and more complicated as an organisation seeks to adopt new or more sophisticated technologies. The requirements for ensuring a change in status for BIM adopters were also identified.

An adoption model was derived from Rogers' technology adoption model and the Bew-Richards' BIM maturity model, aimed at illustrating the realities of the digital divide gap and BIM technology adoption. The model was deductively developed from literature and inductively validated and refined via interviews. This model demonstrates that the digital divide gap which inhibits technological adaptation and adoption of BIM is more complex than presently acknowledged. It provides a unique representation of many essential components such as: the BIM maturity levels; technology adoption layers; the digital divide gap; the gap constraints; and three distinct kinds of pathways or transitions for closing the digital divide - all of which influence how BIM can be adopted. The model captures the 'dynamics of transition' from different BIM Levels and technology adoption categories across the vertical and horizontal digital divide gaps. The ideal move for an organisation would be an XY-move, which is a resultant of an X-move (across BIM maturity levels) and a Y-move (across technology adoption layers). The model thus serves as a tool for organisations to carry out self-evaluation and understanding 'what next' or governments to use in understanding their sub-audience before applying any strategy to promote BIM adoption.

With respect to Rogers technology adoption model, statistical data suggests that in the AEC industry, the size of an organisation (i.e. SME or large) does not necessarily make it an Innovator (or Laggard). Therefore, the AEC industry probably has some nuances that make it deviate from the norm when it comes to diffusion of innovation. Various constraints like cost, culture, expertise, training, lack of client demand, legal requirements and technology were considered as causal factors for the digital divide. To close the gap, requirements such as mandate, nudge (incentives + subsidies), awareness, clear standard and protocols, client demand, evidence based benefits, change management, technology, expertise, legal issues resolution were considered necessary. Change agents in the industry are advised to aim for an XY-move such that as advancement occurs in BIM technology, organisations in the lower levels elevate their status in BIM adoption (e.g. a Late Majority becomes an Early Majority). By so doing, the lower levels of the pyramid get depopulated while the population at the higher levels increase.

References

BIM Industry Working Group. (2011), *A Report for the Government Construction Client Group - Building Information Modelling (BIM) Working Party Strategy Paper*, available at: http://www.bimtaskgroup.org/wp-content/uploads/2012/03/BIS-BIM-strategy-Report.pdf.

Chen, Y., Dib, H. & Cox, R. F. (2012). "A Framework for Measuring Building Information Modeling Maturity in Construction Projects", 29th International Conference on Applications of IT in the AEC Industry - CIB W078, Beirut Lebanon.

Giel, B. & Issa, R.A. (2012). "Quality and maturity of BIM implementation within the AECO industry", In: Proceeding of 14th International Conference on Computing in Civil and Building Engineering (14th ICCCBE), Moscow, June 27-29

Dainty, A., Leiringer, R., Fernie, S. and Harty, C. (2015), "Don't Believe the (BIM) Hype: The Unexpected Corollaries of the UK 'BIM Revolution'", *EPOC 2015 Conference*, pp. 1–13.

HM GOVERNMENT, 2012. *Industrial strategy: government and industry in partnership - Building Information Modeling (BIM)* [online]. Available from: http://hdl.handle.net/10204/3364. [Accessed: 15/12/2015]

HM GOVERNMENT, 2013. *Construction 2025. Industrial Strategy: Government and industry in partnership* [online]. Available from: http://www.bis.gov.uk/assets/biscore/innovation/docs/b/12-1327-building-information-modelling.pdf\nhttps://www.gov.uk/government/publications/construction-2025-strategy\nhttps://www.gov.uk/government/uploads/system/uploads/attachment_data/file/

210099/bis-. [Accessed: 06/12/2015]

HOSSEINI, M.R., AZARI, E., TIVENDALE, L., and CHILESHE, N., 2015. Barriers to Adoption of Building Information Modeling (BIM) in Iran : Preliminary Results. In: *The 6th International Conference on Engineering, Project, and Production Management*. Australia. pp. 384–394.

Kale, S. and Arditi, D. (2010), “Innovation Diffusion Modeling in the Construction Industry”, *Journal of Construction Engineering & Management*, Vol. 136 No. 3, pp. 329–340.

Kassem, M., Succar, B. and Dawood N. (2013). 'A proposed approach to comparing the BIM maturity of countries', Proceedings of the CIB W78 2013: 30th International Conference, Beijing, China, 9-12 October.

KHOSROWSHAHI, F. and ARAYICI, Y., 2012b. Roadmap for implementation of BIM in the UK construction industry. *Engineering, Construction and Architectural Management* [online]. 19 (6), pp. 610–635. Available from: http://www.emeraldinsight.com/doi/abs/10.1108/09699981211277531. [Accessed: 22/12/2015]

MCGRAW-HILL CONSTRUCTION, 2014. *The Business Value of BIM for Construction in Major GLobal Markets: How contractors around the world are driving innovation with Building Information Modeling* [online]. SmartMarket Report. Available from: http://static-dc.autodesk.net/content/dam/autodesk/www/solutions/building-information-modeling/construction/business-value-of-bim-for-construction-in-global-markets.pdf. [Accessed: 16/12/2015]

MELLON, S., and KOUIDER, T., 2014. SMES and BIM in Preparation for 2016: A Case Study. In: *Conference Proceedings of the 5th International Congress of Architectural Technology* [online]. Aberdeen. pp. 226–241. Available from: http://openair.rgu.ac.uk. [Accessed: 18/12/2015]

Miles, M.B. and Huberman, M.A. (1994), *Qualitative Data Analysis*, Second Edi., Sage Publication, Thousand Oaks, London.

