Oluseye Olugboyega

Mr Oluseye Olugboyega, Ph.D. candidate, Faculty of Engineering and Built Environment, Department of Construction Economics & Management, Level 5, Snape Building, University of Cape Town, Upper Campus, Rondebosch, Cape Town, 7701, South Africa.
Phone: +277802303909,
E-mail: <OLGOLU005@myuct.ac.za>

Abimbola Windapo

Prof. Abimbola Windapo, Faculty of Engineering and Built Environment, Department of Construction Economics & Management, Level 5, Snape Building, University of Cape Town, Upper Campus, Rondebosch, Cape Town, 7701, South Africa.
Phone: +27216502049,
E-mail: <Abimbola.windapo@uct.ac.za>

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Theoretical model of trust-based relationships in building information modelling supply chain for construction projects

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Abstract

The structure of relationships among project participants has a significant impact on trust development, while the number of participants involved in the relationship increases the complexity of trust. Hence, it becomes inappropriate to generalise the existing dimension and components of trust-based relationships to trust-based relationships among the building information modelling (BIM) supply chain members because of the multiple structures of relationship and the numerous interpersonal and inter-organisations that participate on BIM-based construction projects. This article investigates the nature of trust-based relationships among the BIM supply chain members and establishes whether the requirements of the BIM process influence trust-based relationships among the BIM supply chain members. A five-stage PRISMA was adopted for systematic reviews and meta-analysis. The systematic review enabled the development of a theoretical model of trust-based relationships in BIM supply chain which was subjected to meta-analysis for validation.

The findings revealed that trust-based relationships among the BIM supply chain members entail trusting and trustworthy behaviours, positive expectations, and positive reputations, under which twenty-seven components were identified and classified appropriately. The article concludes that the nature of trust-based relationships among the BIM supply chain members, as influenced by the requirements of the BIM process, can be explained as trusting and trustworthy behaviours, positive expectations, and positive reputations. The article advances the understanding of trust-based relationships among the BIM supply chain members and recommends a first-hand investigation into the nature of trust-based relationships among the BIM supply chain members in future studies.

Keywords: BIM, BIM supply chain, construction projects, trust-based relationships

Abstrak

Die struktuur van verhoudings tussen die projekdeelnemers het 'n beduidende impak op vertroue-ontwikkeling, terwyl die aantal deelnemers wat betrokke is in die verhouding, die kompleksiteit van vertroue verhoog. Daarom word dit onvanpas om die bestaande dimensie en komponente van vertrouensgebaseerde verhoudings te veralgemeen na vertrouensgebaseerde verhoudings tussen die building information modelling (BIM)-toevoerketting lede as gevolg van die veelvoudige strukture van verhoudings en verskeie interpersoonlike en interorganisasies wat deelneem aan BIM-gebaseerde konstruksieprojekte. Hierdie studie ondersoek die aard van vertrouensverwante verhoudings onder lede van die die BIM-toevoerketting en stel vas of die vereistes van die BIM-proses die trustgebaseerde verhoudings tussen die lede van die BIM-toevoerketting beïnvloed. 'n Vyf-stadium PRISMA is aangeneem vir sistematiese oorsigte en meta-analise. Die sistematiese oorsig het die ontwikkeling van 'n teoretiese model van vertrouensgebaseerde verhoudings in BIM-toevoerketting moontlik gemaak wat aan meta-analise onderworpe gestel is vir validering. Die bevindinge het getoon dat vertroue-gebaseerde verhoudings tussen die lede van die BIM-toevoerketting behels vertroue en betroubare gedrag, positiewe verwagtinge en positiewe reputasies waaronder sewe-en-twintig komponente geïdentifiseer en gepas geklassifiseer is. Die studie het tot die gevolgtrekking gekom dat die aard van vertrouensgebaseerde verhoudings tussen lede van die BIM-toevoerketting, soos beïnvloed deur die vereistes van die BIM-proses, as vertroue en betroubare gedrag, positiewe verwagtinge en positiewe reputasie verklaar kan word. Die studie bevorder die begrip van vertrouensgebaseerde verhoudings onder lede van die BIM-toevoerketting en beveel aan om 'n eerstehandse ondersoek te doen na die aard van vertrouensgebaseerde verhoudings tussen lede van die BIM-toevoerketting in toekomstige studies.

Sleutelwoorde: BIM, BIM-toevoerketting, bouprojekte, vertrouensgebaseerde verhoudings

1. Introduction

Trust as a concept is complex and dynamic, because it is difficult to create and slow to develop (Woolthuis, Hillebrand & Nooteboom, 2005: 821). Buvik and Rolfsen (2015: 1485) as well as Bakker (2010: 467) subscribe to the complexity of trust by indicating that it requires time, the experience of other parties' trustworthiness, and prior collaboration to build. Similarly, Diallo and Thuillier (2005: 238) describe

trust as a psychological state that brings about constructive interaction without fear of selfish intentions or hidden motives from partners. Despite its complexity, trust is fundamental to successful interactions and dispositions among the construction project supply chain (McKnight & Chervancy, 2000). Swan, Wood, McDermott and Cooper (2002) confirm that trust is essential for achieving flexibility, ensuring a smooth flow of information, and ensuring effective collaboration in construction project supply chain. Nooteboom (1996: 987) claims that trust is an interaction that indicates a positive perception of an intention to behave in a trustworthy manner.

Simons and Peterson (2000: 108) establish that trust has a positive impact on conflicts, costs, and team effectiveness. Complementary to this, Erdem and Ozen (2003: 133) maintain that trust causes the development and protection of the team spirit by providing cooperation and solidarity among team members. Trust-building requires time. However, owing to its importance to the success of construction project delivery, construction project supply chains (CPSCs) are allowed to develop a 'temporary trust' (trust-based relationship) because of the temporary nature of construction projects (Diallo & Thuillier, 2005: 240; Chow, Cheung & Chan, 2012: 931).

Bachmann and Inkpen (2011: 286) posit that a trust-based relationship (TBR) is an interactive process on which trusting behaviour develops. Although TBR is permissible for CPSC, its development is influenced by the characteristics of construction projects and the nature of relationships in construction projects. Construction projects are temporary, unique, limited by time, and characterised by a high number of participants. All these characteristics have an impact on trust development (Simons & Peterson, 2000: 110). The nature of relationships in construction projects is such that the participating members have to work with new, old, unfamiliar, and heterogeneous members. The effect of this type of relationship on trust development is significant, because there may be no history of interactions, dispositions, and priorities among the members which are imperative to trust development (Buvik & Rolfsen, 2015: 1487).

The nature of relationships in, and the characteristics of construction projects generate hierarchical and non-collaborative interactions among the project participants. This has given rise to opportunities such as excessive change orders and decentralised decisions for the pursuance of self-interest by the project participants (Kadefors, 2004: 176). The solution to this problem, according to Khalfan, McDermott and Cooper (2004: 2), is an integrated CPSC wherein the supply chain is centrally coordinated; relationships in

the chain are maintained during and beyond a specific project; the chain is directed towards sharing of information and transfer of knowledge; there is optimised integration, collaboration, and sharing of risks.

An integrated CPSC typifies a Building Information Modelling Supply Chain (BIM-SC), because it significantly correlates with information-sharing, network communication, and knowledge transfer, all of which are the hallmark of BIM-based construction projects and BIM-SC (Taylor & Bernstein, 2009: 71; Papadonikolaki, Vrijhoef & Wamelink, 2016: 486; Talavera, 2013; Chu & Fang, 2006: 225). This implies that a BIM-SC automatically forms in BIM-based construction projects and that its members are expected to avoid the exploitation of opportunities for the pursuance of self-interests. In so doing, members of the BIM-SC are obligated to undertake TBR for decision-making, information model development and exchange, communication, and collaboration. This will enable members of the BIM-SC to understand their respective responsibilities in the BIM process as well as each other's needs and concerns, thereby guaranteeing a successful construction project delivery (Talavera, 2013).

It thus becomes imperative to develop an understanding of TBR in BIM-SC so as to establish the dimensions of TBR in BIM-SC (Kadefors, 2004: 178). Researchers have made several attempts to investigate the dimensions of TBR in a supply chain. These attempts can be categorised as TBR in buyer-supplier supply chain (Holtgrave, Nienaber & Ferreira, 2017: 529; Ashnai, Henneberg, Naude & Francescucci, 2016: 130; Mayer, Davis & Schoorman, 1995: 721); TBR in client-contractor supply chain (Pinto, Slevin & English, 2009: 641; Tai, Sun & Zhang, 2016: 1783); TBR in contractor-subcontractor relationship (Manu, Ankrah, Chinyio & Proverbs, 2015: 1500; Costa, 2003: 619; Webber, 2008: 753); TBR in lean and agile supply chain (Delbufalo, 2012), and TBR in project stakeholders relationships (Simons & Peters, 2000). Specifically, Holtgrave *et al*. (2017) explain that TBR consists of competence and good will, while Ashnai *et al*. (2015) report attitude, behaviour, and outcome as the constituents of TBR. Mayer *et al*. (1995) report more detailed dimensions of TBR together with their components. These include ability (skills, competencies, and characteristics), benevolence (loyalty, receptivity, and caring), and integrity (consistency, fairness, reliability, openness, and value). Tai *et al*. (2016) propose a reputation-integrity-competence model of TBR for client-contractor relationships. Likewise, Delbufalo (2012: 382) proposes a reliability-credibility model of TBR in the lean and agile supply chain.

