Emerging Contractual and Legal Risks from the Application of Building Information Modelling

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Abstract:

Purpose: There has been a mounting interest in building information modelling (BIM) in the construction industry sector worldwide due to its perceived benefits. However, reliance on information technology is associated with risks. To facilitate the successful implementation of BIM in the construction industry, this paper proposes to offer a better understanding of the emerging contractual and legal risks which might influence the successful adoption of BIM.

Design/methodology/approach: The risks used in the study were documented from the literature, and primary data was collected by a questionnaire survey. The analysis of the results was driven by univariate and inferential statistics (ANOVA) to identify the emerging contractual and legal risks.

Findings: The findings showed that there were little significant differences in the mean rating of the occurrence of contractual and legal risks between the respondents**.** The study confirmed that emerging risks are likely to be related to BIM documentations, intellectual rights and liability, missing data, and misplaced assumptions among project stakeholders. The results showed that BIM success depends on close collaboration at the outset of the project with the client, designers, contractors and consultants.

Practical implications: The findings suggest that contract documents and contract agreements may need to be created in accordance with of the identified risks, so that the questions of contractual and legal responsibilities are appropriately defined and allocated among the participants.

Originality/value: Important legal and contractual risks have been identified in the application of BIM. It renders a new understanding of the risks that might influence the successful adoption of BIM.

Keywords: BIM, contractual risks, legal risks, construction management

Introduction:

The scope of BIM is evolving rapidly, and its full benefit realisation is expected to be attained with time. There has been extensive research investigating the usage of ICT technologies in the construction industry. Including, global positioning systems (Kim and Teizer, 2014) and web-based project management systems (Arnold and Javernick-Will, 2013). The ICT studies revolved around exploring issues related to adoption strategies, success criteria and performance indicators. However, these technologies and traditional approaches were unable to handle the complexity and intensity of information flow between stakeholders leading to poor coordination and scope changes in projects (Doloi et al., 2012). Because of these changes, BIM technology has been put forward to simulate and analyse problems and try to find solutions before initiating the actual implementation processes. Due to some of the ICT problems, BIM has received considerable attention from construction industry stakeholders. According to Ding et al (2015), the BIM approach is aiming at "*visualization of design, rapid generation of alternative design, building performance prediction, automatically monitoring the integrity of model and reports, providing a communication platform and promoting collaboration between design and construction professions*". Previous research on BIM adoption has focussed on the issues of the perception of stakeholders (Ding et al 2015). The purpose of BIM is to add value to the construction industry, such as decreasing project cost, increasing quality productivity, and reducing project implementation time. For example, Eastman et al. (2011: 544) stated that "*BIM represents a paradigm change that will have far-reaching benefits, not only for those in the building industry but for society at large, as better buildings are built that consume less energy and require less labour and capital resources*".

It was claimed that the BIM paradigm created a new way that could facilitate the efficiency of the different building processes through the variety of BIM dimensions (3D, 4D, 5D, and 6D) (Tjell, 2010). However, the application of BIM as a working methodology is subject to greater risk and uncertainty from several aspects. This is due to BIM contractual and legal risks and that BIM practices have yet to mature. It is widely accepted that BIM represents a new risk frontier to the construction industry (Rogers et al., 2015; Barra 2012). When the stakeholders participate in a project, data will be exchanged and used in the BIM model, this raises the issues of intellectual property, licencing, and ownership. Furthermore, as the model is populated with data, contractual issues will arise regarding the control and responsibility for data entry. This leads to all sorts of liabilities and disputes among the project team members. It was claimed that "*the integrated concept of BIM blurs the level of responsibility so much that risk and liability are likely to be enhanced*" Azhar (2011). Chang et al (2017) investigated contractual legal provisions associated with BIM implementation. The authors identified several contract provisions that might be used in BIM contracts to reduce legal liability. Using BIM as a working methodology, i.e., collaborative approach, to bring together the construction industry stakeholders across the lifecycle of the building or infrastructure will result in new risks. This view is supported by Boyes (2014) who points out that "a number of new risks are inherent in the adoption of BIM". It is acknowledged that BIM represents a new risk frontier to the construction industry (Barra 2012). The author went on to point out that "*those desiring to use BIM should anticipate spending a little more in a legal effort to draft and negotiate the risk-shifting contract provisions that properly allocate risks to the party best able to manage them*". Boyes (2014) commented on the endeavour of the UK Government to promote the use of BIM as "this is not without risk as the greater reliance on information technology has associated cyber security risks". The author went on to emphasise that the "*integration of BIM information models and operational building systems presents a significant risk".* Winfield and Rock (2018) argued that it is for the interests of the project team members to "*discuss and agree what this will actually involve from a project specific risk allocation, services and liability perspective to avoid potential disputes arising from differing expectations*". The authors went further to articulate that "*there appears to be a general consensus amongst the interviewees that a potential source of BIM-related disputes relates to lack of sufficient clarity of BIM obligations, rights and risk allocation*".

Takashi and et al (2017) reported on the problems associated with implementation in Japan. The authors cited that the top-down processes of implementing BIM are not always encouraged. The authors went on to stress that in Japan the design risk is managed by transferring the task design and drawings to a general contractor. The authors didn't report on issues related legal aspects of BIM implementation.

Thus, while paving the way for documenting and assessing the emerging BIM contractual and legal risks, the research contributes to the body of knowledge for BIM-based contract administration.

It is widely debated in the literature as to the different meanings of risk and uncertainty. In most literature the two terms are defined differently. The debate goes back to Knight's (1921) hypothesis where risk is numerically measurable, whereas uncertainty is statistically immeasurable. Several authors support Knight's view. For example, Hastings et al. (2004) who explained that uncertainties are issues that are unknown or known only imprecisely. Holton (2004) agrees with the view that our knowledge is directly linked to the uncertainty. He went on to explain that "uncertainty is a state of not knowing [if] a proposition is true or false". Aven (2011) stressed that uncertainties signify that decision makers do not know exactly when events may occur and what their consequences will be. Generally, the literature points to Knights's position and has classified uncertainty into epistemology and ontology. For example, Boussabaine (2013) reported that "uncertainty can be divided into epistemic uncertainty include lack of data, knowledge, etc. and ontological uncertainty such as inherent variability, environment changes, etc." The former is attributed to the lack of knowledge about risk model parameters, data, processes, model equations, etc., whereas the latter is attributed to the variability inherent in the initial condition of a system or model. In this research, uncertainty due to epistemology is mainly associated with the processes and information that were used to collect and classify the emerging BIM. Concerning the variability that may result from ontological uncertainty that is associated with the equations used in the statistical analysis, it may not be possible to reduce it to zero.