Mom, M. & Hsieh, S.-H. (2012). “Toward Performance Assessment of BIM Technology Implementation”, in 14th International Conference on Computing in Civil and Building Engineering, Moscow. http://www.icccbe.ru/paper_long/0187paper_long.pdf

NBS, 2015. *NBS National BIM Report* [online]. Available from: http://www.bimforum.cl/wp-content/uploads/2017/05/BIM-Report-2016.pdf. [Accessed: 25/07/2017]

NBS, 2016. *NBS National BIM Report* [online]. Available from:

https://www.thenbs.com/knowledge/nbs-national-bim-report-2015. [Accessed: 21/12/2015]

NBS, 2017. *NBS National BIM Report* [online]. Available from: file:///C:/Users/S17102250/Downloads/NBS%20National%20BIM%20Report%202017.pdf. [Accessed: 25/07/2017]

Panuwatwanich, K. and Peansupap, V. (2013), “Factors Affecting the Current Diffusion of BIM: A Qualitative Study of Online Professional Network”, *Creative Construction Conference*, Budapest Hungary, pp. 575–586.

Rogers, E.M. (1983), *Diffusion of Innovations, Newyork Free Press*, 3rd Editio., London, available at:https://doi.org/citeulike-article-id:126680.

Sexton, M., Barrett, P. and Aouad, G. (2006), “Motivating small construction companies to adopt new technology”, *Building Research & Information*, Vol. 34 No. 1, pp. 11–22.

Singh, V. and Holmstrom, J. (2015), “Needs ans technology adoption: observation from BIM experience”, *Engineering, Construction and Architectural Management*, Vol. 22 No. 1, pp. 128–150.

Succar, B. (2009). “Building information modelling framework: A research delivery foundation for industry stakeholders”, Automation in Construction, vol. 18, pp.357-375.

Succar, B. (2010). "Building Information Modelling Maturity Matrix, In Jason Underwood & Umit Isikdag (Eds.), Handbook of Research on Building Information Modelling and Construction Informatics: Concepts and Technologies”, New York: IGI Publishing.

Succar, B. and Kassem, M. (2015), “Macro-BIM adoption: Conceptual structures”, *Automation in Construction*, Elsevier B.V., Vol. 57, pp. 64–79.

Tahrani, S., Poirier, E.A., Aksenova, G. and Forgues, D. (2015), “Structuring the adoption and implementation of BIM and integrated approaches to project delivery across the Canadian AEC industry : Key Drivers from Abroad”, *5th International/11th Construction Specialty Conference (ICSC’15)*, Vancouver, p. 10p.

van Dijk, J.A.G.M. (2006), “Digital divide research, achievements and shortcomings”, *Poetics*, Vol. 34 No. 4–5, pp. 221–235.

van Dijk, J.A.G.M. (2012), “The evolution of the digital divide: The digital divide turns to inequality of skills and usage”, *Digital Enlightenment Yearbook 2012*, IOS Press, Amsterdam, pp. 57–75.

Wielicki, T. and Arendt, L. (2010), “A knowledge-driven shift in perception of ICT implementation barriers: Comparative study of US and European SMEs”, *Journal of*

Information Science, Vol. 36 No. 2, pp. 162–174.

Yan, H. and Damian, P., 2008. Benefits and Barriers of Building Information Modelling. In: *12th International Conference on Computing in Civil and Building Engineering 2008.* Beijing.

Endnotes

1. Moving from 2a to 3c would require significant disruption in adopting radically new technology at a very fast pace or short time.

2. There was supporting explanation for those respondents outside the UK to make them aware of the mechanics of Level 2 BIM even if they do not recognise the terminology.

3. The gaps increase from: x to x^{n+1} to x^{n+2} (along X-axis) and from: y to y^{n+1} to y^{n+2} (along Y-axis)

4. The BIM maturity gap and technology adoption gap constraints arrows in the illustration represent the constraints that tend to pull organisations down and stop them from moving forward in BIM adoption.