The dimensions of TBR such as goodwill and attitude, as provided by these existing models of TBR, denigrate the interactive process of TBR and contradict the complexity and requirements of trust development in a supply chain. Apart from the contradictions in these existing models of TBR, they are inadequate for explaining TBR in BIM-SC for three major reasons. First, a BIM supply chain is network-related in that it consists of multiple interpersonal and inter-organisational relationships such as client-contractor, contractor-consultant, contractor-supplier, BIM manager-project manager, and BIM manager-BIM coordinator. Secondly, the BIM process comes with certain expectations such as, for example, integration, cooperation, coordination, interoperability, and collaboration that alter the nature of supply chain relationships. Thirdly, in BIM-SC, representatives of the participating organisations have a personal and organisational trustworthy reputation to protect (Lau & Rowlinson, 2011: 640). Thus, it becomes clear that the concept and dimensions of TBR vary, based on the structure of relationships and the number of parties involved in the relationship. The structure of relationships has a significant impact on trust development, while the number of parties involved in the relationship increases the complexity of trust (Simons & Peterson, 2000: 111). With BIM-SC exhibiting multiple structures of relationship and multiple interpersonal and inter-organisational participants, it becomes inappropriate to generalise the existing dimension and components of TBR to BIM-SC (Wong, Cheung, Yiu & Pang, 2008: 823; Costa, 2003: 615).

This article aims to understand the nature of TBR in BIM-SC and establish whether the requirements of the BIM process influence TBR. In this article, the term BIM supply chain (BIM-SC) refers to short- or long-term networks of multidisciplinary BIM-based project participants such as clients, subcontractors, main contractors, suppliers, and BIM consultants (Getuli, Ventura, Capone & Ciribini, 2016: 545; Papadonikolaki *et al.*, 2016: 480; Papadonikolaki & Wamelink, 2017: 652; Robson, Boyd, and Thurairajah, 2014; Nawi, Haron, Hamid, Kamar & Baharuddin, 2014: 7; Wu, Mao & Li, 2017: 43). Members of the BIM-SC denotes BIM-based project participants as represented by persons or organisations. TBR refers to direct and intense interaction and dispositions that are based upon positive expectations of the behaviour and intentions of another over time.

2. Research framework

2.1 Theoretical framework

Trust as a concept is multifaceted in nature. Therefore, to effectively capture the complexity or multifaceted nature of TBRs in BIM-SC, this article draws from theoretical perspectives in Behavioural Decision Theory, Social Exchange Theory (SET), and BIM-enabled collaboration theory. The theory of Behavioural Decision-making in construction projects postulates on the actuality of project decisions such as trust, commitment, and risk management, as well as the influence of these decisions on project participants (Stingl & Geraldi, 2017: 126; Morton & Fasolo, 2009: 270; Lloyd-Walker, Mills & Walker, 2014: 233). The SET, on the other hand, explains the relational exchange and mutual dependence among a network of actors, by postulating that social exchange occurs when the exchange partners have resources of value to exchange with each other and they must conduct an analysis of the exchange afterwards (Zeng, Huang & Dou, 2009: 7; Cropanzaro & Mitchell, 2005: 879; Chinowsky, Diekmann & Galotti, 2008: 808).

BIM application on construction projects requires the initiation and sustenance of collaboration among the BIM-SC right from the early phases of construction projects through information-sharing and exchange, knowledge-sharing and transfer, communication, and collaborative procurement (Manu *et al*., 2015: 1499). This indicates that the BIM process is more about cooperation and collaboration, and that trust is an important ingredient for the continuous nurturing of collaborative processes (Vangen & Huxham, 2003: 11). The theoretical perspectives provided by Lloyd-Walker *et al*. (2014), Zeng *et al*. (2009), Cropanzaro and Mitchell (2005), Chinowsky *et al*. (2008), and Manu *et al*. (2015) offer the required insights into the nature of TBR in BIM-SC. These insights are summarised in the following five major principles that are significant to understanding TBR in BIM-SC:

- Trust is a behavioural decision to be made by members of the BIM-SC.
- Trust is a resource of exchange among members of the BIM-SC.
- Trust is an element of collaboration in the BIM process.
- Successful collaboration among members of the BIM-SC depends on TBR.
- Relationships among members of the BIM-SC manifest as collaboration through information-sharing and exchange, knowledge-sharing and transfer, communication, and collaborative procurement.

This was done so as to make available a theoretical grounding that will guide the formulation of the model of TBR in BIM-SC.

2.2 Theoretical model

Figure 1 illustrates a theoretical model of TBR in BIM-SC. This model arises from the principles extracted from the theoretical perspectives in section 2.1 and theoretical background in section 3.2. The model explains that members of a BIM-SC must meet the positive expectations from persons or organisations participating in a BIM-based project; behave appropriately and as expected of a BIM-proficient person or organisation, and develop a positive reputation through consistent positive attributes.

Construction projects require heterogeneous relationships (Buvik & Rolfsen, 2015: 1488), while BIM-SC entails multidisciplinary collaboration (Manu *et al.*, 2015). This understanding differentiates the relationships in construction projects from the other types of relationships and supports the complexity of TBR in BIM-SC. Figure 2 explains the nature of relationships in BIM-SC and shows that TBR in BIM-SC can manifest in a variety of ways (see Figure 2):

- 'Interpersonal relationships': a relationship involving or occurring between two or more people. For example, client and main contractor, client and subcontractor, BIM manager and BIM coordinator, BIM manager and project manager, client and BIM consultant, and client and BIM manager.
- 'Organisational relationships': a relationship between a person or organisations other than the one s/he represents or works for.
- 'Intra-organisational relationships': a relationship between multiple individuals across two or more organisations.

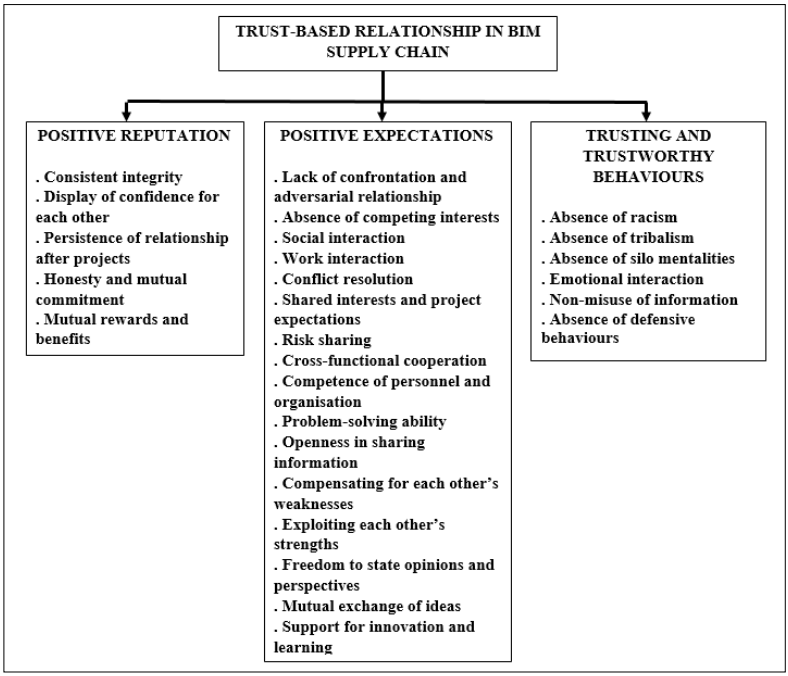

Figure 1: Theoretical model of TBRs in BIM-S
Source: Author

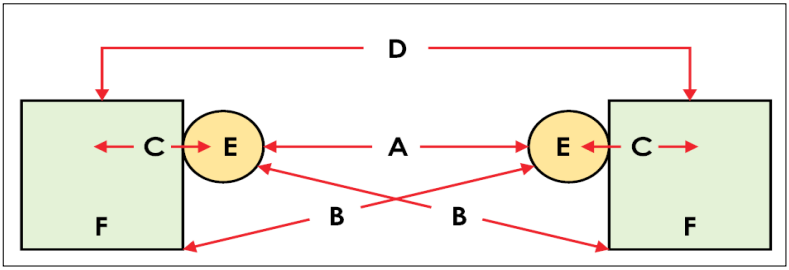

Figure 2: Pattern of relationships in BIM-SC (A = interpersonal relationship; B = organisational relationship; C = intra-organisational relationship; D = inter-organisational relationship; E = representative of the organisation, and F = organisation)
Source: Author

2.3 Theoretical background

2.3.1 Trusting and trustworthy behaviours

Behaviour is a pattern of reactions over time or a manifestation of intentions through actions. In relation to trust, behaviour could manifest as trustworthy behaviour (actions that demonstrate trustworthiness), trusting behaviour (action that demonstrates how a truster relies on a trustee), or as both (Lazzeri, 2014; Vidotto, Massidda, Noventa & Vicentini, 2012: 581). Behavioural problems in interpersonal and/or inter-organisational relationships usually manifest as injurious behaviour, duplicitous behaviour, inconsistent behaviour, haughty behaviour, or opportunistic behaviour (Talavera, 2013). According to Jagtap and Kamble (2015: 23), opportunistic behaviour emanates from the lack of trust among the supply chain members, with features such as motive to maximise one's self-interest, failure to interact, and misuse of information.

Likewise, Jaffar, Tharim and Shuib (2011: 197) identify behavioural problems among construction project supply chain members as including reluctance to check the clarity of information, professional stereotypes, and poor communication. Ensuring the absence of behavioural problems in relation to the collaborative requirements of BIM-SC means that certain cooperative behaviours such as reliability, promise fulfilment, and fairness are expected of members of the BIM-SC (Mayer *et al*., 1995: 7, 15). Talavera (2013) claims that collaborative requirements of BIM-SC, as manifested in cooperative behaviours, are founded on trusting and trustworthy behaviours, because they refer to the absence of behavioural problems in that they prevent members of the BIM-SC from pursuing personal or professional interests and misusing shared information. A study by Zhang, Lu and Rowlinson (2013) reports a case study of BIM-based projects, where members of the BIM-SC, who exhibited behavioural problems, are swiftly replaced with new members because of the need to sustain cooperative behaviours among members of the BIM-SC. The study further links the absence of power conflicts and hierarchical behaviours to trusting and trustworthy behaviour among members of the BIM-SC.