Likewise, with the notion of uncertainty, there is ample evidence of existing literature defining risks within a particular context. The Oxford Dictionary definition of risk is "the chance or hazard of commercial loss specifically in the case of insured property or goods". Kliem and Ludin (1997) articulated the view that risk can be attributes of the occurrence of an event that has an impact on the outcome of an entity. Aven (2011) believes that risk is an event which may lead to an uncertain outcome. Boussabaine (2014) summarised the definitions of risks that exist in the literature as risks of Chance of Loss, Exposure, Unwanted Event, Hazard, and Probability of an Event's occurrence. But the general consensus in the construction industry is that risk is viewed as the probability or likelihood of an event's occurrence and measured as: Risk = probability x consequence. The popularity of this definition stems from the fact that risk can be statistically measured and predicted. However, in reality this is not always the case. In this study BIM risks are seen as consequences of uncertainty related to issues such as who owns the BIM library, data sharing/collaboration, BIM management, BIM content, emerging technologies and processes, etc.

In this study, risk is defined as the condition, behaviour, or other factor that increases liability, loss, or any other negative occurrence/consequences that may emerge from BIM as a working method.

The rationale for this study is based on the recognition that BIM technology is increasingly being used within the construction industry. Despite the growing interest in the use of these new technologies in the construction industry, there are many studies that indicate that there are many organizations that have concerns about the use of BIM in their projects, as there are some aspects of BIM that remain unclear within the industry, such as legal, contractual, technical, managerial, application, and security issues (Zou et al., 2016; Sieminski, 2007; Ashcraft, 2008; Simonian and Korman, 2010;Azhar, 2011;Ku and Taiebat, 2011; Chawla, 2012; Udom, 2012). Unsurprisingly, when new technologies are used, problems such as these will emerge and this is because BIM approaches new and untested concepts in the construction industry. These issues constitute a threat to the use of BIM technology. To reduce such concerns and enhance the use of BIM technology within the construction industry, research is needed to identify the risk factors with the view to develop strategies to manage the emerging BIM risks.

This research aims to augment the BIM literature by identifying BIM contractual and legal risks during the lifecycle of projects. In addition, this study will assess the difference between practitioners' perceptions regarding the likelihood of emergence of BIM risks. This research is driven by the following question:

> *What are the contractual and legal risks that influence the use of BIM technology in a project lifecycle?*

For practical implication, this research would define and articulate the emerging risks from BIM application with the view that stakeholders can develop appropriate contractual and legal instruments to manage these risks. From an academic perspective, the research has augmented the BIM literature by identifying and classifying legal and contractual BIM risks. The results generated from the study can provide stakeholders with an instrument to improve the efficiency rate of BIM application management.

The remainder of the paper is structured into four main sections: The first section presents the theoretical background and identifies possible BIM risks related to contractual and legal issues. The second section provides and documents the research methodology. The third section presents the results from the field study. The fourth section provides a discussion on the BIM risks and reconciles between the views of the respondents and literature in project management. The study ends with conclusions outlining implications and recommendations for further research.

Theoretical background

The phenom of adoption of technology and innovations has been studied for more than three decades. It is well understood in the literature that adoption is related to the decision to use an innovation or technology in term of both product and processes (Roger 2010). Similarly, in the construction industry is attributed to the decision made to use new systems to implement in projects and organisations (Winch 1998 and Hosseini et al 2015, 2016). Hosseini, et al (2015) pointed that BIM adoption is closely aligned with the innovation adoption process. Davies and Harty (2013) advanced the view that companies adopt BIM and implement it on their projects according to the innovation adoption process. Furthermore, BIM adoption in academic literature has been considered as technology innovation. More importantly, Murphy (2014) postulated that innovation adoption process is the most effective approach for the acceptance of BIM in construction companies. Thus, the innovation adoption definitions advanced by (Roger 2010, Hosseini 2015, 2016, and Winch 1998) is an appropriate approach for framing the emerging legal risks from BIM adoption in the constructor sector.

The basis of UK BIM adoption is rooted back to the " Strategy Paper for the Government Construction Client Group" written by the BIM task working group (BIM Task Group 2011). The report key recommendations for legal, contracts and insurance include IP and copy transfer, right, standard contract amendments to comply with BIM protocols, standardisation of BIM Protocols, duties for consultants and contractors under BIM, database right and risk transfer as model passes between different stakeholders (BIM Task Group 2011, 2012). Although the report outlined a high-level strategy and benefits for the use of BIM, it did not explicitly categorise BIM risks, or suggest statements (constructs) for measuring the occurrence of such risks. Subsequent to the winding down of the BIM task group in 2015, UK national standard body BS, industry and academic organisations embarked on the development of several standards to facilitate BIM adoption. For example, BS 1192: 2014 and 2016, only establish the methodology for managing the production, distribution and quality of construction information. Similarly, BS 8536 (2015) provided details or briefing for design and construction. Likewise, This Publicly Available Specification (PAS

1192-2:2013) only describes the requirement for achieving BIM at level. Equally, PAS (1192-5:2015) only deals with security in utilizing digital technologies. The latest PAS (1192-6:2018) explains the requirements for sharing health and safety requirement.

Construction Industry Council BIM protocol (2018) sets the basis for the Intellectual property rights for BIM models. The purpose of the protocol is to cover aspects of BIM usage level 2. The protocol consists of three parts. The first part is a legal document that addresses the legal obligation of the employer and the suppliers. The second part, appendix 1, deals with model production delivery timetable. The third part, appendix 2, deals with the employer's information requirements. The protocol is created to address concerns that were raised about BIM level 2 application. Generally, there were concerns regarding clarity of obligation between BIM parties, clarity of information requirements, contractual roles and responsibilities, points at which information is exchanged, modality of information exchange, collaborations agreements, and intellectual property rights for data driven models (CIC, 2018). It appears from these that the protocol offers a sensible approach to the licensing of BIM models. However, the protocol underestimates the complexity of information models. This will largely be somehow bespoke to each company's stage of the project in question. Furthermore, it appears that the protocol excludes any guarantee as to the integrity of electronic data delivered. Similarly, the protocol discounts liability in respect of any corruption or amendments of data after transmission. In brief, the protocol advocates that the client takes the liability as a licensing intermediary on behalf of all BIM project members. This raises the issues of contractual mechanisms for adjudicating license disputes between BIM project members. This may suggest that additional contractual guidelines are required to identify responsibility, risks, and allocate them fairly among BIM project members.