Table 1: Breakdown of Survey Respondents Job Title

Participants' Job Role	Frequency	Percent
Architect	25	10.4%
Civil/Structural Engineer	44	18.3%
Construction Manager	11	4.6%
Mech./Electrical Engineer	10	4.1%
Quantity Surveyor	10	4.1%
Project Manager	11	4.6%
BIM Manager/Coordinator	85	35.3%
Others	45	18.7%
Total	241	100.0%

Table 2: Breakdown of Survey Respondents Company Location

Company Location	Frequency	Percent
UK	108	44.8%
Asia	44	18.3%
Africa	27	11.2%
Europe	24	10.0%
Australia	13	5.4%
North America	19	7.9%
South America	6	2.5%
Total	241	100%

Table 3: Profile Information of Interviewees

Participants	**Location**	**Company size**	**Job role**	**Years of experience**
Interviewee 1	UK	SME	BIM Manager	10

Interviewee 2	Asia	SME	BIM Lead	6
Interviewee 3	Asia	Large firm	BIM Manager	6
Interviewee 4	Africa	Large firm	Architect	5
Interviewee 5	UK	Large firm	Bridge Engineer	2
Interviewee 6	UK	Large firm	BIM Manager	8
Interviewee 7	North America	SME	Architect	28
Interviewee 8	Europe	Large firm	Architectural Technologist	20
Interviewee 9	UK	SME	BIM Manager	30

Table 4: Chi-Square Test for Hypothesis

	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	1.346[a]	3	.718
Likelihood Ratio	1.350	3	.717
Linear-by-Linear Association	.070	1	.791
N of Valid Cases	241		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 13.42.

Table 5: Summary of seven constraints that make up the digital divide gap

Themes	**Issues**
Cost	Cost was tagged a major constraint that creates a gap. This is mostly related to: • Cost of *training* and *purchasing* software licences • *Too many new versions of software* emerging frequently • Constraint of lower cash flow (e.g. for SMEs).
Culture	• *Traditional nature* of the construction is perceived as a significant barrier which contributes to the gap. • *Older persons in organisations tend to be more traditional than the younger professionals* • The *older professionals are often at the top management level* in most organisations and hence the *decision makers*. Their perception of BIM and its technology can have a knock on effect on an organisation’s entire outlook towards innovation. • *Lack of understanding of the benefits of BIM contributes to resistance to change* as some stakeholders are not convinced about the reason why changing their practices and processes is necessary.
Expertise	• Training the existing workforce is a barrier to both large and small firms due to the *cost of training internal employees or hiring BIM experts* • The *resources* required for the training poses a major concern. As new BIM technologies continue to emerge the *workforce have to be constantly re-trained on how to use them*.

Technology & interoperability	A technological barrier exists in terms of how to operate BIM technologies (e.g. software utilisation capability) • This was perceived as a threat to Level 3 BIM adoption. *If one technology cannot be recommended for everyone, then the problem of interoperability should be resolved immediately*.
Client demand	Lack of interest from clients in Level 3 BIM • Clients are still *yet to realise the benefits of Level 2 BIM* and the idea of another level may seem far-fetched as they are *not clear about what Level 3 BIM means or what it will deliver that cannot be done in Level 2 BIM*.
Legal issues	Issues relating to contracts and procurement routes were highlighted as having potential legal consequences. • Protection of *intellectual properties on a shared BIM platform is difficult* and discourages collaboration.

Table 6: Pre-requisites for closing the digital divide gap

Themes	Solutions
Mandate	Government BIM *mandate* was perceived as one of the requirement of closing the gap • Using the *mandate approach* is necessary because *without it organisations will stick to their old ways*
Nudge (Incentives, Subsidies, tax breaks etc.)	The use of *incentives* and *subsidies*. These nudges were framed in form; • Providing supports through subsidised; • Trainings; • Education; • Software licences.
Awareness	The importance of *familiarity* was emphasised • It can help *prevent resistance* from people • A nudge from the government through *awareness can direct attention to BIM* and increases its rate of adoption.
Clear standard and protocols	• Having *concise standards and protocols* that allow everyone to operate on the same basis of understanding and implementation. • Too *many of these documents tend to discourage people*, while some practices struggle to follow the standards, others may be found doing the barest minimum just to comply. • The *bulkiness of these documents discourages BIM adoption* because people perceive BIM standards as too difficult and make them reluctant to adopt.
Client demand	• Companies may *not invest in technologies that clients are not interested in* • *Client demand* can be a push from the government as they represent the biggest construction client in most countries.
Evidence based benefits	• People have to really *perceive or believe something is worth it* before they make attempt to give it a trial. • More *pilot projects* can be used to provide the evidence base that organisations (e.g. laggards) need to motivate them to that moving to the next level of BIM would provide better results than remaining at their current level**.**

Change management	• Factoring in *effective change management* procedure was identified as having the potential to close the gap. • The *minds of traditional minded people in an organisation have to be refreshed,* through a top down motivation approach from top managers
Technology	• Too many *complications in BIM technologies* have to be avoided so that the problem of requiring special knowledge or expertise to use these technologies can be eradicated or minimised.
Expertise	Getting the *right skills* required is essential for closing the gap in BIM adoption. • A proposed solution is looking into *training young professionals from the universitie*s so that upon graduation, organisations (large and small) can absorb them and exploit their knowledge and skills for BIM implementation
Legal aspects	• Legal aspect of BIM is crucial going forward in BIM adoption and should be looked into. • Provision of a means of *intellectual properties protection on a shared BIM platform* is required to facilitate collaboration.