Conclusively, trust develops over time and, in construction projects, the long-time relationship is not feasible, owing to the temporary nature of construction projects. Hence, trust and trustworthy behaviour become essential to trust development among members of the BIM-SC, because such behaviours accelerate trust development. With regard to the link between trust and trustworthy

behaviours, a case can be made that trusting behaviour is the same as trustworthy behaviour, because trusting behaviour promotes trustworthy behaviour and trustworthy behaviour nurtures trusting behaviour (Barr, 2003: 621). Tanis and Postones (2005: 418) agree with this claim, explaining that, in a group, team or supply chain, members engage in trusting behaviour, because they expect their behaviours to be reciprocated by other members.

2.3.2 Positive expectations

Positive expectations are positive noteworthy contributions towards the success of construction projects by members of a BIM-SC (Nalewaik & Mills, 2015: 6; Nalewaik, 2011), because they help members anticipate the needs, concerns, and interests of one another. Traditionally, the components of positive expectations from project supply chain include discretion, reliability, competence, integrity, concern, benevolence, consistency, foresight, intuition, empathy, commitment, self-awareness, responsiveness, and value congruence (Chow *et al.*, 2012: 929; Das & Teng, 2001: 261; Mishra, 1996: 261; Costa & Anderson, 2011: 131). However, in construction projects, together with the collaborative requirements of BIM, greater responsibilities are placed on members of the BIM-SC. These responsibilities represent positive expectations from members of the BIM-SC and cut across roles, competencies, ethics, skills, and contractual relationships (Husain, Razali & Eni, 2018: 411).

The positive expectations that enable TBR among members of the BIM-SC are risk-sharing, cross-functional cooperation, the competence of personnel and organisation, problem-solving ability, openness in sharing information, lack of confrontation and adversarial relationship, work and social interaction, conflict resolution, and absence of competing interests (Mikapagaro & Germin, 2018: 138). For example, in a case study of BIM-SC reported by Zhang *et al*. (2013), openness in sharing information was a major positive expectation from members of the BIM-SC, as every member of the BIM-SC is expected to update and upload each revision of discipline-specific information models to the integrated BIM database rather than delivering it to the BIM manager.

2.3.3 Positive reputation

Because of the short-term and multiple nature of relationships in BIM-SC as well as the requirements of the collaborative interaction of the BIM process, positive reputation becomes an essential part of TBR in BIM-SC, because it helps predict trustworthy behaviours

and positive expectations of members of the BIM-SC (Cicmil & Marshall, 2005: 529). Trustworthy behaviour and positive expectations reveal a trustworthy attribute on the part of members of the BIM-S, but it is only a consistent occurrence. These attributes lead to a positive reputation (Aqueveque & Ravasi, 2006). Without prior ties and prior collaboration, abundant time to study the trustee's attributes and experience of the trustee's trustworthiness, a truster will have to engage in TBR with the trustee, based on his forecast of the trustee's positive reputation (a set of consistent positive attributes) (Vidotto *et al*., 2012: 583). This is a typical arrangement for accelerated trust development among members of the BIM-SC. However, any negative attributes from any member of the BIM-SC are detrimental to trust development (Kadefors, 2004: 177). Notwithstanding the need for accelerated trust development among members of the BIM-SC, one-off positive attributes such as honesty and mutual commitment are required to initiate the process of trust development at the early stages of the construction projects. This must be followed up with a consistent exhibition of some unique positive and trustworthy attributes such as integrity.

As pointed out by Jiang, Lu and Le (2016: 428), integrity is a function of circumstances and opportunities. If it does not happen consistently, the individual or organisation in question cannot be said to possess integrity. A positive reputation is, therefore, defined as a set of consistent positive attributes of an entity (organisation or individual). An example of studies providing support for positive reputation as a dimension of TBR in BIM-SC is the study by Jamal and Bakar (2017), in which positive reputation is associated with efficiency and a high level of professionalism. Similarly, Naismith, Price, Dainty, Bryman, Greasley and Soetanto (2005: 16) report that a reputation for consistent positive attributes is a necessity for the occurrence of integration and collaboration on construction projects. Naismith *et al*. (2005: 20) further identify positive reputation such as honesty, integrity, commitment, and confidence in other members, as significant factors in TBR.

In summary, there is no TBR without positive reputation. As positive expectations and trusting and trustworthy behaviour ensure the initiation and development of TBR in BIM-SC, positive reputation maintains the TBR at the later stages of construction projects or possibly on subsequent construction projects. The BIM-SC is expected to collaborate through all the stages of a construction project and, if possible, on subsequent construction projects. Therefore, a positive reputation is an important ingredient of TBR in BIM-SC.

3. Research methods

This study adopts the 5-stage Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) method proposed by Shamseer, Moher, Clarke, Ghersi, Liberati, Petticrew, Shekelle & Stewart (2015). A systematic review attempts to collate all relevant evidence that fits pre-specified eligibility criteria, in order to answer a specific research question (Shamseer *et al*., 2015: 3). PRISMA outline a structured guide (protocol) that researchers agree to follow, in order to manage identification, screening, eligibility, and inclusion of articles that formed the body of research studies included in their investigation (Shamseer *et al*., 2015: 3). For this article, the 5-stage process includes defining the criteria for collecting articles from the data set (*Scopus, Engineering Village, Ebesco, Google Scholar, and Web of Science*); searching for articles in the data set; identifying dimensions from the articles; categorising the dimensions with variables (components), and conducting a meta-analysis. The criteria for collecting articles from the data set stipulate that the articles must be peer-reviewed, within the fields of trust and trust-based relationships in construction supply chain and BIM-SC, written in the English language, and not have been published prior to 1997.

3.1 Data-collection method

The actual searching for articles in the data set was done using keywords such as BIM-enabled trust, trust-based relationships in construction supply chain/BIM supply chain, relationships among project participants in BIM, effects of BIM process on stakeholders' relationships, and BIM requirements and trust development. In total, 1,984 articles were collected at this stage. These articles were screened for eligibility by checking the relevance and content of their titles and abstracts. The searching and screening stages together with their respective number of articles are illustrated in Figure 3. Data from these articles were extracted onto structured fill-in forms with headings showing the formal data such as the purpose of the study, the method of data collection, a summary of the study's aim, the country where the study took place, and the method of analysis.

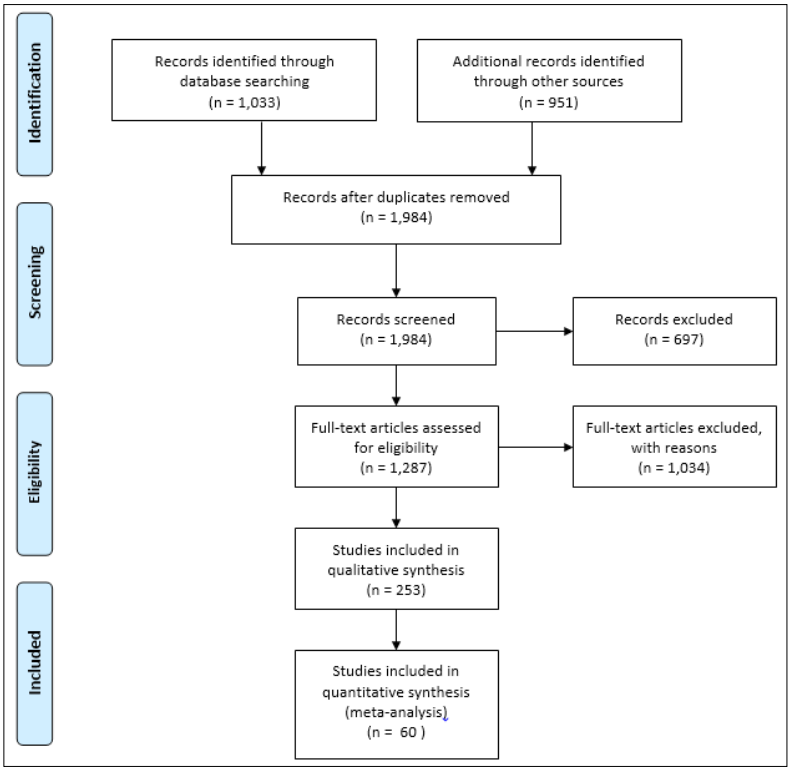

Figure 3: PRISMA flowchart for database screening

3.2 Data analysis and interpretation

The selected articles were analysed to identify the dimensions and components of TBRs in BIM-SC. The analysis was done using ATLAS.ti 8 Qualitative Research Tool following the procedures outlined by Smit (2002: 69-70). The coding process for the analysis was carried out by assigning categories and concepts to the various segments of information that relate to the research objectives. The analysis was interpreted and summarised using qualitative data set synthesis process. According to Major and Savin-Baden (2010: 130), data set synthesis brings original insights and mechanism to understand a phenomenon through a collective body of research. The synthesis process includes categorising the identified concepts into major themes (dimensions and components) and reaching consensus on the major themes, in order to assure credibility. The analysis was summarised graphically using a

descriptive figure (see Figure 1). The analysis yielded three dimensions (positive reputation, positive expectations, and trusting and trustworthy behaviours) and twenty-seven components as the dimensions of TBRs in BIM-SC. Positive reputation has 5 components; positive expectations have sixteen components, and trusting and trustworthy behaviours have 6 components.