All these Publication and others were about BIM adoption motivation and benefit realisation, BIM standards and high-level requirements for BIM implantation at different levels of adoption and life cycle of projects. Although some of these documentations discussed the development of register format, they did not categorise BIM risks nor did they list BIM risks associated with Contractual issues, Dealing with Data, Intellectual Property Rights and Liability and Participants. This study discovered forty risks that are attributed to these six themes that are associated with BIM adoption. Thus, this study expands the understanding about BIM application risks which are relevant to all the levels of BIM adoption.

The process used to categorize risk follows Tah and Carry’s (2001) methodology. The process starts with identifying BIM practices then moves on in identifying risks associated with BIM usage. Once the risks are identified from the literature, the common risk factors were categorized according to the source and influence of the risk factors. The reliability of our approach to identify and categorize is based on consistency (which means reliability). It is the degree to which an instrument will give similar results for the same experiment at different times. In this research, the extracted BIM risks and categories are reliable due to the fact they have been reported in several sources.

BIM Risks Related to Contractual issues

In current practice, the contract document is used as a printed submission form, even if the communications flow digitally (Hsieh et al., 2012). Many of the stakeholders still use traditional submissions and are not yet ready to use and review digital information (Ashcraft, 2009). One of barriers to BIM implementation is lack of contractual agreements (Ku and Taiebat, 2011). This is due to the fact that the majority of models do not contain all of the construction details needed for a project (Foster, 2008). The complete design of BIM models is only visualized when it is imported into viewing software platforms. In many countries that have different contractual systems, many processes in FM are not based on the BIM model, which are important in facility management, cost estimates and project schedules, and respective contracts have not yet been developed and standardized for these applications. Nevertheless, such responsibilities for risky materials onsite are listed in new construction (O'Connor and Hinkle, 2008).

Work is underway to find solutions to such problems and solutions on respective contractual guidelines, and these are published as contract samples (Eastman et al., 2011; ConsensusDocs 2008; AGC 2006). However, there are legal uncertainties and concerns in BIM implementation and specifications in AEC/ FM and the construction sectors (Becerik-Gerber et al., 2012).

In addition, there are risks of contractual inconsistencies and errors that have legal effects on the future uses of BIM. Simonian and Korman (2010) mention that BIM technology has been used with the supportive software performing the contract. If the contract clearly indicates the party liabilities for avoiding the associated risk, this kind of risk assumption would be transformed into contract obligation, and in accordance with the freedom of the contract principle and agreement, the contractual parties are obligated to share their liabilities. Should it not be regulated in the contract or the nature of risks exceeds the agreement, the losses incurred by unallocated risks, i.e. risks which are not attributable to any party, shall be reasonably allocated based on mutual agreement between the project team members. Such inconsistencies and errors may occur as a result of the lack of defining model responsibilities in the contract documents and risk allocation.

Integration of the BIM approach into the contractual relationship of the parties is the issue which needs to be drafted into a new form of contracts due to the substantial nature of new changes that will arise from the adoption of BIM compared to traditional contracts (Ashcraft, 2009). This is especially the case at level 3 of the BIM maturity index in the UK, which requires a new form of contract to cover all different relationships between the parties involved in the project (Udom, 2012). This is because in practice, the main contracts and the employer's requirement in the JCT Standard Building Contract (SBC) in the UK may conflict with the legal terms of the BIM protocol. For example, the licensing procedure of intellectual property is more comprehensive and important in a BIM protocol than that provided in construction contracts used in the current construction industry. Therefore, if the BIM protocol was adopted as part of the JCT, priority is given to the terms of the JCT contract, according to clause 1.3 from the employer's requirement in the JCT (Udom, 2012). This means that in case of any dispute, it is still unclear how to deal with the BIM document's precedence, and it is unclear if the BIM model is a main contract document or a current construction contract.

Most importantly, despite BIM's advantages, BIM deliverables are still unclear and there is a "lack of immediate BIM benefits from projects delivered to date" that can be taken as a measure or standard in the process of legal agreements (Ashcraft, 2009), in the event that the business value is unclear and results are unknown, and of course risks and conflicts between the parties involved will emerge which lead to reduction of the use of BIM (Mutai, 2009).

Legal contractual issues may become barriers limiting the benefits to the use of BIM. Consequently, it is important to provide the priorities of the BIM protocol on contract documents to cover all legal issues (liability for contribution waivers, indemnities, etc.), adaptation to existing uses of BIM and update the responsibilities that would be appropriate for the BIM approach. Therefore, BIM risks related to contractual issues are important issues to the adoption and use of BIM technology, Table 1 summarizes the risks reported in the literature. The first research hypothesis is posited as follows:

H01: There is no statistically significant difference between the respondents' perceptions on the likely emergence of "BIM risk related to Contractual issues"

Insert table 1 here

BIM Legal Risks Related to Dealing with Data

Dealing with data management effectively is essential for businesses. However, in addition to the security risks of unauthorized access or theft, data storage media itself may be a source of vulnerability. Data loss usually leads to the loss of worker productivity and increased costs. The BIM model, like all digital data, is susceptible to data loss (Ashcraft, 2008). Reliance on model data is a key issue that cannot be divorced from its purpose, and care should be taken to spell out and determine levels of permitted reliance on model data in contracts (Lowe and Muncey, 2009). Thus, the main base to create a BIM model is totally dependent on the input data in the model. McAdam (2010) examined the critical issue of ownership of the design data. The author postulated several questions regarding the status of data post project and data leaked to competitor. The author also concorded with Ashcraft on the issue of data integrity and file corruption.

