Systematic review of critical drivers for delay risk prediction: towards a conceptual framework for BIM-based construction projects

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Abstract

Purpose – This study aims to develop a comprehensive conceptual framework that serves as a foundation for identifying most critical delay risk drivers for Building Information Modelling (BIM)-based construction projects.

Design/methodology/approach – A systematic review was conducted using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) to identify key delay risk drivers in BIM-based construction projects that have significant impact on the performance of delay risk predictive modelling techniques.

Findings – The results show that contractor related driver and external related driver are the most important delay driver categories to be considered when developing delay risk predictive models for BIM-based construction projects.

Originality/value – This study contributes to the body of knowledge by filling the gap in lack of a conceptual framework for selecting key delay risk drivers for BIM-based construction projects, which has hampered scientific progress toward development of extremely effective delay risk predictive models for BIM-based construction projects. Furthermore, this study's analyses further confirmed a positive effect of BIM on construction project delay.

Keywords BIM, Conceptual framework, Delay drivers, Delay risk prediction, PRISMA, Systematic review

Paper type Research paper

1. Introduction

Construction projects are one-of-a-kind and are seen to be inherently risky owing to the involvement of many parties with competing interests. The risks associated with construction projects are many and have the potential to result in negative outcomes. One of such risks is delay risk as construction industry rarely completes projects in time due to its complex nature

– vagaries of project type, scope, location and size (Egwim *et al.*, 2021a, b). Risk management methods that are systematic and realistic are required to handle and control delay risks so that project success may be assured. As a result of the detrimental impact of such construction projects delay on the economy and society in general, researchers have recently used delay risk predictive modelling as a major risk management method for developing construction project delay risk predictive models. For instance, Owolabi *et al.* (2018) developed a big data analytics-based predictive model for estimating delays in public-private partnership projects between 1992 and 2015 across Europe. Also, Yaseen *et al.* (2020) developed a hybrid artificial intelligence predictive model to mitigate construction projects delay in Diyala city, Iraq. Furthermore, Egwim *et al.* (2021a, b) developed a multilayer high-performance ensemble of ensembles predictive model utilising hyper parameter optimised ensemble machine learning techniques for construction projects in Nigeria among many others.

Prior to the use of delay risk predictive models to mitigate delay, numerous investigations on causes of construction project delay by several researchers exists as evident in vast body of international literature, e.g. planning and scheduling deficiencies in Australia, delay in payment certificates in Ghana and poor site management in Malaysia by Shah (2016); ground problems and inefficient structural connections for prefabricated components in both the UK and India by Agyekum-Mensah and Knight (2017) and Ji *et al.* (2018), respectively and finally shortage of adequate equipment and poor communication among contracting parties in China by Chen *et al.* (2019) etc. Sequel to these studies, a few literature-reviews/systematic-reviews studies (Derakhshanfar *et al.*, 2019) (Sanni-Anibire *et al.*, 2020) (Tafesse, 2021) were conducted to identify key drivers that causes construction project delay in the construction industry. These drivers put together forms the variables that inform construction project delay. However, a structured model of data that represents building elements with its usage spanning beyond the pre-construction phase to the post-construction phase known as Building Information Modelling (BIM) in Architecture, Engineering and Construction (AEC) industry has been introduced for a while now (Ameziane, 2000; Egwim *et al.*, 2021a, b, 2022).

Surprisingly, researches (Al-Mohammad *et al.*, 2021; Cooney *et al.*, 2021; Evans *et al.*, 2021; Gharouni Jafari *et al.*, 2021; Saka and Chan, 2021; Silverio and Suresh, 2021; Tai *et al.*, 2021) have revealed that the delay drivers that impact non-BIM-based and BIM-based construction projects are not necessarily the same. This is due to a variety of reasons, including the adoption of BIM for accurate geometric model development within the continuum modelling strategy (Kassotakis and Sarhosis, 2021), ability to integrate BIM with emerging radio frequency identification technologies in structural engineering (Duan and Cao, 2020), use of BIM to control the geometry of arch pylon as it is being built while taking into account seasonal temperature fluctuations (Wang *et al.*, 2022), or since BIM now allows for the storage of modularisation data from past projects (Tidhar *et al.*, 2021), and as argued by Johnston *et al.* (2018) the weights of various structural forms are more readily available as a result of the increased usage of BIM and structural analysis models, and may be used to swiftly compute embodied carbon etc.

Major delay risk factors for BIM-based projects have been identified by several researchers as evident in vast body of international literature. For instance, lack of software compatibility by (Migilinskas *et al.*, 2013; Porwal and Hewage, 2013), inadequate top management commitment by (Migilinskas *et al.*, 2013; Won *et al.*, 2013), increase in short-term workload and rise in short-term costs by (Eadie *et al.*, 2013; Egwim *et al.*, 2021a, b), inefficient data interoperability and model management difficulties by (Bryde *et al.*, 2013; Won *et al.*, 2013) among many others. Consequently, in examining whether BIM might help with mitigating adverse delay risk factors, Mohd and Latiffi (2013) reported that the employment of BIM tools by construction players aids the mitigation of delay in construction projects through project scheduling. Examples of such BIM tool include Autodesk Revit, Autodesk NavisWorks, AutoCAD Civil 3D, Digital Project, Bentley, Vectorworks, Tekla and Vico (Jones *et al.*, 2008). Project scheduling is known to generate an overall project duration by using logic

and mathematical calculations to sequence all the activities needed to complete the works (CIOB, 2011). According to Gibbs *et al.* (2013) a critical path on the schedule is used to represent the major activities necessary to finish a project with the shortest time possible and an overlap on these activities will signify an extension in project time hence resulting to project delay.

Thus, since BIM offers a way of coordinating all project activities throughout its lifecycle stored in a common data environment and linked to a 3D model plus time (4D), these BIM tools are able to offer support for project control against delay(s) (Gibbs *et al.*, 2013; Hartmann *et al.*, 2012). The hypothesis of BIM was established in 1970 by Professor Charles Eastman at the Georgia Tech School of Architecture as building description systems (BDS) (Young *et al.*, 2008). Undeterred by its long-time existence, interest in BIM only took off few years ago. This present-day construction industry is predisposed by the wariness about BIM. Varying concerns around what exactly BIM is, whether BIM is only meant for large projects with complex geometries, how to change from the traditional design process to BIM among many others. BIM involves the creation and use of a three-dimensional (3D) virtual model that replicates the design, construction and operation of a building. Also, BIM is perceived by facility managers as a tool used to improve building's performance and manage operations more efficiently throughout a building's life (Abbasnejad and Moud, 2013).