The validities of the components were determined using meta-analysis (effect size and percentage of mention of the components). Meta-analysis uses statistical techniques to combine and summarise the results of multiple studies/articles and report the findings in terms of effect sizes (Hunter & Schmidt, 2000: 278-280; Rosenthal, 1995:184).

For this article, the statistical analysis was done by determining the number of studies mentioning the components, the sample means, the frequency of mentioning the components, the population mean, the percentage of mention, and the effect size. The frequency and number of studies mentioning the components were identified from the outputs of the ATLAS.TI 8. A cloud-based statistical analysis tool (online calculator) from Select Statistics was used to calculate the sample means and the population mean (SelectStatistics, n.d.: online). The sample means were determined using the total number of articles and the number of studies mentioning the components. The percentage mention of each component was based on the total number of studies mentioning the components and the frequency whereby these studies mentioned the components. The effect size was estimated using a cloud-based practical meta-analysis software (online calculator) from Campbell Collaboration (Wilson, n.d.: online). Only components with an effect size of 0.2 and above were considered relevant.

4. Results

Tables 1-3 present the meta-analysis estimates for the components of TBR among members of the BIM-SC and show overwhelming evidences for the components as valid elements of TBRs among members of the BIM-SC. Specifically, Table 1 explains that 'consistent integrity' has the strongest effect size (d=2.78) and the highest percentage (81.6%) of mention among the articles used for the meta-analysis. The component with strong effect size and high percentage of mention is 'display of confidence for each other' (d=1.49; 63.30%). The other components have a medium effect size

and percentage of mention: 'honesty and mutual commitment' (d=0.50; 35%), 'persistence of relationship after projects' (d=0.21; 43.33%), and 'mutual rewards and benefits' (d=0.20; 40%). This result suggests that all the components have an acceptable effect size and more than 10% of mention by the studies in the meta-analysis. 'Display of confidence for each other' has the highest percentage of mention by the studies, while 'consistent integrity' has the strongest effect size.

Table 1: Meta-analysis estimates for positive reputation as a dimension of TBR among members of the BIM-SC

Components	*F*	*N*	*χ*	*%*	*d*
Consistent integrity	498	49	1.22	81.6	2.78
Display of confidence for each other	213	38	1.57	63.30	1.49
Persistence of relationship after projects	322	26	2.31	43.33	0.21
Honesty and mutual commitment	238	21	2.86	35.00	0.50
Mutual rewards and benefits	599	24	2.50	40.00	0.20
D = Cohen's d effect size, F = frequency of mention in the database, N = Number of studies mentioning the components, χ = Sample mean					

Table 2 shows the results of the meta-analysis estimates for the components of positive expectations. 'Mutual exchange of ideas' (d=1.14; 58.33%) has the strongest effect size and the highest percentage of mention. The component with strong effect size and low percentage of mention is 'exploiting each other's strength' (d=1.09; 26.67%). The other components with a medium effect size and percentage of mention are 'absence of competing interest' (d=0.62; 33.33%); 'lack of confrontation and adversarial relationships' (d=0.20; 40%); 'social interaction' (d=0.21; 43.33%); 'work interaction' (d=0.22; 45%); 'conflict resolution' (d=0.50; 35%); 'shared interests and project expectations' (d=0.32; 46.67%); 'risk sharing' (d=0.22; 45%); 'cross-functional cooperation' (d=0.27; 38.33%); 'competence of personnel and organisation' (d=0.78; 53.33%); 'problem-solving ability' (d=0.55; 50%); 'openness in sharing information' (d=0.32; 46.67%); 'compensating for each other's weaknesses' (d=0.85; 30%); 'freedom to state opinions and perspectives' (d=0.74; 31.67%), and 'support for innovation and learning' (d=0.55; 50%).

Table 2: Meta-analysis estimates for positive expectations as a dimension of TBR among members of the BIM-SC

Components	*F*	*N*	*χ*	*%*	*d*
Lack of confrontation and adversarial relationship	276	24	2.50	40.00	0.20
Absence of competing interests	185	20	3.00	33.33	0.62
Social interaction	168	26	2.31	43.33	0.21
Work interaction	215	27	2.22	45.00	0.22
Conflict resolution	164	21	2.86	35.00	0.50
Shared interests and project expectations	208	28	2.14	46.67	0.32
Risk sharing	231	27	2.22	45.00	0.22
Cross-functional cooperation	215	23	2.61	38.33	0.27
Competence of personnel and organisation	296	32	1.88	53.33	0.78
Problem-solving ability	262	30	2.00	50.00	0.55
Openness in sharing information	183	28	2.14	46.67	0.32
Compensating for each other's weaknesses	113	18	3.33	30.00	0.85
Exploiting each other's strengths	156	16	3.75	26.67	1.09
Freedom to state opinions and perspectives	124	19	3.16	31.67	0.74
Mutual exchange of ideas	298	35	1.71	58.33	1.14
Support for innovation and learning	204	30	2.00	50.00	0.55
D = Cohen's d effect size, F = frequency of mention in the database, N = Number of studies mentioning the components, χ = Sample mean					

Although the results suggest that positive reputation is mainly characterised by the 'mutual exchange of ideas' and 'exploiting each other's strength', according to the strength of the effect size and percentage of mention, it also suggests that all the components characterise positive reputation, because they have an acceptable effect size and more than 10% of mention by the studies in the meta-analysis.

Table 3 explains the results of the meta-analysis estimates for the components of trusting and trustworthy behaviour. Four of the components have a medium effect size and percentage of mention: 'absence of silo mentalities/professional stereotypes' (d=0.90, 55%); 'emotional interaction' (d=0.20, 41.67%); 'non-misuse of information' (d=0.90, 55%), and 'absence of defensive behaviours' (d=0.85, 30%). Two components have strong effect size: 'absence of racism' (d=1.91, 15%), and 'absence of tribalism' (d=2.15, 11.67%). At 0.2 effect size and minimum of 10% of mention, the result suggests that all the components have an acceptable effect size and percentage of mention and are, therefore, considered valid components of trusting and trustworthy behaviour.

Table 3: Meta-analysis estimates for trusting and trustworthy behaviour as a dimension of the TBR among members of the BIM-SC

Components	*F*	*N*	*χ*	*%*	*d*
Absence of racism	40	9	6.66	15.00	1.91
Absence of tribalism	26	7	8.57	11.67	2.15
Absence of silo mentalities/professional stereotypes	269	33	1.82	55.00	0.90
Emotional interaction	132	25	2.40	41.67	0.20
Non-misuse of information	280	33	1.82	55.00	0.90
Absence of defensive behaviours	116	18	3.33	30.00	0.85
D = Cohen's d effect size, F = frequency of mention in the database, N = Number of studies mentioning the components, χ = Sample mean					

5. Discussion of findings

5.1 Influence of BIM process requirements on TBR

Based on the theoretical model and meta-analysis estimates, this study identified 3 elements that determine TBR among members of the BIM-SC. These elements are 'positive reputation', 'positive expectations', and 'trusting and trustworthy behaviours' (see Figure 4). These elements were analysed to achieve a general understanding of their components, and the influence of BIM process requirements on these elements was established. Traditionally, opportunism and non-cooperative relationships characterise the construction project supply chain. However, the application of BIM in construction projects fundamentally changes the nature of relationships among members of the BIM-SC through the BIM process requirements such as information-sharing, network communication, and knowledge transfer (Chu & Fang, 2006; Papadonikolaki *et al*., 2016; Talavera, 2013). Based on these collaborative requirements of the BIM process, the nature of relationships among members of the BIM-SC requires trust. The findings of this study explain that trust development or trust-based relationship among members of the BIM-SC depends on the 'positive reputation', 'positive expectations', and 'trusting and trustworthy behaviours'. Tai *et al*. (2016) list information-sharing, communication, interaction history, relation-specific investments, competence, reputation, integrity, and opportunistic behaviours as the factors affecting TBR in construction projects. These factors disagree with the complexity and requirements of trust development in a BIM-SC.

The dimensions or elements of TBR in BIM-SC that agree with the complexity and requirements of trust development in a BIM-SC, as

identified and validated in this study, are broadly consistent with the findings by Jaffar *et al.* (2011: 196), Singh, Gu and Wang (2011: 137), Porwal and Hewage (2013: 208), Hooper and Ekholm (2011), Fazli, Fathi, Enferadi, Fazli and Fathi (2014: 1119), Bryde, Broquetas, and Volm (2013: 975), Gilligan and Kunz (2007: 39), Ilozor and Kelly (2012: 28), Kuiper and Dominik (2013: 8), Miettinen and Paavola (2014:87), Chen and Luo (2014: 67), and Khalfan *et al*. (2004: 2). Jaffar *et al*. (2011) identify trusting and trustworthy behaviours such as racism, tribalism, and professional stereotypes as factors of conflict in construction project delivery. Khalfan *et al*. (2004) identify integrity and display of confidence as a way of building a positive reputation among the integrated construction project supply chain. However, the dimensions of TBR in BIM-SC, as identified in this study, do not agree with the model of first-based relationships proposed by Wong *et al*. (2008). Wong *et al*. (2008) identify communication, organisation policy, knowledge, thoughtfulness, emotional investments, and contracts as the dimensions of TBR in construction projects, information sharing, communication, interaction history, relation-specific investments, competence, reputation, integrity, and opportunistic behaviours.