Therefore, risks of dealing with data are one of the most important risks of using BIM, and it should take adequate measures to face possible liability against data loss and the ensuing losses. This study will investigate the likely emergence of risk documented, Table 2. The second research hypothesis is posited as follows:

H02: There is no statistically significant difference between the respondents' perceptions on the likely emergence of "BIM data risks"

Insert table 2 here

BIM Legal Risks Related to Intellectual Property Rights (IPR)

Many BIM-related issues stem from concerns about the IPR issues in BIM projects. The current generation of standard form agreements in the BIM projects has not adequately addressed these issues, especially copyright and issues relating to licensing contractors and subcontractors and contributions (Lowe and Muncey, 2009). Therefore, risks of intellectual property rights are critical issues for the adoption and use of BIM technology, and thus this study will investigate the likely emergence of risk listed, Table 3. The third research hypothesis is theorised as follows:

H03: There is no statistically significant difference between the respondents' perceptions on the likely emergence of "BIM Intellectual Property Rights risks"

Insert table 3 here

BIM Legal Risks Related to Liability and Participants

The most prominent issue for implementing BIM is the access collaboration to the model by all parties involved in the project during the construction stages (Eastman and Teicholz, 2008). BIM models are used as an approach to facilitate the design and construction processes. As the use of BIM spreads throughout construction, ideas certainly turn to the case of legal contracts, and consequently, legal implications over its use may arise (Glover, 2012). The use of BIM significantly changes the relationships between parties in the project and blends their responsibilities and roles; however, it also assumes a more collaborative environment among participants of the project with clearer allocations of their responsibility, and the legal risks may arise when BIM projects become more commonplace (Simonian, 2010). McAdam (2010) reported on the tension that may exist between BIM participants. He argued the compatibility of public authority legal requirement and design liability under BIM paradigm. The author went on to point out if there will be anomality between building regulation in BIM data, the responsibility for non-compliance will be dubious.

It is anticipated that liability and participant's issues are important to the adoption and use of BIM technology, this study will investigate the likely emergence of risk listed, Table 4. The fourth research hypothesis is postulated as follows:

H04: There is no statistically significant difference between the respondents' perceptions on the likely emergence of "BIM participants liability risks"

Insert table 4 here

Method and Processes

The questionnaire survey method was selected for data collection. it is considered accepted that a survey method is an effective and preferred method for statistical data and opinion collection (Muijs 2004). The research constructs and risk factors were extracted from the literature, as outlined in the previous section of the paper, these were converted into to risk statements and questions to collect the opinions of experts. Once the questions were developed, they were sent to experts to test their validity. Comments and suggestion from this process were used to modify the questions. Once the questionnaire was ethically approved by the university, the online survey was deployed.

The questionnaire was organised in two parts. The first part was about collecting general information about the respondents. The questions in this section are related to their professional roles, type of organization or institution, and experiences with BIM and risks. The second section deals with the emerging contractual and legal risks for BIM application. A five-point Likert scale was adopted for measuring the likely occurrence of BIM risks. A five-point Likert scale is deemed to be provide a good reliability over the normal range of the measures, it is a widely used scale for measuring the attitudes and opinions of respondents in BIM studies such as Monko et al., 2017 and Chien et al., 2014. The respondents were asked to rate the occurrence or emergence of risks on a Likert scale (spanning very unlikely, unlikely, neutral, likely and very likely).

An online questionnaire survey was circulated electronically through emails to BIM experts in various government and private sectors in the UK, Europe, USA, Canada, Australia, India, China and Japan. The online format was selected for its many strengths, out of which are greater coverage of respondents, flexibility, speed and timeliness, ease of data entry and analysis, and access to large sample (Evans and Mathur, 2018). While the number of experts who are knowledgeable about BIM technology could be very high, it was difficult to determine this population, as the BIM experts who are knowledgeable about emerging risks from BIM application could be very small indeed. This guess is based on the lack of literature that exists in this area. Therefore, one could assume that only a few experts may know about risks in BIM. Thus a moderate estimate that the emerging risks from BIM application will be known to only 5% of the professionals ($p= 0.05$), to achieve the target of a sampling error within 5% ($SE= 0.05$) at a confidence level of 95% $[(1-\alpha) = 0.95; Z\alpha/2 = 1.96]$, the minimum sample size (s) would be 73 (McClave et al., 2010)

Respondents comprised of 426 professionals in various roles, such as architect, engineer, constructor, consultants, cost consultants, and other experts. A total of 105 complete responses were received (35% response rate). This response rate is higher than the average response rate of similar studies, which is around 27% as reported by Monko et al. (2018).

The descriptive statistics for the mean score were computed using results from the Likert. The severity index was used to pre-analyse and rank the responses, which provides standardized criteria to ensure inter-rater uniformity in assigning severity. Analysis of Variance (ANOVA) is a statistical method used to test the degree of differences between two or more groups in an experiment (Keller & Warrack 2003, Matthews & Farewell, 2007). The ANOVA technique uses one categorical independent predictor and tests the differences in the centroid (vector) of means of the multiple interval dependents for various categories (Keller & Warrack, 2003). An ANOVA analysis was conducted in order to justify the groups' statistical differences. In this study, ANOVA was used to identify the similarities and differences among the opinions of respondents on the risk factors identified in this study based on the experiences of respondents. Tukey tests were used as one of the HSD post-hoc multiple comparison tests by identifying that the mean difference is significant at the 0.05 levels.

The coefficient variation has been used in this study, which is a standardized measure of dispersion of a probability distribution or frequency distribution. in addition, the severity index was used, which provides standardized criteria to ensure inter-rater uniformity in assigning severity. The Kendall's W Test was used, which is used to attribute agreement analysis among participants in the various professions, and overall ranking was used to establish the respondent's ranking on each of the factors according to their importance and impact on usage of BIM (McClave et al., 2010).

Using SPSS software, the hypotheses tests were computed using alpha=0.05, while observing the F-statistic and the p-value. The details of each analysis are explained in the following sections.

Results: analysis of the responses

Demographic profile of respondents

The survey sample comprised of 426 professionals in various roles, including architects, engineers, constructor, consultants, cost consultants, and academics. A total of 105 complete responses were received (35% response rate).

Respondent sample included experienced practitioners from both the industry and academia. Twenty-nine (28%) were Architects, thirty nine (37%) were consultants/contractors, and thirty-seven (35%) respondents were from the education sector.

Thirty-three respondents (31%) were engaged in the private sector, nine (8%) respondents were engaged in the public sector, and sixty-four (60%) respondents were engaged in the education sector.

Overall, the background of the respondents provides a rich background in providing reliable data for the study.

Overall perception on the likelihood of contractual risks emerging from BIM adoption

Table 5 shows the mean scores and mean score rankings of BIM contractual risks for the overall sample and for each category of the sample respectively. The mean scores for overall results range from 3.35 to 3.92, which indicate that, on average, the respondents believe the seventeen contractual risks are of similar likelihood of occurrence. As shown in Table 5. The severity indices are between 43.72% to 74.58% and the Kendall’s W Test range is within 57.67 to 78.10 which indicates the level of likelihood of these risks emerging because of BIM adoption.