The practical adoption of BIM by the AEC industry for construction project started around the mid-2000s (Mohd and Latiffi, 2013). BIM was first implemented by the United States of America (USA) with example BIM-based construction projects seen in Sutter Medical Centre, Castro Valley California USA (Davis, 2007). Presently, BIM-based construction projects have been implemented in several countries such as "Sydney Opera House", in Australia; "One Island East Office Tower", in Hong Kong; "Crussel Bridge", in Helsinki, Finland; "National Cancer Institute (NCI)", in Putrajaya, Malaysia; "Barking Riverside Extension and Rail Station", in London, UK etc (Young *et al.*, 2008; Latiffi *et al.*, 2013). The rate of adoption of BIM differs between countries. For instance, according to a report by Cassino (2010) 50% adoption rate amidst contractors was reached in North America compared to 24% of the counterparts in Western Europe, while Western Europe has higher percentage of BIM user rate (approximately 34%) compared to North American counterpart (18%).

With reference to House (House *et al.*, 2007) the major benefit of BIM is its accurate geometrical representation of building parts in an integrated data. Some research (Johansen, 2015; Jones *et al.*, 2008; Mohd and Latiffi, 2013) indicated that BIM is generally used during pre-construction, construction and post construction stages to produce better project design; aid in decision making process; improve collaboration and communication among stakeholders; centralise data administration in a common data environment; reduce changes during construction; reduce conflict during construction; minimise risks in execution period; visualise design solution in 3D; reduce project delay; improve overall project quality and achieve better cost control/predictability. Undeterred by these BIM-based delay analysis studies with corresponding benefits of BIM to construction projects, there is no amalgamating study that has consolidated key drivers that affect BIM-based construction projects. As a result, using delay risk drivers from BIM-based construction projects is crucial and has been actively promoted in AEC to accomplish early prediction, which is necessary in any robust predictive modelling to provide adequate time for correction (Narlawar *et al.*, 2019) (Amany *et al.*, 2020). Consequently, this study aims to develop a comprehensive conceptual framework that serves as a foundation for identifying the most critical delay risk drivers for BIM-based construction projects. To accomplish this aim, the following objectives will be used:

(1) To identify key delay risk drivers in BIM-based construction projects that have significant impact on the performance of delay risk predictive modelling via systematic review of literature.

(2) To examine the systematic review's summary of findings and rank the discovered delay drivers to determine which are the most critical.

The contribution of this study is therefore to fill the gap in lack of a conceptual framework for selecting key delay risk drivers for BIM-based construction projects, which has hampered scientific progress toward development of extremely effective delay risk predictive models for BIM-based construction projects. Furthermore, this study will solve the challenge of analysing variables under all existing drivers to find the most critical ones before developing delay risk predictive models for BIM-based construction projects in future research. As such, only variables that fall under the selected categories will be examined, thus significantly enhance the efficiency of delay risk predictive modelling for BIM-based construction projects. The next section details the research methodology, which begins with an explanation of the systematic review methods. The data analysis section follows afterwards (section 3), explaining the systematic review's data analysis step by step. The analysis' findings are then presented discussed in section 4. The discussion part examines how the findings connect to existing theories, while the conclusion summarises the findings in section 5.

2. Methodology
Pragmatism is the philosophical paradigm used in this study. This is because it focuses on practical applied research using several viewpoints to aid in data interpretation such that depending on the research question, either observable occurrences or subjective meanings might give acceptable knowledge (Saunders *et al.*, 2019). This systematic review is conducted in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page *et al.*, 2021). PRISMA is a protocol for conducting systematic reviews and meta-analyses that includes a 27-item checklist and a four-phase flow diagram. It was created by a consortium of twenty-nine professors in the medical community with the aim of improving the clarity and consistency of literature reviews. PRISMA was therefore, chosen over other existing guidelines because of its comprehensiveness, its use in a variety of disciplines around the world outside of medicine, and its ability to improve accuracy through articles (Pahlevan Sharif *et al.*, 2019).

In order to record the research process and inclusion criteria, a protocol was created in advance. A thorough literature search was conducted to find articles for this study. More precisely, only articles published until 1st of August 2021 in Scopus and American Society of Civil Engineers (ASCE) databases were used as its primary source of information for the search. These databases were chosen because the formal is the "largest abstract and citation database of peer-reviewed literature" (Cantú-Ortiz and Fangmeyer, 2017) while the latter is the "world's largest publisher of civil engineering content" (ASCE, 2010). The abstract, title and keywords of publications in these databases were searched using the following search terms: ("BIM" OR "Building Information Model*" OR "Building Information Manage*" AND ("Delay*" OR "Schedule Overrun*")) with no date, language and article type restrictions. The eligibility criteria are thus, all articles stored in these databases whose title, abstract or keywords matched the search terms. This is because titles, abstracts and keywords serve as cues for article search.

A total of three hundred and eighty-eight articles were identified (see supplementary Figure (Figure S1)). The author's name, author's affiliation, articles title, articles abstract, authors keywords, publication year and source title were exported to a Comma-Separated Values (CSV) file. At first, two different authors of this study screened each title and abstract in the exported CSV file independently. Full text of articles from the file that fell within the eligibility criteria (mentioned above) were subsequently accessed and evaluated. The bibliographic information for the included articles, as well as the necessary elements from the PRISMA checklist (with a few changes), were added to the data management CSV file. Meta-analysis study findings (items 12–16 and 19–23 from the PRISMA checklist) were excluded because they were related to meta-analyses only, outside the scope of this research.

Finally, all articles used were thoroughly examined for data extraction (research aim, project type, country/region, research method(s), tool(s), etc.) and coding by one author as summarised in Figure S1. This figure displays the flow diagram of the research selection process. It details the total number of articles identified through database search, total number of articles screened based on eligibility criteria and total number of these articles whose full text were access and finally total number of these articles that were used for analysis in this study.

3. Result and analysis

Performing the search terms on the electronic databases yielded a total of three hundred and eighty-eight articles (see Figure S1). A total of three hundred articles which either despite meeting the eligibility criteria, does not relate to the objective of this study or due to limited access of the authors to subscription-based articles were excluded from this research (For example, Yan *et al.*, 2008, Studebaker, 2014; Egwim, 2017; Surendhra Babu and Hayath Babu, 2018; Moselhi *et al.*, 2020; Balogun *et al.*, 2021 etc) were not relevant to the effect of BIM on construction projects delay; thus, remaining a total of eighty-eight articles. Furthermore, each author read the full-length of the remaining articles carefully to ensure that they were relevant. Thirty-eight of these were further discarded because they did not satisfy the eligibility criteria. Consequently, a total of fifty articles – thirty-one journals, seventeen conference proceedings, and two books remained and were used for this research. Supplementary Table (Table S1) summarises the extracted variables and information as the main characteristics of all the reviewed articles towards the discovery of key delay risk drivers for BIM-based construction projects.