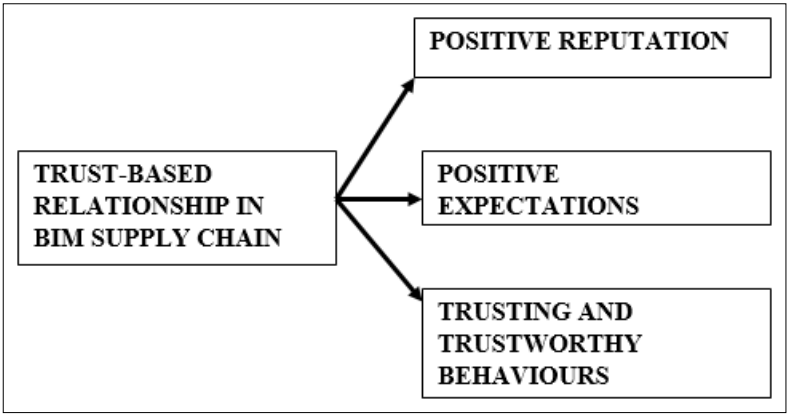

Figure 4: Dimensions of TBR in BIM-SC

5.2 The nature of TBR in BIM-SC

5.2.1 Positive reputation and its association with TBR among members of the BIM-SC

Reputation is required by members of the BIM-SC in order to form opinions about each other and decide on how to relate and interact with each other (see Table 1 and Figure 5). A positive reputation will lead to trust development. This study found that a positive reputation can be created and maintained in BIM-SC through consistent integrity, display of confidence for each other, persistence of relationship, honesty, mutual commitment, and mutual rewards and benefits. This component provides an explanation for the role of positive reputation in TBR among members of the BIM-SC, because maintaining a positive reputation is fundamental to being transparent, responsive, and trustworthy. This indicates that consistent integrity is essential to the survival of TBR in BIM-SC. Integrity and consistent integrity refer to uncompromising truthfulness, accuracy, and adherence to ethical and contractual principles.

BIM is a process involving a fair amount of relationships. Trust development in these relationships will not be smooth without consistent adherence to BIM principles and requirements. This means that, without consistent integrity, there is no foundation on which to build TBR, because consistent integrity makes a person or an organisation trustworthy and dependable.

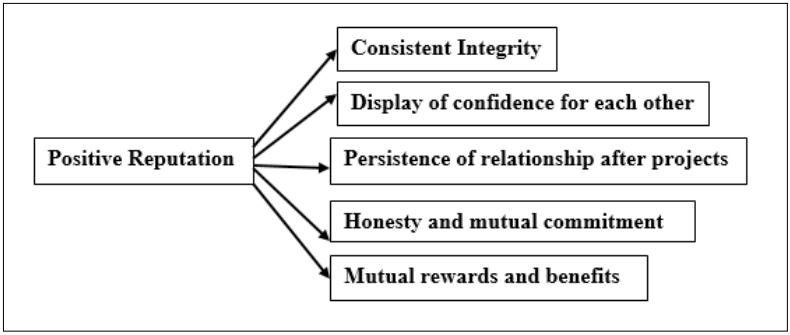

Figure 5: Components of positive reputation as a dimension of TBR in BIM-SC

The persistence of relationships among members of the BIM-SC after a particular project is also a way to develop trust through positive reputation, because positive reputation leads to better relationships in the BIM-SC network. Thus, this relationship could persist after

the current project in the form of referrals and recommendations. The study by Dossick and Neff (2013) confirms that the display of confidence for each other by members of the BIM-SC is associated with a trust-based relationship. Dossick and Neff (2013) indicate that the display of confidence for each other by members of the BIM-SC allows the quick defection of problems in the BIM process. The display of confidence for each other by members of the BIM-SC is an indication of a positive reputation, because it reveals a lack of fear and insecurities about the responsiveness and trustworthiness of each other. Display of confidence for each other by members of the BIM-SC is an essential ingredient for TBR, because they are expected to respect time, principles, and deadlines, so as to inspire confidence in each other.

Straightforward and mutual commitment, as a component of a positive reputation, indicate a mutual dependence that motivates members of the BIM-SC to trust each other, thereby promoting a TBR. They guarantee that members of the BIM-SC will do their best for the success of the projects and the BIM process. This finding is consistent with that of Hooper and Ekholm (2011) who found that mutual commitment among members of the BIM-SC is important to a collaborative process in BIM. Similarly, Mathews, Love, Mewburn, Stobaus and Ramanayaka (2018: 209) report that BIM application on projects creates a BIM-SC where a network relationship is formed from hierarchical relationships that lead to mutual rewards and benefits. Mutual rewards and benefits find a place in TBR among members of the BIM-SC, because, when all the members are interested in contributing value to the BIM process and expecting advantages that correspond to their respective value, the trust will effortlessly develop among them.

5.2.2 Positive expectations and their association with TBR among members of the BIM-SC

This study describes positive expectations as a dimension of TBR in BIM-SC, because positive expectations entail the behavioural forces that expect positive contributions from member of the BIM-SC towards the success of the project and the BIM process, while maintaining positive attributes that will attract positive contributions (see Table 2 and Figure 6). Positive expectation is anticipation and exhibition of positive contributions from all the members of the BIM-SC. Some of the ways in which to achieve positive expectations are the absence of confrontation and adversarial relationships, absence of competing interests, work and social interactions, conflict resolution, shared interests and project expectations, risk sharing, problem-solving ability,

and openness in sharing information. Confrontations and adversarial relationships occur when people or organisations on the BIM-SC are opposing each other. This will create oppositional relationships that are devoid of trust and will affect project performance. However, a lack of confrontation and adversarial relationships will ensure TBR. This finding accords with the findings by Glick and Guggemos (2009) and Olatunji (2015: 308), indicating that members of the BIM-SC are expected to have a spirit of cooperation that will eliminate the functional and traditional adversarial relations among them.

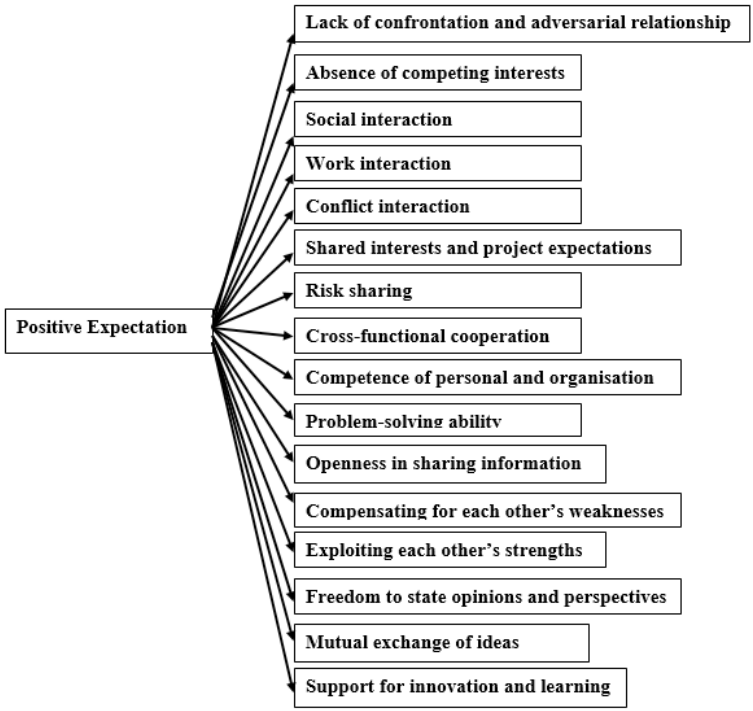

Figure 6: Components of positive expectation as a dimension of TBR in BIM-SC

Closely related to confrontation and adversarial relationships is competing interests. Competing interests occur when multiple interests are involved in a relationship. The existence of competing interests usually generates a conflict of interests and professional judgement that will interfere with project interests. Therefore, the absence of competing interests will support the realisation of one

of the main BIM objectives, namely collaboration. This qualifies the absence of competing interests as a component of TBR in BIM-SC. Love, Edwards, Han and Goh (2011: 179) confirm that the absence of competing interests among members of the BIM-SC is important, in order to achieve collaboration in the BIM process, and this will be achieved when members of the BIM-SC share common interests and problems through regular interaction. In addition, certain accidental, regulated, repeated, and regular social and work interactions must occur between members of the BIM-SC. Such interactions allow members to make positive contributions to the project at hand through their actions and reactions. Liu, Van Nederveen and Hertogh (2017: 678) confirm that there is a need for frequent social and work interactions in BIM-enabled collaboration among members of the BIM-SC, in order to stimulate the trust effects of BIM application on projects. In the BIM process, when a dispute arises, as it must, all members of the BIM-SC are expected to make efforts to facilitate the peaceful ending of the dispute or conflict. Doing so signifies not only professional growth, but also the existence of TBR. Studies by Azhar (2011: 19), Ashcraft (2008: 9), as well as Sacks, Koskela, Dave and Owen (2010: 973) provide support for this argument.

BIM is required to foster a common understanding of project expectations among member of the BIM-SC. Therefore, when the understanding of the project expectations is common to all members of the BIM-SC, it reflects a certain positive expectation that will lead to TBR. In support of this argument, Dossick and Neff (2008) explain that shared interests and project expectations can influence collaboration and eliminate conflicting obligations among members of the BIM-SC. In the BIM process, the probability and impact of risks are expected to be reduced through the appropriate distribution of the risk. Failure to do this will frustrate trust development. This suggests that risk sharing among members of the BIM-SC is a way of avoiding obstacles to information-sharing and exchange among members of the BIM-SC (Gilligan & Kunz, 2007: 40; Wong & Fan, 2013: 141; Aranda-Mena, Crawford, Chevez & Froese, 2009: 424). The personnel or organisations on the BIM-SC must be able to demonstrate a set of BIM-related skills, knowledge, and capability. This constitutes a positive expectation, because the competence of organisation and personnel positively stimulates the productivity level and the quality of work that influences project performance (Aranda-Mena *et al*., 2009: 426).