Insert table 5 here

From the general point of view of the respondents, the most likely to emerge risks were, LC2 "Trades on site may not be working from the model”, LC1 “Unclear how to deal with BIM documents’ precedence”, and LC5 “Misplaced assumptions that the design team, with a “push of a button”, is able to produce a perfectly coordinated series of documents through BIM”. The benefits of the BIM approach will be especially apparent when all the site traders will be working from the BIM model. Taking a set of instructions from the BIM visualization models will make construction and installation tasks clear. To do so the tradesman must receive training on how to read and interpret BIM models. The clarity of BIM documentation is of important potential for improving collaboration between project team members. Thus, any ambiguities within the documents or a lack of clarity which as to which document takes priority, may lead to conflict and legal wrangling between project team members. The construction industry has well established standard contracts, there is no reason why   BIM cannot be incorporated within the standard form contracts (Winfield and Rock 2018).

From the general opinion of respondents, the three least ranked to emerge risks were, LC8 “Risks associated with the inaccuracy of cost estimates from model quantities”, LC9 “Ineffective and incompatible transition between design and constructability”, and LC17 “Unclear of the legal recourse if some stockholders face suffering economic loss from software malfunction of the BIM software”.

The ranking in table 5 shows some inconsistencies among the respondents in rating the emergence of BIM risks. For example, the table shows that that the architects ranked LC1 “Unclear how to deal with BIM documents’ precedence”, LC5 “Misplaced assumptions that the design team, with a “push of a button”, is able to produce a perfectly coordinated series of documents through BIM” and LC15 “Unclear BIM deliverables” as the most likely risks to occur while engineers and consultants ranked LC16 "Lack of legal/contractual agreements", LC2 "Trades on site may not be working from the model" and LC3 “Unclear if the model is a contract document” as the more likely risks to emerge. Also, the contractors and cost consultants viewed that LC15 “Unclear BIM deliverables”, LC9 “Ineffective and incompatible transition between design and constructability” and LC16 "Lack of legal/contractual agreements" as the most likely to emerge whereas academics ranked LC2 "Trades on site may not be working from the model", LC1 “Unclear how to deal with BIM documents’ precedence” and LC4 “Risk of (as-built) information inaccuracy” as the most likely risks to occur. From the general opinion of respondents LC2 "Trades on site may not be working from the model”, LC1 “Unclear how to deal with BIM documents’ precedence” and LC3 “Unclear if the model is a contract document” are ranked as the most important risks that have more influence on BIM adoption. To test if there is any significant difference in the responses of the respondents, ANOVA was carried out. The result shows that $F_{5,186} = 1.346$, $p = 0.247$. Therefore, since the p-value is greater than 0.05, then it shows that there is no significant difference between the responses of the respondents. However, the ANOVA test showed that for risk LC2 "Trades on site may not be working from the model", F=3.528 with p-value=0.019. Because p is <0.05 suggesting that there is a significant difference between the rating of respondents. Also, the variance test revealed that for risk LC16 "Lack of legal/contractual agreements", F=5.139 with p-value=0.03, this result indicates that there is a difference of opinion on the emergence of this risk.

Further examination of the HSD post-hoc multiple comparison tests, results confirmed that there is a difference in views, in rating LC2 "Trades on site may not be working from the model", between (Constructor/Consultants) and academics.

Similarly, The HSD test for risk LC16 "Lack of legal/contractual agreements" confirmed there were significant differences between some of the respondents in rating the occurrence of this risk. Architects believed LC16 "Lack of legal/contractual agreements" is very unlikely to emerge, whereas the Engineers were of the view it is very likely to be a real risk to BIM adoption. However, both academics and contractors/consultant were of the opinions that "lack of legal/contractual agreements" would result in risks to BIM usage.

Overall perception on the likelihood of legal risks emerging from BIM adoption

This research documented from the literature twenty-three risks related to data, intellectual property rights (IPR), liability and participants. Table 6 shows the mean scores and mean score rankings of BIM legal risks for the overall sample and for each category of the sample respectively. The mean scores for overall results range from 3.10 to 3.83, which indicate that, on average, the respondents believe the thirteen legal risks are of similar likelihood of occurrence. As shown in Table 6. The severity indices are between 62.70% and 85.20% and the Kendall's W Test range is within 47.94 to 76.94 which indicates the level of likelihood of these risks emerging because of BIM adoption.

Insert table 6 here

Table 6 shows the ranking of legal risks in BIM adoption. The table reveals that the architects ranked LP3 "Unclear what indemnities are (or are not) available to each party in the event of subsequent damages", LIPR1 "Lack of clarity of the ownership of the BIM objects" and LP1 "Modelling participant does not meet the standard of care required" as the most likely to emerge risks, while engineers ranged LP1"Modelling participant does not meet the standard of care required", LIPR4 "Lack of control of the ownership over the BIM by the creator" and LD4 "Lack of knowledge of the missing data" as the highest risks than may occur. The table also shows that contactors/consultants ranked LP4"Unclear procedures for compensation accessibility that might result in misuse or re-use of a project participant's contribution" , LP6 "Unclear procedures for dealing with contributions that must be kept secret" and LD3 "Failure of a data recipient to receive all the intended information in a model" as the most likely to emerge risks, whereas academics were of the opining that LIPR1"Lack of clarity of the ownership of the BIM objects" , LIPR2 "Unclear what intellectual property rights will be transferred to facilitate the modelling" and LP10 "The user whose contribution to the design caused the software to alter model details is responsible for inaccurate changes" are more likely to have an influence on BIM adoption. From the general opinion of respondents LIPR1"Lack of clarity of the ownership of the BIM objects", LD4 "Lack of knowledge of the missing data" and LP1 "Modelling participant does not meet the standard of care required" are ranked as the most important risks that might emerge because of BIM adoption.