Furthermore, exploratory analysis of the data from Table S1 revealed seventeen different types of construction projects (see Figure 1) from the articles reviewed in this study, demonstrating the validity of the proposed conceptual framework as being capable of working in a variety of construction projects. In addition, a count of research methods per project revealed that the most commonly used research method, quantitative research, was most prevalent in the general construction project category as shown in Figure 1. Quantitative research method is based on objectivity and is especially useful when it is possible to obtain empirical measures of variables and findings from population samples. For the purpose of gathering numerical data, quantitative research uses formal tools and systematic processes. The numerical data is gathered methodically and objectively and often analysed through statistical tools such as Statistical Package for Social Sciences (SPSS), Python, R, Stata or Scikit-Learn etc. Additionally, Figure 2 displays a count of published
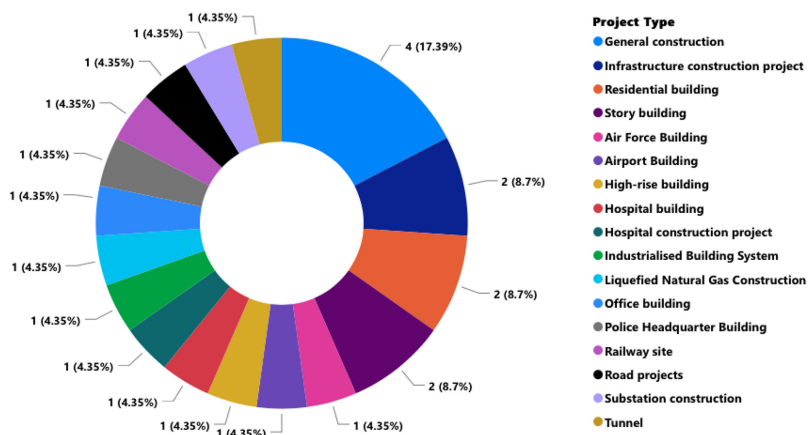

Figure 1.
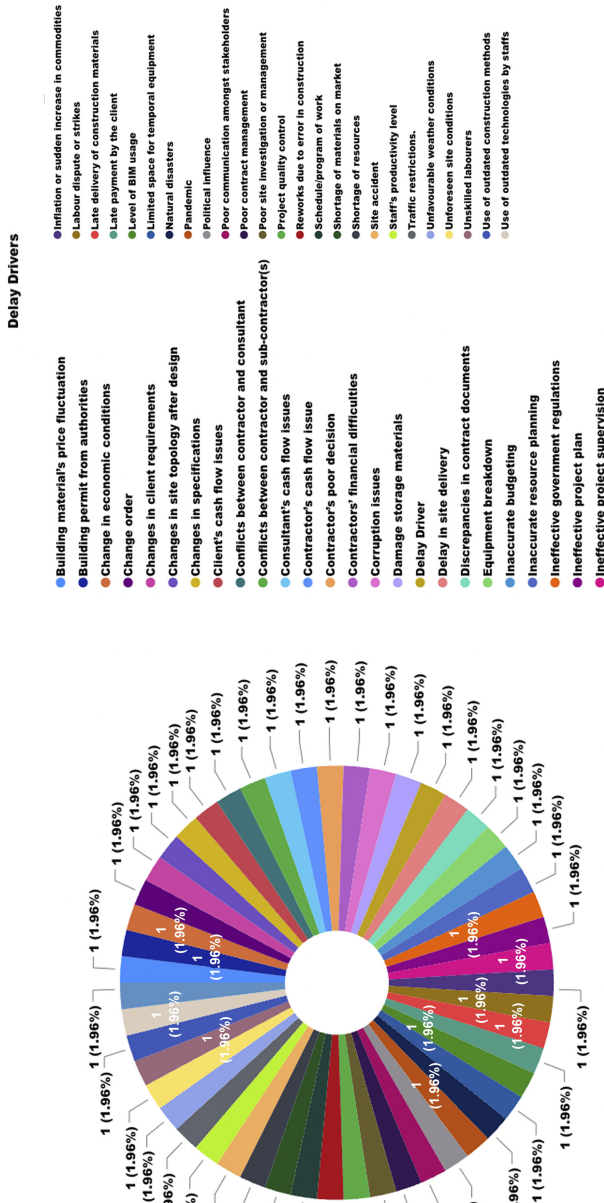A count of research methods by construction project type

Figure 2.
A count of published
articles by delay
drivers

articles by delay drivers revealed that at least one delay driver was present in the final fifty articles selected for this systematic review. This is in line with the findings of Egwim *et al.* (2021a, b) who made an important point by arguing that delay persists in the construction industry despite all these contributing drivers and recommendations for alleviating it.

By observation (see Table 1), it appears that the global construction industry has only paid more attention on the effect of BIM to its project delay in the continent of Asia (in terms of number of publications by researchers and practitioners used in this study) when compared to other continents of the world. This can further suggest the possible increase in the rate of adoption of BIM and a lesser number of delayed projects in that region as was evidently demonstrated in the construction of a 1,000-bed Huoshenshan and 1500-beds Leishenshan Hospitals for COVID-19 patients in Wuhan, China between the 23rd of January and 2nd of February 2020.

To obtain the key delay risk drivers necessary for development of delay risk predictive models for BIM-based construction projects (as part of the objective of this research) we extracted the top drivers each from the fifty research articles used in this systematic review and grouped them into nine delay categories: *owners related driver, contractor related driver, consultant related driver, design related driver, labour related driver, equipment related driver, project related driver, suppliers related driver and external related driver.* These delay drivers were categorised based on the outcome of existing body of knowledge by Gündüz *et al.* (2013) who extracted these nine categories via a thorough analysis of the literature and interviews with construction industry professionals and demonstrated them using the Ishikawa (fishbone) diagram – a framework that can indicate drivers, interrelationships between different groups of drivers and repercussions resulting from the drivers. Furthermore, we ranked them based on these categories (i.e. for each category according to number of times each driver occurred in the fifty articles used) and used the outcome of the ranking to propose a conceptual framework necessary for developing delay risk predictive models for BIM-based construction projects as shown in supplementary Table (Table S2) and Figure 3 below respectively. Quite notably among these categories is the labour related driver in which the slow rate of technology adoption as evidently caused by the constant use of outdated technologies and/the use of outdated construction methods (e.g. pre-cast twin wall technology, 2D drawing etc.) by labourers during construction was widely reported by vast body of literature (Teng *et al.*, 2013; Btoush and Harun, 2017; Tahir *et al.*, 2018; Ibrahim *et al.*, 2019). This is important because fundamental advances in construction technology will enable good construction project management via efficient use of labour, resources and equipment.