Another reason is that the level of BIM competency of organisations determines the realisation of the benefits of the BIM application such as collaboration (Alaghbandrad & Forgues, 2013). More

importantly, competence is a major expectation among members of the BIM-SC, because it enables them to have confidence in the information models and reviews shared by the other members (Liu *et al*., 2017: 688). Another important component of positive expectations as a dimension of TBR in BIM-SC, as identified in this study, is the problem-solving ability of members of the BIM-SC. Problem-solving abilities such as active listening, analytical skills, and team-building skills are highly useful and inevitable in TBR. Problem-solving abilities enable members of the BIM-SC to share with each other their own views on the conflict issues and the likely resolution tactics (Aranda-Mena *et al*., 2009: 428). This study also identifies openness in sharing information as an element of positive expectations among members of the BIM-SC. The explanation for this is that concealment and restriction of access to information is catastrophic to trust development in BIM-SC.

Openness in sharing information stimulates TBR in BIM-SC, because it allows members of the BIM-SC to better understand expectations and predict actions (Won & Lee, 2010: 144; Won, Lee, Dossick & Messner, 2013: 414; Love *et al.*, 2011:181; Lu & Issa, 2005: 63). This study also found that members of the BIM-SC must have the right to pass across their opinions and perspectives. This creates a sense of belonging and provides feedbacks that are imperative to trust development. The freedom to state opinions and perspectives is a clear demonstration of commitment to each other and it nurtures trust among members of the BIM-SC (Liu *et al*., 2017: 691). It is encouraging to compare the findings of this study with those of Grilo and Jardim-Goncalves (2010: 525), which indicate that mutual exchange of ideas secures the commitment of members of the BIM-SC to a mutually agreed solution, thereby fostering trust. This confirms that members of the BIM-SC must be able to come up with a suggestion as to a possible course of action towards the success of the BIM process and projects.

5.2.3 Trusting and trustworthy behaviours and their association with TBR among members of the BIM-SC

Trusting and trustworthy behaviours deal with the promotion of trust development by eliminating behavioural problems such as racism, tribalism, silo mentalities, and defensive behaviours (see Table 3 and Figure 7). Members of the BIM-SC are expected to never exhibit behaviours that stem from strong loyalty to a tribe or social group or race. Racist and tribalistic behaviour will promote prejudices, discrimination, and antagonism that will frustrate TBR. Therefore, the absence of sociocultural issues such as racism and tribalism are

important to trust development in BIM-SC (Davies & Harty, 2013: 18; Carvalho, Braganca & Mateus, 2019: 177; Kuiper & Duffield, 2018). This study found the silo mentalities among members of the BIM-SC to be a strong component of trusting and trustworthy behaviours which is a dimension of TBR in BIM-SC. Nothing damages TBR as a silo mentality on the part of members of the BIM-SC, because it creates hierarchy and division in the BIM-SC that will reduce the efficiency of members of the BIM-SC. A silo mentality is a reluctance to collaborate with the other members of the BIM-SC through non-sharing of resources such as data, information, ideas, and knowledge. Emotional interaction was also identified as a feature of trusting and trustworthy behaviours. Emotional interaction supersedes social and work interactions in that it serves as behavioural responses to the actions and reactions of other members. Emotional interactions convey the internal state of the individuals in the BIM-SC.

Information is of central importance in the BIM process. The misuse of information is associated with the use and distribution of information models that usually manifest as copyright abuse and license abuse (Rosenberg, 2007; Azhar, 2011: 248; Azhar, Khalfan & Maqsood, 2012: 23; Arensman & Ozbek, 2012: 150). The findings of this study agree with these observations. This study also finds the absence of defensive behaviour as a valid component of trusting and trustworthy behaviour. Defensive behaviour is a form of response to perceived or anticipated threats that may not exist. With such behaviour occurring in the BIM-SC, members will be struggling to dominate, deceive, or impress. Defensive behaviour is distrustful and only the absence of defensive behaviour can ensure trust development in BIM-SC.

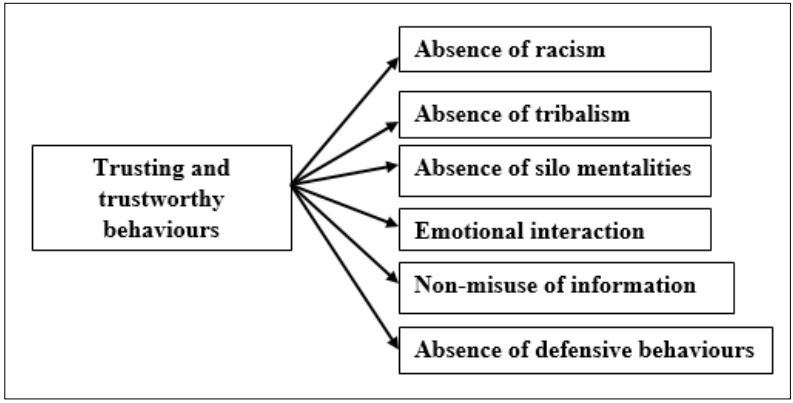

Figure 7: Components of trusting and trustworthy behaviours as a dimension of TBR in BIM-SC

6. Conclusions

Opportunism and non-cooperative relationships are the hallmarks of the traditional construction project supply chain. However, the application of BIM in construction projects fundamentally changes the nature of relationships among members of the BIM-SC. Based on the collaborative requirements of the BIM process, the nature of the relationships among members of the BIM-SC requires trust. This study attempts to understand the nature of trust-based relationships in BIM-SC, in order to establish whether the requirements of the BIM process influence TBR.

In this study, a model of TBR in BIM-SC is developed to provide practical insight into the nature of TBR in BIM-SC. The nature of a concept can be understood by investigating its factors, aspects, dimensions, elements, characteristics, or components. To achieve the objective of this study, dimensions and components of TBR in BIM-SC were investigated and then identified using relevant theoretical perspectives, while the related components were identified using meta-synthesis. The relevance of the components was determined using meta-analysis estimates. This study developed a model of TBR in BIM-SC, which categorised TBR in BIM-SC into a positive reputation, positive expectation, and trusting and trustworthy behaviours. In terms of a **positive reputation**, TBR relates to 'consistent integrity'; 'display of confidence for each other'; 'persistence of relationship after projects'; 'honesty and mutual commitment', and 'mutual rewards and benefits'. **Positive expectation** consists of 'lack of confrontation and adversarial relationship'; 'absence of competing interests'; 'social interaction'; 'work interaction'; 'conflict resolution'; 'shared interests and project expectations'; 'risk sharing'; 'cross-functional cooperation'; 'competence of personnel and organisation'; 'problem-solving ability'; 'openness in sharing information'; 'compensating for each other's weaknesses'; 'Eeploiting each other's strengths'; 'freedom to state opinions and perspectives'; 'mutual exchange of ideas', and 'support for innovation and learning'. While **trusting and trustworthy behaviours** entails 'absence of racism'; 'absence of tribalism'; 'absence of silo mentalities/professional stereotypes'; 'emotional interaction'; 'non-misuse of information', and 'absence of defensive behaviours'.

The findings of this article have provided an opportunity to advance the understanding of TBR among members of the BIM-SC, have furnished information on the influence of the requirements of the BIM process on trust development among members of the BIM-SC, and have given insight for a case study of TBR among members of the

BIM-SC. However, it is beyond the scope of this article to empirically validate the dimensions and components of TBR among members of the BIM-SC. Hence, a future article is required to undertake this.

References

Alaghbandrad, A. & Forgues, D. 2013. Development of a model to select BIM implementation strategy with respect to the BIM maturity level of an organization. In: Bedard, C. & Katsanis, C.J. (Eds.). *Proceedings of the Canadian Society for Civil Engineering Annual (CSCE) Conference*, vol. 2, Montreal, Canada, 29 May-1 June 2013. Montreal: Canadian Society for Civil Engineering, pp. 1149-1159.

Aqueveque, C. & Ravasi, D. 2006. Corporate reputation, affect, and trustworthiness: An explanation for the reputation-performance relationship. Paper presented at the 10th Annual Corporate Reputation Institute Conference, 26 May 2006, New York, NY.

Aranda-Mena, G., Crawford, J., Chevez, A. & Froese, T. 2009. Building information modelling demystified: Does it make business sense to adopt BIM? *International Journal of Managing Projects in Business*, 2(3), pp. 419-434.

Arensman, D.B. & Ozbek, M.E. 2012. Building information modeling and potential legal issues. *International Journal of Construction Education and Research*, 8(2), pp.146-156.

Ashcraft, H.W. 2008. Building information modeling: A framework for collaboration. *Construction Lawyer*, 28(3), pp. 1-14.

Ashnai, B., Henneberg, S.C., Naudé, P. & Francescucci, A. 2016. Inter-personal and inter-organizational trust in business relationships: An attitude-behaviour-outcome model. *Industrial Marketing Management*, vol. 52, pp. 128-139.

Azhar, S. 2011. Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. *Leadership and Management in Engineering*, 11(3), pp. 241-252.

Azhar, S., Khalfan, M. & Maqsood, T. 2012. Building information modelling (BIM): now and beyond. *Construction Economics and Building*, 12(4), pp. 15-28.

Bachmann, R. & Inkpen, A.C. 2011. Understanding institutional-based trust building processes in inter-organizational relationships. *Organization Studies*, 32(2), pp. 281-301.

Bakker, R.M. 2010. Taking stock of temporary organizational forms: A systematic review and research agenda. *International Journal of Management Reviews*, 12(4), pp. 466-486.