These results are consistent with exiting views in literature that LIPR1 "Lack of clarity of the ownership of the BIM objects" is an important fundamental aspect in BIM technology. It was contended that there is a concern about the intellectual property rights, especially the copyright issues relating to licensing contractors and subcontractors' contributions (Lowe and Muncey 2009). The factor that is immediately followed in the ranking as shown in the table is LD4 "Lack of knowledge of the missing data". This risk is important in the sense that the lack of knowledge of the missing data usually leads to the loss of worker productivity and an increase in costs. The result is also in line with claims that BIM data are susceptible to loss, and the main base to create a BIM model is totally dependent on the input data in the model (Lowe & Muncey, 2008). Likewise, LP1 "Modelling participant does not meet the standard of care required" was considered to likely occur by all the respondents. This is important because when the contribution of project team members is blurred, or it does not meet the standards of care required by the BIM approach, it may result in all sort of manners of legal arguments.

From the general opinion of respondents, the three lowest ranked factors in this group were, LD3 "Failure of a data recipient to receive all the intended information in a model", LD2 "Risk of dealing with transferring or sending of data", and LD6 "Manipulation of data or deliberate software malfunction by the users in the project, resulting in additional costs for the project". These results are not in keeping with recent literature on information and cyber security. It is a common knowledge that the risk of transferring data between project team members is increasing exponentially through hacking and other cybercrimes. Much of the data security vulnerability comes from the Internet, which is a vital component of BIM technology infrastructure.

Because of the inconsistency in rating the likelihood of legal risk among the survey participants, one-way ANOVA was conducted to explore the impact of the respondents profession on risk emergence score. From the ANOVA test carried out on the legal risks, the result shows that (with exception of risks LD1 "Holding data (i.e. avert transferred on time)", LIPR4 "Lack of control of the ownership over the BIM by the creator" and LP13 "Risks of separate responsibilities between contractors and design team in their responsibilities and liabilities") there was no statistically significant difference between groups in rating all risks as determined by one-way ANOVA test results ($F_{5,186} = 1.346$, $p = 0.247$).

The results demonstrated there was a statistically significant difference between groups in rating risk LD1 "Holding data (i.e. Avert transferred on time)", thus retaining the null hypothesis (the result showed that F = 4.072 with p-value = 0.010). A Tukey post hoc test showed that there was a difference in views between the users about "Holding data (i.e. Avert transferred on time)" where Constructors/consultants believe that there is no risk in "Holding data (i.e. Avert transferred on time)" while other groups see that there are risks of holding data.

The results also revealed that there were significant differences in rating LIPR4 “Lack of control of the ownership over the BIM by the creator”. Further examination of Tukey’s HSD post-hoc tests indicated that the mean scores for respondents in the group "Engineer" were significantly higher than that of all the other groups. It appears that engineers see the lack of control of the ownership of the BIM by the creator may be a risk source, and thus discourage using BIM models in the project lifecycle. Furthermore, the results showed that there is a difference in the mean rating of LP13 "Risks of separate responsibilities between contractors and design team in their responsibilities and liabilities" (F=4.547 with p-value=0.06). However, Tukey’s test, result indicates that the multi- comparison p-value is above 0.05, indicating that there is no significant difference between the responses of the suvery participants.

Discussion

A summary of the variance analysis is shown in Table 7. In general, the findings showed that there were no significant differences in the mean rating of the likelihood of the occurrence of BIM adoption risks among the respondents. This implies that there was a consensus about contractual risk factors emerging in the adoption of BIM.

Insert table 7 here

This study confirmed that among the risks that most influence contractual issues were “trades on site may not be working from the model; it is unclear how to deal with BIM documents’ precedence; there were misplaced assumptions that the design team, with a “push of a button”, is able to produce a perfectly coordinated series of documents through BIM; the BIM deliverables are unclear; and there is a risk of "as-built" information inaccuracy, where the majority of respondents agreed on the extent of the impact of these factors on the use of BIM. The findings highlighted the risk of discrepancies between the BIM model and contractor execution of the instruction in the model. This raises the question of how to deal with discrepancies through contract administration. One way to solve this is through the incorporation of adequate provisions in the contracts. This is consistent with views which showed that the incorporation of the BIM approach into the contractual relationship of the parties, is the issue which needs new forms of contracts due to the substantial nature of the changes that adoption of BIM will bring compared to traditional contracts. This is especially true at level 3 of the BIM maturity index in the UK, which requires new form of contracts to cover all aspects of BIM relationships. The parties involved in the project will be affected by the working method of the BIM approach (Udom, 2012). Thus, one might argue that further development of contractual agreements is required to support the smooth application of BIM. This conjuncture is consistent with previous studies that have indicated the importance of the likelihood of the emergence of such risks, as highlighted by Ashcraft (2008), Lowe and Muncey (2008), Foster (2008) and Azhar et al. (2012).

Legal and contractual aspects of BIM are still relatively new experiences within the BIM application environment. There is little legal precedence to address the BIM risk factors related to contract issues which can be relied upon to make decisions about potential disputes surrounding the use of this new working methodology. This in turn has raised concerns and questions about BIM usage in many organizations (Sieminski, 2007; Ashcraft, 2008; Azhar, 2011; Chawla, 2012; Udom, 2012). From this perspective, legal contractual issues may become barriers limiting the benefits of using BIM in the absence of identifying and managing these risks. This research confirmed that dealing with data and methods of storing are susceptible to loss, as highlighted by NBIMS (2010), Ashcraft (2008), Lowe and Muncey (2008) and Azhar et al. (2012). Furthermore, this work established that there are concerns and questions about IPR risks and warranties which leads to difficulties in BIM up taking (Azhar et al., 2012; Ashcraft, 2008). Additionally, our findings articulated the likelihood of the emergence of legal and contractual risks as a result of blurred responsibilities of the parties towards each other, unclear responsibility for changes to the model which may cause alteration of the model details, or the emergent risks of separate responsibilities between contractors and the design team in their responsibilities and liabilities regarding the projects, as highlighted by Glover (2012), Simonian (2010), Lowe and Muncey (2009), and Ashcraft (2008). BIM responsibility is defused through a myriad of contracts and subcontracts. If errors in the BIM model go undetected, the tracking responsibility and liability become problematic. Similarly, project members may not be willing to accept responsibility for a BIM model that has been developed, updated or modified by others. Thus, contract clauses, or provisions thereof must be crafted to promote the use of BIM so that questions of responsibility and liability risks can be addressed satisfactorily, and risks are allocated properly.