This conceptual framework details contractor related driver and external related driver as the most important delay driver categories (see Figure 3) to be considered when developing

SN	Continent	Countries (# of research articles)	Total countries	Total articles
1	Africa	Zambia (1), Egypt (2)	2	3
2	North America	Canada (2), USA (2)	2	4
	South America	Peru (1)	1	1
3	Asia	India (3), Malaysia (7), Korea (4), China (5), Thailand (1), Taiwan (2), Jordan (1), Singapore (1), Slovenia (1), Indonesia (1), Hong Kong (1)	11	27
4	Europe	Italy (2), Spain (1), Germany (1)	3	4
5	Oceania	Australia (1)	1	1
6	Multi-continental	Multi-national (10)	n/a	10

Table 1.
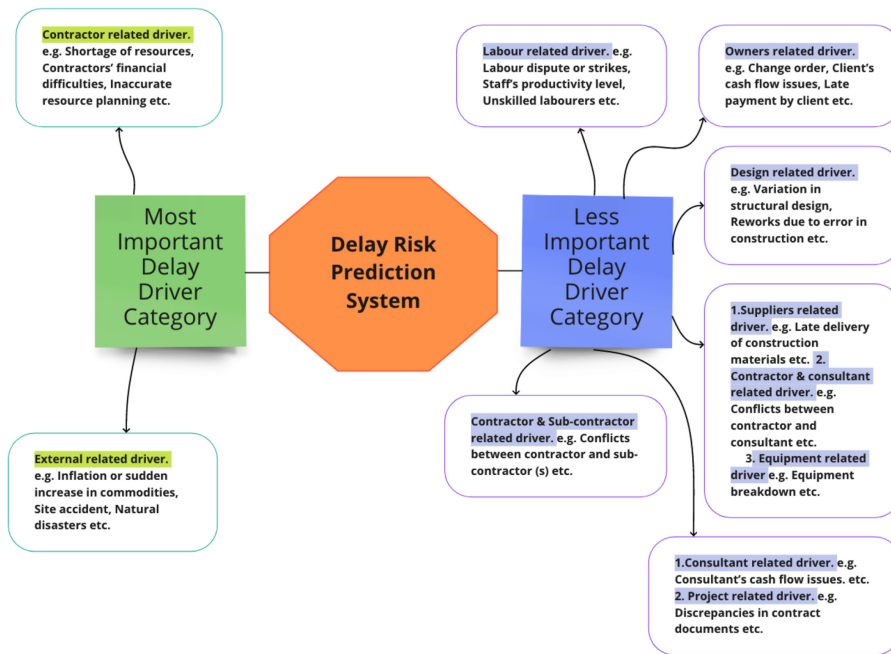List of research articles used and their respective countries/continents

Figure 3.
Conceptual framework
of delay drivers
necessary for
developing delay risk
predictive models for
BIM-based
construction projects

delay risk predictive models for BIM-based construction projects. This is justified based on citation frequency. More precisely, these categories had the highest number of citations from research articles used in this study. Conversely, labour related driver, owner's related driver; design related driver; suppliers related driver; consultant related driver; contractor and consultant related driver; equipment related driver, project related driver; and contractor and sub-contractor related driver were considered less important delay driver categories based on their respective low citation frequencies. Suppliers related driver, contractor and consultant related driver, and equipment related driver were grouped together because they all had equal number of citation (see Table S2). Similarly, because they all received the same number of citations, consultant related driver and project related driver were grouped together.

4. Conclusion
Various attempts at mapping and synthesising the current body of information have emerged in the literature since BIM in AEC (as an area of inquiry) has increasingly grown and supposedly reached intellectual and analytical sophistication in decades. Systematic analyses have emerged as one of the key methods for assessing the key delay risk drivers necessary for development of delay risk predictive models for BIM-based construction projects among the various forms of research undertaken by scholars. Undeterred by these BIM-based delay analysis studies with corresponding benefits of BIM to construction projects, there is no amalgamating study that has consolidated key drivers that affect BIM-based construction projects. As a result, using delay risk drivers from BIM-based construction projects is crucial and has been actively promoted in AEC to accomplish early prediction, which is necessary in any robust predictive modelling to provide adequate time for correction; thus, led to the development of a comprehensive conceptual framework that serves as a foundation for identifying the most critical delay risk drivers for BIM-based construction projects. This was accomplished by first identifying key delay risk drivers in

BIM-based construction projects that have significant impact on the performance of delay risk predictive modelling via systematic review of literature. Secondly, by examining the systematic review's summary of findings and ranking the discovered delay drivers to determine which are the most critical. Consequently, this study therefore filled the gap in lack of a conceptual framework for selecting key delay risk drivers for BIM-based construction projects, which has hampered scientific progress toward development of extremely effective delay risk predictive models for BIM-based construction projects. Secondly, this study's analyses further confirmed a positive effect of BIM on construction project delay risk even though the studies used for its analyses implemented BIM differently on different construction projects across different regions of the world.

This is highly incredible as the novel BIM is said to have the potential to be regarded as a disruptive technology by the AEC across the globe which this study's analyses is further confirming. Also, the BIM mandate required from contractors/consultant by policy makers or government agencies across regions will be realised there by reducing conflicts or law orders between project stakeholders as construction projects achieves timely completion of its projects. Evidently, a systematic review approach served as the foundation for the study's conclusions. The potential limitation of this study strategy may be bias in publication selection because the research article keywords were subject-specific. As a consequence, it's probable that some crucial research articles solely indexed in other databases such as Web of Science, Google Scholar etc. were missed in the course of the search. Also, the identification of delay drivers has no immediate impact on practise or research. Making it worthwhile may be as easy as creating a framework for identifying delays in construction projects. This may be achieved by documenting the construction process for various project types, identifying the various delay reasons at each step and their significance and outlining potential solutions that may be implemented by different stakeholders. Future work may also consider making an effort to identify new drivers that forms the factors that informs construction project delay. More so, future work should conduct comprehensive systematic review on other pertinent issues common to the construction industry.

References

Abbasnejad, B. and Moud, H.I. (2013), "BIM and basic challenges associated with its definitions, interpretations and expectations", *International Journal of Engineering Research and Application*, Vol. 3 No. 2, pp. 287-294, available at: www.ijera.com (accessed 28 April 2020).

Abdelbary, M., Edkins, A. and Dorra, E.M. (2020), "Reducing crr in fast-track projects through bim", *Journal of Information Technology in Construction*, Vol. 25 December 2018, pp. 140-160, doi: 10.36680/j.itcon.2020.009.

Agyekum-Mensah, G. and Knight, A.D. (2017), "The professionals' perspective on the causes of project delay in the construction industry", *Engineering, Construction and Architectural Management*, Vol. 24 No. 5, pp. 828-841, doi: 10.1108/ECAM-03-2016-0085.

Al-Mohammad, M.S., Haron, A.T., Aloko, M.N. and Rahman, R.A. (2021), "Factors affecting BIM implementation in post-conflict low-income economies: the case of Afghanistan", *Journal of Engineering, Design and Technology* [Preprint], doi: 10.1108/JEDT-04-2021-0205.

Amany, A., Taghizade, K. and Noorzai, E. (2020), "Investigating conflicts of expert contractors using the last planner system in building information modeling process", *Journal of Engineering, Design and Technology*, Vol. 18 No. 6, pp. 1381-1402, doi: 10.1108/JEDT-09-2019-0223.