Barr, A. 2003. Trust and expected trustworthiness: Experimental evidence from Zimbabwean villages. *The Economic Journal*, 113(489), pp. 614-630.

Bryde, D., Broquetas, M. & Volm, J.M. 2013. The project benefits of building information modelling (BIM). *International Journal of Project Management*, 31(7), pp. 971-980.

Buvik, M.P. & Rolfsen, M. 2015. Prior ties and trust development in project teams – A case study from the construction industry. *International Journal of Project Management*, 33(7), pp. 1484-1494.

Carvalho, J.P., Bragança, L. & Mateus, R. 2019. Optimising building sustainability assessment using BIM. *Automation in Construction*, 102, pp. 170-182.

Chen, L. & Luo, H. 2014. A BIM-based construction quality management model and its applications. *Automation in Construction*, 46, pp. 64-73.

Chinowsky, P., Diekmann, J. & Galotti, V. 2008. Social network model of construction. *Journal of Construction Engineering and Management*, 134(10), pp. 804-812.

Chow, P.T., Cheung, S.O. & Chan, K.Y. 2012. Trust-building in construction contracting: Mechanism and expectation. *International Journal of Project Management*, 30(8), pp. 927-937.

Chu, S.Y. & Fang, W.C. 2006. Exploring the relationships of trust and commitment to supply chain management. *Journal of American Academy of Business*, 9(1), pp. 224-228.

Cicmil, S. & Marshall, D. 2005. Insights into collaboration at the project level: Complexity, social interaction, and procurement mechanisms. *Building Research & Information*, 33(6), pp. 523-535.

Costa, A.C. 2003. Work team trust and effectiveness. *Personnel review*, 32(5), pp. 605-622.

Costa, A.C. & Anderson, N. 2011. Measuring trust in teams: Development and validation of a multifaceted measure of formative and reflective indicators of team trust. *European Journal of Work and Organizational Psychology*, 20(1), pp. 119-154.

Cropanzano, R. & Mitchell, M.S. 2005. Social exchange theory: An interdisciplinary review. *Journal of Management*, 31(6), pp. 874-900.

Das, T.K. & Teng, B.S. 2001. Trust, control, and risk in strategic alliances: An integrated framework. *Organization Studies*, 22(2), pp. 251-283.

Davies, R. & Harty, C. 2013. Implementing 'Site BIM': A case study of ICT innovation on a large hospital project. *Automation in Construction*, vol. 30, pp. 15-24.

Delbufalo, E. 2012. Outcomes of inter-organizational trust in supply chain relationships: A systematic literature review and a meta-analysis of the empirical evidence. *Supply Chain Management: An International Journal*, 17(4), pp. 377-402.

Diallo, A. & Thuillier, D. 2005. The success of international development projects, trust, and communication: An African perspective. *International Journal of Project Management*, 23(3), pp. 237-252.

Dossick, C.S. & Neff, G. 2008. How leadership overcomes organizational divisions in BIM-enabled commercial construction. Paper presented at LEAD 2008 – The Engineering Project Organisation Society (EPOS), Lake Tahoe, US, 16-19 October 2008.

Dossick, C.S. & Neff, G. 2013. Constructing teams: Adapting practices and routines for collaboration through BIM. In: Carrillo, P. & Chinoswky, P. *Proceedings of the Engineering Project Organization (EPOC 2013)*, Winterpark, CO, USA, 9-11 July 2013. Winterpark, Colorado: EPOC, pp. 1-10.

Erdem, F. & Ozen, J. 2003. Cognitive and affective dimensions of trust in developing team performance. *Team Performance Management: An International Journal*, 9(5/6), pp. 131-135.

Fazli, A., Fathi, S., Enferadi, M.H., Fazli, M. & Fathi, B. 2014. Appraising effectiveness of Building Information Management (BIM) in project management. *Procedia Technology*, 16, pp. 1116-1125.

Getuli, V., Ventura, S.M., Capone, P. & Ciribini, A.L. 2016. A BIM-based construction supply chain framework for monitoring progress and coordination of site activities. *Procedia Engineering*, vol. 164, pp. 542-549.

Gilligan, B. & Kunz, J. 2007. *VDC use in 2007: Significant value, dramatic growth, and apparent business opportunity. Technical Report no. 171.* Stanford University, California: Center for Integrated Facility Engineering (CIFE) Publications.

Glick, S. & Guggemos, A. 2009. IPD and BIM: Benefits and opportunities for regulatory agencies. In: Sulbaran, T. & Sterling, C (Eds.). *Proceedings of the 45th ASC National Conference*, Gainesville, Florida, 1-4 April 2009. Hattiesburg, Mississippi: University of Southern Mississippi, p. CPGT172002009.

Grilo, A. & Jardim-Goncalves, R. 2010. The value proposition on interoperability of BIM and collaborative working environments. *Automation in Construction*, 19(5), pp. 522-530.

Holtgrave, M., Nienaber, A.M. & Ferreira, C. 2017. Untangling the trust-control nexus in international buyer-supplier exchange relationships: An investigation of the changing world regarding relationship length. *European Management Journal*, 35(4), pp. 523-537.

Hooper, M. & Ekholm, A. 2011. A definition of model information content for strategic BIM implementation. In: *Proceedings of the 28th CIB W78-W102 2011 International Conference*, Sophia Antipolis, France, 25-28 October 2011. The Netherlands: CIB, pp. 1-10.

Hunter, J.E. & Schmidt, F.L. 2000. Fixed effects vs. random effects meta-analysis models: Implications for cumulative research knowledge. *International Journal of Selection and Assessment*, 8(4), pp. 275-292.

Husain, A.H., Razali, M.N. & Eni, S. 2018. Stakeholders' expectations on building information modelling (BIM) concept in Malaysia. *Property Management*, 36(4), pp. 400-422.

Ilozor, B.D. & Kelly, D.J. 2012. Building information modeling and integrated project delivery in the commercial construction industry: A conceptual study. *Journal of Engineering, Project, and Production Management*, 2(1), pp. 23-36.

Jaffar, N., Tharim, A.A. & Shuib, M.N. 2011. Factors of conflict in the construction industry: A literature review. *Procedia Engineering*, 20, pp. 193-202.

Jagtap, M. & Kamble, S. 2015. Evaluating the *modus operandi* of construction supply chains using organization control theory. *International Journal of Construction Supply Chain Management*, 5(1), pp. 16-33.

Jamal, J. & Bakar, H.A. 2017. Revisiting organizational credibility and organizational reputation: A situational crisis communication approach. In: Jamal, J. & Bakar, H.A. (Eds.). *SHS Web of Conferences: International Conference on Communication and Media: An International Communication Association Regional Conference (i-COME'16)*, Kuala Lumpur, Malaysia, 18-20 September 2016. (Vol. 33, Paper 00083). UK, London: EDP Sciences, pp. 1-7.

Jiang, W., Lu, Y. & Le, Y. 2016. Trust and project success: A two-fold perspective between owners and contractors. *Journal of Management in Engineering*, 32(6), p. 04016022.

Kadefors, A. 2004. Trust in project relationships – inside the black box. *International Journal of Project Management*, 22(3), pp.175-182.

Khalfan, M., McDermott, P. & Cooper, R. 2004. Integrating the supply chain within the construction industry. In: Khosrowshahi, F. (Ed.). *Proceedings of the 20th Annual ARCOM Conference*, Heriot-Watt University, 1-3 September 2004. Vol. 2. Reading: ARCOM, pp. 897-904.

Kuiper, I. & Dominik, H. 2013. Rethinking the contractual context for Building Information Modelling (BIM) in the Australian built environment industry. *Construction Economics and Building*, 13(4), pp. 1-17.

Kuiper, I. & Duffield, C. 2018. Describing structural configurations towards identifying and establishing theoretical foundations for the exploration and understanding of building information modelling (BIM). Department of Infrastructure Engineering, University of Melbourne, Working Paper 001, pp. 1-33.

Lau, E. & Rowlinson, S. 2011. The implications of trust in relationships in managing construction projects. *International Journal of Managing Projects in Business*, 4(4), pp. 633-659.

Lazzeri, F. 2014. On defining behavior: Some notes. *Behavior & Philosophy*, vol. 42, pp. 65-82.

Liu, Y., Van Nederveen, S. & Hertogh, M. 2017. Understanding the effects of BIM on collaborative design and construction: An empirical study in China. *International Journal of Project Management*, 35(4), pp. 686-698.

Lloyd-Walker, B.M., Mills, A.J. & Walker, D.H. 2014. Enabling construction innovation: The role of a no-blame culture as a collaboration behavioural driver in project alliances. *Construction Management and Economics*, 32(3), pp. 229-245.

Love, P.E., Edwards, D.J., Han, S. & Goh, Y.M. 2011. Design error reduction: Toward the effective utilization of building information modelling. *Research in Engineering Design*, 22(3), pp. 173-187.

Lu, H. & Issa, R.R. 2005. Extended production integration for construction: A loosely coupled project model for building construction. *Journal of Computing in Civil Engineering*, 19(1), pp. 58-68.

Major, C. & Savin-Baden, M. 2010. Exploring the relevance of qualitative research synthesis to higher education research and practice. *London Review of Education*, 8(2), pp. 127-140.

Manu, E., Ankrah, N., Chinyio, E. & Proverbs, D. 2015. Trust influencing factors in the main contractor and subcontractor relationships during projects. *International Journal of Project Management*, 33(7), pp. 1495-1508.

Matthews, J., Love, P.E., Mewburn, J., Stobaus, C. & Ramanayaka, C. 2018. Building information modelling in construction: Insights from collaboration and change management perspectives. *Production Planning & Control*, 29(3), pp. 202-216.