Based on the findings this research offers several implications of practical implementation. First, BIM models are created by imperfect software. BIM users cannot trust infinite certainty such data with potential errors. Thus, duty of care should be factored in the e-business and e-coordination of BIM projects. BIM might influence duties and conditions agreed under the contract or imposed by the law. Furthermore, what is duty of care under digital contract? Do BIM risks that emerge from project digital representations can be used in litigation? Digital representation can be interpreted in different ways. It is hard to accept information in a model that can be interpreted in different ways. If BIM representations are not 100% reliable, then there is the potential of neglected due to duty of care. This calls for creating appropriate legal frame that apportion the legal responsibility and commitments. Secondly, an important issue is how obligations such as agreement of deadlines, risk management, subcontractor poor understanding, compliance with its contractual obligations, errors and/or omissions in the contract document and incomplete design information and employer requirements will be affected by risks that might emerge from BIM adoption. Thirdly, the implication of Jurisdiction, a digital collaborative project delivery form might lead to fuzzy roles of project stakeholders. It is not easy to pin point exactly who owns what on digital products. Fourthly, cyber security and professional liabilities in electronic and integrated project delivery systems might lead to additional costs and loss of know-how to a third party. Existing legal frameworks need to change to cope with data loss. Finally, all the above-mentioned implications potentially open the way for future research.

Conclusion

The research has successfully investigated and documented the legal and contractual risks that might influence BIM application.

The results confirmed risks that are mostly likely to emerge were **"**Trades on site may not be working from the model", "Unclear how to deal with BIM documents' precedence", and "Misplaced assumptions that the design team, with a "push of a button" is able to produce a perfectly coordinated series of documents through BIM". These findings suggest that BIM success depends on close collaboration at the outset with the client, designers, contractors and consultants. The findings may also suggest that contract documents and constancy agreements may need to be created along the line of the identified risks, so that the questions of contractual responsibilities are appropriately defined and allocated among the participants.

Legal risk consisted of twenty-three risks split into three categories; data, intellectual property rights and liability. The respondents generally agreed on the importance of "Lack of clarity of the ownership of the BIM objects", "Lack of knowledge of the missing data" and likewise, "Modelling participant does not meet the standard of care required". This result confirms the concerns expressed in the literature about the intellectual property rights, especially copyright and issues relating to the licensing contractor and subcontractor and contributions of each project participant. Issues related to the incorporation of law, contracts and insurance procedures into BIM practices should be resolved with the maturity of BIM practices. One expects that with the maturity of BIM practices, these issues will be resolved.

This study has contributed to the support for the application of BIM in the industry. The extracted contractual and legal risks' classification is expected to be used within entities such as clients, contractors and consultants to assess their risks. The results will certainly intensify the discussion about BIM risks, risk allocation and all aspects that are related to BIM contractual processes. Also, the compiled list of contractual and legal risks will help stakeholders in assessing financial implications that may result from BIM application. The list of risks could be used in pricing consultancy and construction services. More importantly, the list might be useful in developing an international standard for BIM risk management. The risk classification developed in this study will provide a unique opportunity to advance the research capability in this emerging field. The results will help to increase the maturity and importance of BIM risk assessment.

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Table 1: BIM Risks Related to Contractual issues

R.F Code	BIM Legal Risks Related to Contractual issues	References
LC1	Unclear how to deal with BIM documents' precedence	Ku and Taiebat (2011) Foster (2008) Becerik-Gerber et al., (2012) O'Connor and Hinkle (2008) Mutai (2009)
LC2	Trades on site may not be working from the model	
LC3	Unclear if the model is a contract document	
LC4	Risk of (as-built) information inaccuracy	
LC5	Misplaced assumptions that the design team, with a "push of a button", is able to produce a perfectly coordinated series of documents through BIM	

LC6	Unclear what documents will be contract documents	Simonian and Korman (2010) Ashcraft (2009) Udom (2012)
LC7	Unclear what dimensional accuracy is expected in documents	
LC8	Risks associated with the inaccuracy of cost estimates from model quantities	
LC9	Ineffective and incompatible transition between design and constructability	
LC10	Ineffective delivery and contracting strategy for the project	
LC11	Lack of defining model content in the contract documents	
LC12	Lack of defining model responsibilities in the contract documents	
LC13	Lack of defining BIM risk allocation in the contract documents	
LC14	Lack of BIM standard contracts	
LC15	Unclear BIM deliverables	
LC16	Lack of legal/contractual agreements	
LC17	Unclear of the legal recourse if some stockholders face suffering economic loss from software malfunction of the BIM software	

Table 2: BIM Legal Risks Related to dealing with data

R.F Code	BIM Legal Risks Related to dealing with data	References
LD1	Holding data (i.e. avert transferred on time)	Ashcraft (2008) NBIMS (2010) Azhar et al. (2012) Sieminski (2007)
LD2	Risk of dealing with transferring or sending of data	
LD3	Failure of a data recipient to receive all the intended information in a model	
LD4	Lack of knowledge of the missing data	
LD5	Unclear protocol for data sharing upstream and downstream to various parties	
LD6	Manipulation of data or deliberate software malfunction by the users in the project, resulting in additional costs for the project	

Table 3: BIM Legal Risks Related to Intellectual Property Rights (IPR) issues

R.F Code	BIM Legal Risks Related to Intellectual Property Rights (IPR)	References
L.IPR1	Lack of clarity of the ownership of the BIM objects	Foster (2008) Ashcraft (2008) Lowe and Muncey (2009)
L.IPR2	Unclear what intellectual property rights will be transferred to facilitate the modeling	
L.IPR3	The collaboration may grey the line of ownership due to the multiplicity of parties	
L.IPR4	Lack of control of the ownership over the BIM by the creator	

Table 4: BIM Legal Risk Factors Related to Participants and Liability issues

R.F Code	BIM Legal Risk Factors Related to Participants and Liability issues	References
LP1	Modeling participant does not meet the standard of care required	Lowe and Muncey (2009) Ashcraft (2006) Hsieh et al., (2012) Ashcraft (2008) Sieminski (2007) Udom (2012)
LP2	Lacking contribution by stakeholders	
LP3	Unclear what indemnities are (or are not) available to each party in the event of subsequent damages	
LP4	Unclear procedures for compensation accessibility that might result in misuse or re-use of a project participant's contribution	
LP5	Lack of commitment by the parties involved in sharing information by using BIM collaboratively	
LP6	Unclear procedures for dealing with contributions that must be kept secret	
LP7	Unknown allocation of liability in case of the BIM software malfunctioning	
LP8	Unclear responsibility for changes to the model	
LP9	Blurred responsibilities of the parties towards each other	
LP10	The user whose contribution to the design caused the software to alter model details is responsible for inaccurate changes	
LP11	Risks affecting the software owner, resulting from inaccurate modifications being made to the design	
LP12	Risk resulting from a project participant, or any person under their control, responsible for any contribution they make to the design	
LP13	Risks of separate responsibilities between contractors and design team in their responsibilities and liabilities	