Ameziane, F. (2000), "Information system for building production management", *International Journal of Production Economics*, Vol. 64 No. 1, pp. 345-358, doi: 10.1016/S0925-5273(99)00071-7.

Ansah, R.H. Sorooshian, S., Mustafa, S.B. and Duvvuru, G. (2016), "Advancing towards delay-free construction project: a review", *Proceedings of the International Conference on Industrial Engineering and Operations Management*, pp. 744-751.

ASCE (2010), "About asce", *ASCE News Online*, p. 1, available at: https://www.asce.org/about_asce/ (accessed 22 April 2021).

Balogun, H., Alaka, H. and Egwim, C.N. (2021), "Boruta-grid-search least square support vector machine for NO 2 pollution prediction using big data analytics and IoT emission sensors", *Applied Computing and Informatics*, Vol. ahead-of-print No. ahead-of-print, doi: 10.1108/aci-04-2021-0092.

Bryde, D., Broquetas, M. and Volm, J.M. (2013), "The project benefits of building information modelling (BIM)", *International Journal of Project Management*, Vol. 31 No. 7, pp. 971-980, doi: 10.1016/J.IJPROMAN.2012.12.001.

Btoush, M. and Harun, A.T. (2017), "Minimizing delays in the Jordanian construction industry by adopting BIM technology", *IOP Conference Series: Materials Science and Engineering*, Vol. 271 No. 1, doi: 10.1088/1757-899X/271/1/012041.

Cantú-Ortiz, F.J. and Fangmeyer, J. (2017), "University performance in the age of research analytics", in *Research Analytics: Boosting University Productivity and Competitiveness through Scientometrics*, CRC Press, pp. 237-258, doi: 10.1201/9781315155890.

Cassino, K.E., Bernstein, H.M., Gudgel, J., Advisor-Bim, E., Jones, S.A., Gudgel, J.E., Messina, F., Partyka, D., Lorenz, A., Buckley, B., Fitch, E., Laquidara-Carr, D. (2010) *McGraw-Hill Construction The Business Value of BIM in Europe SmartMarket Report Executive Editor SmartMarket Report*, available at: www.construction.com (accessed 22 September 2021).

Chen, C. and Tang, L. (2019), "BIM-based integrated management workflow design for schedule and cost planning of building fabric maintenance", *Automation in Construction*, Vol. 107 August, 102944, doi: 10.1016/j.autcon.2019.102944.

Chen, G.X., Shan, M., Chan, A.P., Liu, X. and Zhao, Y.Q. (2019), "Investigating the causes of delay in grain bin construction projects: the case of China", *International Journal of Construction Management*, Vol. 19 No. 1, pp. 1-14, doi: 10.1080/15623599.2017.1354514.

Chiponde, D.B., Mutale, L.P., Ziko, J.M. and Jalo, L. (2017), "Assessing the feasibility of using building information modelling (BIM) to improve collaboration on public sector projects in the Zambian construction industry", *WIT Transactions on the Built Environment*, Vol. 169, pp. 191-199, doi: 10.2495/BIM170181.

Chou, H.Y. and Chen, P.Y. (2017), "Benefit evaluation of implementing BIM in construction projects", *IOP Conference Series: Materials Science and Engineering*, Vol. 245 No. 6, doi: 10.1088/1757-899X/245/6/062049.

CIOB (2011), "Guide to good practice in the management of time in complex projects", *Structural Survey*, Vol. 29 No. 3, pp. 73-76, doi: 10.1108/ss.2011.11029caa.017.

Cooney, J.P., Oloke, D. and Gyoh, L. (2021), "A novel heritage BIM (HBIM) framework development for heritage buildings refurbishment based on an investigative study of microorganisms", *Journal of Engineering, Design and Technology*, [Preprint]. doi: 10.1108/JEDT-07-2021-0370/FULL/PDF.

Couto, R. and Ericson, D. (2017), "A Case Study of Logan International Airport's Terminal C to e Connector: structural Challenges and Risks for Existing Building Projects", *Structures Congress 2017: Business, Professional Practice, Education, Research, and Disaster Management - Selected Papers from the Structures Congress 2017*, American Society of Civil Engineers (ASCE), pp. 1-13, doi: 10.1061/9780784480427.001.

Dallasega, P., Revolti, A., Follini, C., Schimanski, C.P. and Matt, D.T. (2019), "BIM-based construction progress measurement of non-repetitive HVAC installation works", *27th Annual Conference of the International Group for Lean Construction*, 2019, IGLC, pp. 819-830, doi: 10.24928/2019/0152.

Davis, D. (2007), "National building information model standard NBIMS ● BIM GIS integration ● why NBIMS ● what is NBIMS ● issues of interoperability chair-national BIM standards scoping chair", Infosystems, [Preprint], available at: https://buildinginformationmanagement.files. wordpress.com/2011/06/nbimsv1_p1.pdf.

Delgado, F., Martínez, R., Puche, J. and Finat, J. (2015), "Towards a client-oriented integration of construction processes and building GIS systems", *Computers in Industry*, Vol. 73, pp. 51-68, doi: 10.1016/j.compind.2015.07.012.

Derakhshanfar, H., Ochoa, J.J., Kirytopoulos, K., Mayer, W. and Tam, V.W. (2019), "Construction delay risk taxonomy, associations and regional contexts A systematic review and meta-analysis", Vol. 26 No. 10, pp. 2364-2388, doi:10.1108/ECAM-07-2018-0307.

Diaz, B., Rivera, M., Rodriguez, S. and Carrera, E. (2019), *Time and cost optimization for road projects through BIM", 2019 Congreso Internacional de Innovacion y Tendencias en Ingenieria, CONIITI 2019 - Conference Proceedings*, Institute of Electrical and Electronics Engineers. doi: 10.1109/CONIITI48476.2019.8960767.

Duan, K.K. and Cao, S.Y. (2020), "Emerging RFID technology in structural engineering – a review", *Structures*, Vol. 28, pp. 2404-2414, doi: 10.1016/J.ISTRUC.2020.10.036.

Eadie, R., Browne, M., Odeyinka, H., McKeown, C. and McNiff, S. (2013), "BIM implementation throughout the UK construction project lifecycle: an analysis", *Automation in Construction*, Vol. 36, pp. 145-151, doi: 10.1016/J.AUTCON.2013.09.001.

Egwim, C.N. (2017), "A cloud-based C/C++ compiler for smart devices", available at: http://repository.aust.edu.ng/xmlui/handle/123456789/4884 (accessed 24 November 2021).

Egwim, C.N., Alaka, H., Toriola-Coker, L.O., Balogun, H. and Sunmola, F. (2021a), "Applied artificial intelligence for predicting construction projects delay", *Machine Learning with Applications*, Vol. 6, 100166, doi: 10.1016/j.mlwa.2021.100166.