Mayer, R.C., Davis, J.H. & Schoorman, F.D. 1995. An integrative model of organizational trust. *Academy of Management Review*, 20(3), pp. 709-734.

McKnight, D.H. & Chervany, N.L. 2000. What is a trust? A conceptual analysis and an interdisciplinary model. In: Chung, H.M. (Ed.). *Proceedings of the 2000 Americas Conference on Information Systems* (AMCIS 2000), Long Beach, CA, 10-13 August 2000, paper 382.

Miettinen, R. & Paavola, S. 2014. Beyond the BIM utopia: Approaches to the development and implementation of building information modelling. *Automation in Construction*, vol. 43, pp. 84-91.

Mikapagaro, N.A. & Germin, J. 2018. Forms and adequacy of risk sharing in building construction projects in Tanzania. *International Journal of Construction Engineering and Management*, 7(4), pp. 133-152. DOI: 10.5923/j.ijcem.20180704.02

Mishra, A.K. 1996. Organizational responses to the crisis. In: Kramer, R.M. & Tyler, T.R. (Eds.). *Trust in organizations: Frontiers of theory and research*. Thousand Oaks, CA: Sage Publications, pp. 261-287.

Morton, A. & Fasolo, B. 2009. Behavioural decision theory for multi-criteria decision analysis: A guided tour. *Journal of the Operational Research Society*, 60(2), pp. 268-275.

Naismith, N., Price, A.D., Dainty, A.R.J., Bryman, A. & Greasley, K. 2005. Engendering trust in the construction supply chain. *Journal of Construction Procurement*, 11(2), pp.136-165.

Nalewaik, A. 2011. Stakeholder expectations regarding public project oversight. In: *Proceedings of the 25th IPMA World Congress: Project management – Delivering the promise*, Brisbane 9-12 October 2011. Brisbane, Australia: Leishman Associates.

Nalewaik, A. & Mills, A. 2015. Project stakeholder concerns and expectations. In: *Proceedings of the 19th Pacific Association of Quantity Surveyors (PAQS) Congress* Yokohama, Japan, 29 May-1 June 2015. Yokohama, Japan: PAQS, pp. 1-10.

Nawi, M.N.M., Haron, A.T., Hamid, Z.A., Kamar, K.A.M. & Baharuddin, Y. 2014. Improving integrated practice through building information modeling-integrated project delivery (BIM-IPD) for Malaysian industrialised building system (IBS) Construction Projects. *Malaysia Construction Research Journal* (MCRJ), 15(2), pp.1-15.

Nooteboom, B. 1996. Trust, opportunism, and governance: A process and control model. *Organization Studies*, 17(6), pp. 985-1010.

Olatunji, O.A. & Akanmu, A. 2015. BIM-FM and consequential loss: How consequential can design models be? *Built Environment Project and Asset Management*, 5(3), pp. 304-317.

Papadonikolaki, E. & Wamelink, H. 2017. Inter-and intra-organizational conditions for supply chain integration with BIM. *Building Research & Information*, 45(6), pp. 649-664.

Papadonikolaki, E., Vrijhoef, R. & Wamelink, H. 2016. The inter-dependences of BIM and supply chain partnering: Empirical explorations. *Architectural Engineering and Design Management*, 12(6), pp. 476-494.

Pinto, J.K., Slevin, D.P. & English, B. 2009. Trust in projects: An empirical assessment of owner/contractor relationships. *International Journal of Project Management*, 27(6), pp. 638-648.

Porwal, A. & Hewage, K.N. 2013. Building Information Modeling (BIM) partnering framework for public construction projects. *Automation in Construction*, vol. 31, pp. 204-214.

Robson, A., Boyd, D. & Thurairajah, N. 2014. UK construction supply chain attitudes to BIM. In: Sulbaran, T. (Ed.). *50th Associated Schools of Construction (ASC) Annual International Conference*, Blacksburg, Virginia, 26-28 March 2014. Fort Collins, Colorado: The Associated Schools of Construction, pp.1-8.

Rosenberg, T.L. 2007. Building Information Modeling. [Online]. Available at: <https://www.academia.edu/1283324/Building_Information_Modeling> [Accessed: 13 October 2018].

Rosenthal, R. 1995. Writing meta-analytic reviews. *Psychological Bulletin*, 118(2), pp. 183-192.

Sacks, R., Koskela, L., Dave, B.A. & Owen, R. 2010. Interaction of lean and building information modeling in construction. *Journal of Construction Engineering and Management*, 136(9), pp. 968-980.

SelectStatistics. n.d. Population Mean – Confidence Interval. [Online]. Available at: <https://select-statistics.co.uk/calculators/confidence-interval-calculator-population-mean/> [Accessed: 6 June 2019].

Shamseer, L., Moher, D., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P. & Stewart, L.A. 2015. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: Elaboration and explanation. *British Medical Journal (BMJ)*, 349(g7647), pp.1-25. DOI: https://doi.org/10.1136/bmj.g7647

Simons, T.L. & Peterson, R.S. 2000. Task conflict and relationship conflict in top management teams: The pivotal role of intragroup trust. *Journal of Applied Psychology*, 85(1), pp.102-111.

Singh, V., Gu, N. & Wang, X. 2011. A theoretical framework of a BIM-based multi-disciplinary collaboration platform. *Automation in Construction*, 20(2), pp.134-144.

Smit, B. 2002. Atlas. ti for qualitative data analysis. *Perspectives in Education*, 20(3), pp. 65-75.

Stingl, V. & Geraldi, J. 2017. Errors, lies, and misunderstandings: Systematic review on behavioural decision making in projects. *International Journal of Project Management*, 35(2), pp. 121-135.

Swan, W., Wood, G., McDermott, P. & Cooper, R. 2002. Trust in construction: Conceptions of trust in project relationships. In: Lewis, T.M. (Ed.). *Proceedings of the International Symposium of the Working Commission CIB W92* (Procurement Systems), Trinidad & Tobago, 14-17 January 2002. St. Augustine, Trinidad and Tobago: Dept. of Civil Engineering, University of the West Indies, pp. 461-470.

Tai, S., Sun, C. & Zhang, S. 2016. Exploring factors affecting owners' trust of contractors in construction projects: A case of China. *SpringerPlus*, 5(1), p.1783. DOI 10.1186/s40064-016-3393-9

Talavera, M.V. 2013. Exploring the relationship of supply chain collaboration and trust. Paper presented at the BSP-UP Professorial Chair Lecture Series, Bangko Sentral ng Pilipinas Main Complex, Malate, Manila, 24 May 2013, pp.1-14.

Tanis, M. & Postmes, T. 2005. A social identity approach to trust: Interpersonal perception, group membership, and trusting behaviour. *European Journal of Social Psychology*, 35(3), pp. 413-424.

Taylor, J.E. & Bernstein, P.G. 2009. Paradigm trajectories of building information modeling practice in project networks. *Journal of Management in Engineering*, 25(2), pp. 69-76.

Vangen, S. & Huxham, C. 2003. Nurturing collaborative relations: Building trust in inter-organizational collaboration. *The Journal of Applied Behavioral Science*, 39(1), pp. 5-31.

Vidotto, G., Massidda, D., Noventa, S. & Vicentini, M. 2012. Trusting beliefs: A functional measurement study. *Psicologica: International Journal of Methodology and Experimental Psychology*, 33(3), pp. 575-590.

Webber, S.S. 2008. Development of cognitive and affective trust in teams: A longitudinal study. *Small Group Research*, 39(6), pp. 746-769.

Wilson, D.B. n.d. Practical Meta-Analysis Effect Size Calculator [Online calculator]. Available at: <https:/www.campbellcollaboration.org/research-resources/research-for-resources/effect-size-calculator.html> [Accessed: 6 June 2018].

Won, J. & Lee, G. 2010. Identifying the consideration factors for successful BIM projects. In: Tizani, W. (Ed.). *Proceedings of the International Conference on Computing in Civil and Building Engineering (icccbe2010)*, Nottingham, UK, 30 June-2 July 2010, Vol. 30. Nottingham, UK, pp. 143-148.

Won, J., Lee, G., Dossick, C. & Messner, J. 2013. Where to focus on the successful adoption of building information modeling within an organization. *Journal of Construction Engineering and Management*, 139(11) [paper 04013014], pp. 1-10. doi.org/10.1061/(ASCE)CO.1943-7862.0000731

Wong, K.D. & Fan, Q. 2013. Building information modelling (BIM) for sustainable building design. *Facilities*, 31(3/4), pp.138-157.

Wong, W.K., Cheung, S.O., Yiu, T.W. & Pang, H.Y. 2008. A framework for trust in construction contracting. *International Journal of Project Management*, 26(8), pp. 821-829.

Woolthuis, R.K., Hillebrand, B. & Nooteboom, B. 2005. Trust, contract and relationship development. *Organization Studies*, 26(6), pp. 813-840.

Wu, C., Xu, B., Mao, C. & Li, X. 2017. Overview of BIM maturity measurement tools. *Journal of Information Technology in Construction* (ITcon), 22(3), pp. 34-62.

Zeng, F., Huang, L. & Dou, W. 2009. Social factors in user perceptions and responses to advertising in online social networking communities. *Journal of Interactive Advertising*, 10(1), pp. 1-13.

Zhang, D., Lu, W. & Rowlinson, S. 2013. Exploring BIM implementation: A case study in Hong Kong. In: Kajewski, S., Manley, K. & Hampson, K. (Eds.). *Proceedings of the International Council for Research and Innovation in Building and Construction (CIB) World Building Congress*, Brisbane, Australia, 5-9 May 2013. Brisbane: Queensland University of Technology, paper 317, pp. 1-11.