Table 5: Ranking of the factors' impact on the uses of BIM in Contractual Issues

R.F Code	Mean	St. Deviation	Ranking				Coefficient variation	Severity index	Kendall's W Test	Aspect Ranking
			Architect	Engineer	Constructors, Consultants and Cost Consultants	Other				
LC 1	3.92	1.196	1	6	17	2	30.51	43.72	77.94	2
LC 2	3.96	1.080	5	2	16	1	27.27	54.16	78.10	1
LC 3	3.79	1.210	12	3	13	4	31.93	46.85	73.06	6
LC 4	3.83	1.088	9	5	12	3	28.41	51.12	74.13	5
LC 5	3.88	1.150	2	8	4	6	29.64	49.01	75.53	3
LC 6	3.64	1.225	7	10	15	9	33.65	48.92	67.44	9
LC 7	3.58	1.308	17	4	5	8	36.54	48.88	65.69	10
LC 8	3.42	1.123	16	12	14	16	32.84	65.27	61.17	16
LC 9	3.46	.992	14	16	2	15	28.67	72.79	61.10	15
LC 10	3.54	1.020	10	11	11	14	28.81	67.12	63.72	11
LC 11	3.54	1.020	8	13	10	12	28.81	67.12	64.49	12

LC 12	3.53	1.021	6	15	6	13	28.92	67.99	64.33	14
LC 13	3.54	.978	13	14	9	11	27.63	65.81	62.57	13
LC 14	3.72	1.153	4	9	8	7	30.99	57.66	73.01	8
LC 15	3.75	1.058	3	7	1	10	28.21	63.84	75.07	4
LC 16	3.76	1.014	15	1	3	5	26.97	65.05	72.97	7
LC 17	3.35	1.090	11	17	7	17	32.54	74.58	57.67	17

Table 6: Ranking of the factors' impact on the uses of BIM in Legal Issues

R.F Code	Mean	St. Deviation	Ranking				Coefficient variation	Severity index	Kendall's W Test	Aspect Ranking
			Architect	Engineer	Constructors, Consultants, Cost Consultants	Other				
LD1	3.44	.890	14	16	8	21	25.87	66.20	58.68	16
LD2	3.32	1.087	22	23	19	18	32.74	73.18	53.85	22
LD3	3.32	1.053	20	22	22	20	31.71	77.44	54.33	21
LD4	3.83	.979	4	3	3	11	25.56	62.85	73.58	2
LD5	3.46	.996	21	11	9	14	28.79	79.31	61.51	15
LD6	3.10	1.107	23	21	23	22	35.71	84.47	47.94	23
L.IPR 1	3.89	.943	2	13	4	1	24.24	62.90	76.94	1
L.IPR 2	3.79	.913	8	15	14	2	24.09	68.66	73.39	4
L.IPR 3	3.71	.923	5	14	11	9	24.88	75.07	70.80	8
L.IPR 4	3.44	1.105	12	2	15	23	32.12	65.18	61.64	17
LP1	3.83	1.028	3	1	5	8	26.84	63.51	76.83	3
LP2	3.62	1.118	11	9	20	12	30.88	62.70	67.42	11

LP3	3.77	.879	1	18	12	7	23.32	69.86	70.78	5
LP4	3.49	.972	15	6	1	13	27.85	76.20	64.94	14
LP5	3.76	.950	6	17	13	19	25.26	69.85	63.81	6
LP6	3.41	1.065	9	4	2	6	31.23	77.60	75.76	18
LP7	3.37	1.037	19	12	10	15	30.77	80.90	60.91	20
LP8	3.70	.925	16	20	18	16	25.00	73.66	58.69	9
LP9	3.72	.972	10	8	7	10	26.13	68.59	68.35	7
LP10	3.70	.925	13	5	21	3	25.00	73.66	70.44	10
LP11	3.37	1.000	7	7	17	5	29.67	85.20	69.40	19
LP12	3.59	.860	18	19	16	17	23.95	79.53	56.79	12
LP13	3.57	.943	17	10	6	4	26.41	76.33	63.79	13

Table 7: Summary of the variance analysis

Research Question	Is there a statistically significant difference between the respondents' perceptions in rating the likely emergence of contractual and emerging risk from BIM application?
Hypotheses	*H01: β1 = 0. H01: There is no statistically significant difference between the respondents' perceptions on the likely emergence of "BIM risk related to Contractual issues"* *H02: There is no statistically significant difference between the respondents' perceptions on the likely emergence of "BIM data risks"* *H03: There is no statistically significant difference between the respondents' perceptions on the likely emergence of "BIM Intellectual Property Rights risks"* *H04: There is no statistically significant difference between the respondents' perceptions on the likely emergence of "BIM participants liability risks"*
Results	The ANOVA results indicate that in general, the findings showed that there were no significant differences in the mean rating of the likelihood of the occurrence of BIM adoption risks among the respondents. However, there were significant differences between the respondents on the likely emergence of **LC2 & CL16, LD1, L.IPR4, and LP13** risks
Authors Observation	• Differing views on these risks could be due to various experiences and specialties of participants about dealings with BIM usage • Risks related to contractual trades issues on site and lack of legal/contractual agreements, which might have an impact on direct contracting practices on the site. • Risks related to "Holding data" (i.e., avert transferred on time), which might lead to the delay in data transfer due to the large amount of information within the BIM model, which leads to delays in the implementation of BIM processes • Risk related to "Lack of control of the ownership of the BIM by the creator", which might have risks on the delay in data transfer due to the large amount of information within the BIM model, which leads to delays in the implementation of BIM processes • Risk related to "Risks of separate responsibilities between contractors and the design team in their responsibilities and liabilities", which might have influence on required cooperation by team members and commitment in sharing information when using BIM collaboratively • Differing views on these risks could be due to various experiences and specialties of participants about dealings with BIM usage that could affect the rejection of these factors
Conclusion	The null hypothesis Ha_0 *($p<0.05$)* was rejected for these risks **LC2 & LC16 LD1, L.IPR4, and LP13**.