Egwim, C.N., Alaka, H., Toriola-Coker, L.O., Balogun, H., Ajayi, S. and Oseghale, R. (2021b), "Extraction of underlying factors causing construction projects delay in Nigeria", *Journal of Engineering, Design and Technology*, Vol. ahead-of-print No. ahead-of-print. doi: 10.1108/jedt-04-2021-0211.

Egwim, C.N., Alaka, H., Egunjobi, O.O. and Gomes, A. (2022), "Comparison of machine learning algorithms for evaluating building energy efficiency using big data analytics", *Journal of Engineering, Design and Technology*, 691986, [Preprint]. doi: 10.1108/JEDT-05-2022-0238.

Elhusseiny, H.O., Nosair, I. and Ezeldin, A.S. (2021), "Systematic processing framework for analyzing the factors of construction projects' delays in Egypt", *Ain Shams Engineering Journal*, [Preprint]. doi: 10.1016/j.asej.2020.10.016.

Ern, P.A.S., Ooi, Y.Y. and Al-Ashmori, Y.Y. (2020), "Comparative study on the perspective towards the benefits and hindrances of implementing building information modelling (Bim)", *International Journal of Sustainable Construction Engineering and Technology*, Vol. 11 No. 1, pp. 194-205, doi: 10.30880/ijscet.2020.11.01.019.

Evans, M., Farrell, P., Mashali, A. and Zewein, W. (2021), "Critical success factors for adopting building information modelling (BIM) and lean construction practices on construction mega-projects: a Delphi survey", *Journal of Engineering, Design and Technology*, Vol. 19 No. 2, pp. 537-556, doi: 10.1108/JEDT-04-2020-0146/FULL/PDF.

Gharouni Jafari, K., Ghazi Sharyatpanahi, N.S. and Noorzai, E. (2021), "BIM-based integrated solution for analysis and management of mismatches during construction", *Journal of Engineering, Design and Technology*, Vol. 19 No. 1, pp. 81-102, doi: 10.1108/JEDT-02-2020-0044/FULL/PDF.

Gibbs, D.-J., Emmitt, S., Ruikar, K. and Lord, W. (2013), "An investigation into whether building information modelling (BIM) can assist with construction delay claims", *International Journal of 3-D Information Modeling*, Vol. 2 No. 1, pp. 45-52, doi: 10.4018/ij3dim.2013010105.

Giel, B.K. and Issa, R.R.A. (2013), "Return on investment analysis of using building information modeling in construction", *Journal of Computing in Civil Engineering*, Vol. 27 No. 5, pp. 511-521, doi: 10.1061/(asce)cp.1943-5487.0000164.

Gündüz, M., Nielsen, Y. and Özdemir, M. (2013), "Quantification of delay factors using the relative importance index method for construction projects in Turkey", *Journal of Management in Engineering*, Vol. 29 No. 2, pp. 133-139, doi: 10.1061/(asce)me.1943-5479.0000129.

Handayani, T.N., Likhitruangsilp, V. and Yabuki, N. (2019), "A building information modeling (BIM)-integrated system for evaluating the impact of change orders", *Engineering Journal*, Vol. 23 No. 4, pp. 67-90, doi: 10.4186/ej.2019.23.4.67.

Hartmann, T., Van Meerveld, H., Vossebeld, N. and Adriaanse, A. (2012), "Aligning building information model tools and construction management methods", *Automation in Construction*, Elsevier, pp. 605-613, doi: 10.1016/j.autcon.2011.12.011.

Hossain, M.A., Abbott, E.L., Chua, D.K., Nguyen, T.Q. and Goh, Y.M. (2018), "Design-for-safety knowledge library for BIM-integrated safety risk reviews", *Automation in Construction*, Vol. 94 June, pp. 290-302, doi: 10.1016/j.autcon.2018.07.010.

House, S.O., Ballesty, S., Mitchell, J., Drogemuller, R., Schevers, H., Linning, C., Singh, G. and Marchant, D. (2007), "Adopting BIM for facilities management: solutions for managing the sydney Opera house, CRC for construction innovation participants", *CRC for Construction Innovation*. doi: 10.1061/(ASCE)CO.1943-7862.0000433.

Husin, A.E. (2019), "Time performance upgrade by critical chain project management and BIM 4D integration on top structural work of a high rise building construction project", *ARPN Journal of Engineering and Applied Sciences*, Vol. 14 No. 17, pp. 3063-3072, doi: 10.13140/RG.2.2.26024.11523.

Ibrahim, H.S., Hashim, N. and Ahmad Jamal, K.A. (2019), "The potential benefits of building information modelling (BIM) in construction industry", *IOP Conference Series: Earth and Environmental Science*, Vol. 385 No. 1, doi: 10.1088/1755-1315/385/1/012047.

Jang, S. and Lee, G. (2018), "Impact of organizational factors on delays in bim-based coordination from a decision-making view: a case study", *Journal of Civil Engineering and Management*, Vol. 24 No. 1, pp. 19-30, doi: 10.3846/jcem.2018.296.

Ji, Y., Qi, L., Liu, Y., Liu, X., Li, H.X. and Li, Y. (2018), "Assessing and prioritising delay factors of prefabricated concrete building projects in China", *Applied Sciences (Switzerland)*, Vol. 8 No. 11, p. 2324, doi: 10.3390/app8112324.

Johansen, T.F. (2015), "How does BIM contributes to LEAN?", *KEA-Copenhagen School of Design and Technology*, p. 57, available at: https://buildingsmart.no/sites/buildingsmart.no/files/2015_kea_thomas_felipe_johansen_how_does_bim_contributes_to_lean.pdf (accessed 27 April 2020).

Johnston, R.P.D., McGrath, T., Nanukuttan, S., Lim, J.B.P., Soutsos, M., Chiang, M.C., Masood, R. and Rahman, M.A. (2018), "Sustainability of cold-formed steel portal frames in developing countries in the context of life cycle assessment and life cycle costs", *Structures*, Vol. 13, pp. 79-87, doi: 10.1016/J.ISTRUC.2017.11.003.

Jones, S.A., Young, N.W. Jr and Bernstein, H.M. (2008), "Building information modeling (BIM): transforming design and construction to achieve greater industry productivity", *McGraw Hill Construction - SmartMarket Report*, p. 45.

Kassotakis, N. and Sarhosis, V. (2021), "Employing non-contact sensing techniques for improving efficiency and automation in numerical modelling of existing masonry structures: a critical literature review", *Structures*, Vol. 32, pp. 1777-1797, doi: 10.1016/J.ISTRUC.2021.03.111.

Kermanshahi, E.K., Tahir, M.B.M., Lim, N.H.A.S., Balasbaneh, A.T. and Roshanghalb, S. (2020), "Implementation of building information modeling for construction clash detection process in the design stage: a case study of Malaysian police headquarter building", *IOP Conference Series: Earth and Environmental Science*, Vol. 476 No. 1, doi: 10.1088/1755-1315/476/1/012009.

Khalesi, H., Balali, A., Valipour, A., Antucheviciene, J., Migilinskas, D. and Zigmund, V. (2020), "Application of hybrid swara–bim in reducing reworks of building construction projects from the perspective of time", *Sustainability (Switzerland)*, Vol. 12 No. 21, pp. 1-20, doi: 10.3390/su12218927.

Latiffi, A.A., Mohd, S., Kasim, N. and Fathi, M.S. (2013), "Building information modeling (BIM) application in Malaysian construction industry", *International Journal of Construction Engineering and Management*, Vol. 2 No. 4A, pp. 1-6, p-ISSN 2326-1080 e-ISSN 2326-11022013, doi: 10.5923/s.ijcem.201309.01.

Liu, D., Li, X., Chen, J. and Jin, R. (2020), "Real-time optimization of precast concrete component transportation and storage", *Advances in Civil Engineering*. doi: 10.1155/2020/5714910.

Liu, R. and Liu, F. (2020), *Research on Bim and Mobile Equipment in Substation Construction Schedule Management, Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, Springer International Publishing. doi: 10.1007/978-3-030-49183-3_5.

Li, C.Z., Zhong, R.Y., Xue, F., Xu, G., Chen, K., Huang, G.G. and Shen, G.Q. (2017), "Integrating RFID and BIM technologies for mitigating risks and improving schedule performance of prefabricated house construction", *Journal of Cleaner Production*, Vol. 165, pp. 1048-1062, doi: 10.1016/j.jclepro.2017.07.156.

Malacarne, G., Toller, G., Marcher, C., RiedlRiedl, M. and Matt, D.T. (2018), "Investigating benefits and criticisms of BIM for construction scheduling in SMEs: an Italian case study", *International Journal of Sustainable Development and Planning*, Vol. 13 No. 1, pp. 139-150, doi: 10.2495/SDP-V13-N1-139-150.

Migilinskas, D., Popov, V., Juocevicius, V. and Ustinovichius, L. (2013), "The benefits, obstacles and problems of practical BIM implementation", *Procedia Engineering*, Vol. 57, pp. 767-774, doi: 10.1016/j.proeng.2013.04.097.

Mohd, S. and Latiffi, A.A. (2013), "Building Information Modeling (BIM): what?, when? and why?", available at: https://www.semanticscholar.org/paper/Building-Information-Modeling-(BIM)%3A-what%2C-when-and-Mohd-Latiffi/5c11e5c18901231359252e6823c8785e929a222a/ (accessed 22 April 2021).

Moselhi, O., Bardareh, H. and Zhu, Z. (2020), "Automated data acquisition in construction with remote sensing technologies", *Applied Sciences (Switzerland)*, Vol. 10 No. 8, doi: 10.3390/APP10082846.

Muhammad, M.T, Haron, N.A., Alias, A.H., Harun, A.N. (2017), "Strategies to improve cost and time control using building information model (BIM); conceptual paper", *Malaysian Construction Research Journal*, Vol. 1 No. 1, pp. 23-39.

Narlawar, G.S. and Chaphalkar, N.B., S.S. (2017), "Strategies to improve cost and time control using building information model (BIM); Conceptual paper", *International Conference on Innovation and Management (ICIM)*, Vol. 2 No. 2, p. 270, 2016, available at: https://www.cream.my/main/index.php/publication/malaysian-construction-research-journal-mcrj?download=46:mcrj-special-issue-volume-1-no-1-2017.

Narlawar, G.S., Chaphalkar, N.B. and Sandbhor, S. (2019), "Time and resource management of residential apartment construction using building information modeling", *International Journal of Innovative Technology and Exploring Engineering*, Vol. 8 No. 10, pp. 4238-4246, doi: 10.35940/ijitee.J9951.0881019.

Nawi, M.N.M., Haron, A.T., Hamid, Z.A., Kamar, K.A.M. and Baharuddin, Y. (2014), "Improving integrated practice through building information modeling-integrated project delivery (BIM-IPD) for Malaysian industrialised building system (IBS) construction projects", *Malaysian Construction Research Journal*, Vol. 15 No. 2, pp. 29-38.

Ocheoha, I.A. and Moselhi, O. (2013), "Impact of building information modeling on just-in-time material delivery", *ISARC 2013-30th International Symposium on Automation and Robotics in Construction and Mining, Held in Conjunction with the 23rd World Mining Congress*, Canadian Institute of Mining, Metallurgy and Petroleum, pp. 793-801, doi: 10.22260/isarc2013/0086.

Owolabi, H.O., Bilal, M., Alaka, L.O., Ajayi, H., Akinade, S.O. and Owolabi (2018), "Predicting completion risk in PPP projects using big data analytics", *IEEE Transactions on Engineering Management* [Preprint], doi: 10.1109/TEM.2018.2876321.

Park, J., Cai, H., Dunston, P.S. and Ghasemkhani, H. (2017), "Database-supported and web-based visualization for daily 4D BIM", *Journal of Construction Engineering and Management*, 04017078, doi: 10.1061/(asce)co.1943-7862.0001392.

Park, J.H. and Lee, G. (2017), "Design coordination strategies in a 2D and BIM mixed-project environment: social dynamics and productivity", *Building Research and Information*, Vol. 45 No. 6, pp. 631-648, doi: 10.1080/09613218.2017.1288998.

Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R., Glanville, J., Grimshaw, J.M., Hróbjartsson, A., Lalu, M.M., Li, T., Loder, E.W., Mayo-Wilson, E., McDonald, S., McGuinness, L.A., Stewart, L.A., Thomas, J., Tricco, A.C., Welch, V.A., Whiting, P. and Moher, D. (2021), "The PRISMA 2020 statement: an updated guideline for reporting systematic reviews", *The BMJ*, Vol. 372, doi: 10.1136/BMJ.N71.

Pahlevan Sharif, S., Mura, P. and Wijesinghe, S.N.R. (2019), "Systematic reviews in Asia: introducing the 'PRISMA' protocol to tourism and hospitality scholars", in Rezaei, S. (Ed.), *Quantitative Tourism Research in Asia. Perspectives on Asian Tourism*, Springer, Singapore. doi: 10.1007/978-981-13-2463-5_2.

Porwal, A. and Hewage, K.N. (2013), "Building Information Modeling (BIM) partnering framework for public construction projects", *Automation in Construction*, Vol. 31, pp. 204-214, doi: 10.1016/J.AUTCON.2012.12.004.

Ryu, D.W., Kim, J.I., Suh, S. and Suh, W. (2015), "Evaluating risks using simulated annealing and Building Information Modeling", *Applied Mathematical Modelling*, Vol. 39 No. 19, pp. 5925-5935, doi: 10.1016/j.apm.2015.04.024.

Saka, A.B. and Chan, D.W.M. (2021), "BIM divide: an international comparative analysis of perceived barriers to implementation of BIM in the construction industry", *Journal of Engineering, Design and Technology*, Vol. ahead-of-print No. ahead-of-print, doi: 10.1108/JEDT-07-2021-0348.

Sami Ur Rehman, M., Thaheem, M.J., Nasir, A.R. and Khan, K.I.A. (2020), "Project schedule risk management through building information modelling", *International Journal of Construction Management* [Preprint]. doi: 10.1080/15623599.2020.1728606.

Sanni-Anibire, M.O., Mohamad Zin, R. and Olatunji, S.O. (2020), "Causes of delay in the global construction industry: a meta analytical review", *International Journal of Construction Management*, [Preprint]. doi: 10.1080/15623599.2020.1716132.

Saunders, M.A., Lewis, P. and Thornhill, A. (2019), "RESEARCH methods for business students sixth edition, research methods for business students", available at: www.pearsoned.co.uk (accessed 26 September 2021).

Sepasgozar, S.M.E., Karimi, R., Shirowzhan, S., Mojtahedi, M., Ebrahimzadeh, S. and McCarthy, D. (2019), "Delay causes and emerging digital tools: a novel model of delay analysis, including integrated project delivery and PMBOK", *Buildings*. doi: 10.3390/buildings9090191.

Shah, R.K. (2016), "An exploration of causes for delay and cost overruns in construction projects: case study of Australia, Malaysia and Ghana", *Journal of Advanced College of Engineering and Management*, Vol. 2, p. 41, doi: 10.3126/jacem.v2i0.16097.

Shin, M.H., Lee, H.K. and Kim, H.Y. (2018), "Benefit-cost analysis of building information modeling (BIM) in a railway site", *Sustainability (Switzerland)*, Vol. 10 No. 11, pp. 1-10, doi: 10.3390/su10114303.

Sigalov, K. and König, M. (2018), "4d bim model adaptation based on construction progress monitoring", *eWork and eBusiness in Architecture, Engineering and Construction - Proceedings of the 12th European Conference on Product and Process Modelling, ECPPM 2018*, CRC Press/Balkema, pp. 337-344, doi: 10.1201/9780429506215-42.

Silverio, A.K. and Suresh, S. (2021), "Status of BIM implementation in the Dominican Republic construction industry – an empirical study", *Journal of Engineering, Design and Technology*, [Preprint]. doi: 10.1108/JEDT-05-2021-0253/FULL/PDF.

Srao, B.K., Rai, H.S. and Mann, K.S. (2018), "Why India should make it compulsory to go for BIM", *Analyzing the Role of Risk Mitigation and Monitoring in Software Development*, pp. 266-277, doi: 10.4018/978-1-5225-6029-6.ch017.

Stegnar, G. and Cerovšek, T. (2019), "Information needs for progressive BIM methodology supporting the holistic energy renovation of office buildings", *Energy*, Vol. 173, pp. 317-331, doi: 10.1016/j.energy.2019.02.087.

Studebaker, P. (2014), "BIM on the Run: building information systems are revolutionizing how industry manages equipment data", *Control*, Vol. 27 No. 5, pp. 53-57.

Subramani, T. and Ammai, A. (2018), "Maturing construction management up the BIM model and scheduling using Primavera", *International Journal of Engineering and Technology (UAE)*, Vol. 7 No. 3, pp. 1-4, doi: 10.14419/ijet.v7i3.10.15617.

Suermann, P.C. and Issa, R.R.A. (2009), "Dynamic prototyping: the United States air force building information modeling initiative", *Proceedings of the 2009 ASCE International Workshop on Computing in Civil Engineering*, pp. 485-494, doi: 10.1061/41052(346)48.

Surendhra Babu, P.R. and Hayath Babu, N. (2018), "Using technology to achieve lean objectives", *IGLC 2018 - Proceedings of the 26th Annual Conference of the International Group for Lean Construction: Evolving Lean Construction Towards Mature Production Management Across Cultures and Frontiers*, The International Group for Lean Construction, pp. 1069-1078, doi: 10.24928/2018/0543.

Tafesse, S. (2021), "A review on the critical factors causing delay of delivery time in construction projects", *International Journal of Engineering Technologies IJET*, Vol. 6 No. 4, pp. 69-81, doi: 10.19072/ijet.815025.

Tahir, M.M., Haron, N.A., Alias, A.H., Harun, A.N., Muhammad, I.B. and Baba, D.L. (2018), "Improving cost and time control in construction using building information model (BIM): a review", *Pertanika Journal of Science and Technology*, Vol. 26 No. 1, pp. 21-36.

Tahir Muhammad, M., Azam Haron, N., Hizami, A., Alias, A. Taha Al-Jumaa, A., Bala Muhammad, I. (2019), "The impact of BIM application on construction delays and cost overrun in developing countries", *IOP Conference Series: Earth and Environmental Science*, Institute of Physics Publishing, doi:10.1088/1755-1315/357/1/012027.

Tai, S., Zhang, Y. and Li, T. (2021), "Factors affecting BIM application in China: a social network model", *Journal of Engineering, Design and Technology*, Vol. 19 No. 2, pp. 373-384, doi: 10.1108/JEDT-12-2019-0330/FULL/PDF.

Teng, J.Y., Wu, X.G., Zhou, G.Q., Zhao, W.J., Cao, J. (2013), "Study on integrated project delivery construction project collaborative application based on building information model", *Advanced Materials Research*, pp. 370-374, doi: 10.4028/www.scientific.net/AMR.621.370.

Tidhar, N., Li, Y., Kristombu Baduge, K.S., Mendis, P., Thilakarathna, P.S.M. and Chandrathilaka, E.R.K. (2021), "A Slack approach to optimised modularisation of prefabricated structures using a multi-variable modularisation index", *Structures*, Vol. 33, pp. 1235-1251, doi: 10.1016/J.ISTRUC.2021.04.064.

Tserng, H.P., Ho, S.P. and Jan, S.H. (2014), "Developing BIM-assisted as-built schedule management system for general contractors", *Journal of Civil Engineering and Management*, pp. 47-58, doi: 10.3846/13923730.2013.851112.

Vacanas, Y., Themistocleous, K., Agapiou, A. and Hadjimitsis, D. (2015), "Building Information Modelling (BIM) and Unmanned Aerial Vehicle (UAV) technologies in infrastructure construction project management and delay and disruption analysis", *Third International Conference on Remote Sensing and Geoinformation of the Environment* (RSCy2015), Vol. 9535, September, p. 95350C, doi:10.1117/12.2192723.

Vahdatikhaki, F. and Mawlana, M. (2017), "A framework for augmenting 4D visualization of construction projects with scheduling uncertainties", *6th CSCE-CRC International Construction Specialty Conference 2017 - Held as Part of the Canadian Society for Civil Engineering Annual Conference and General Meeting*, 2017, Vol. 1, pp. 70-78.

Vilventhan, A., Razin, S. and Rajadurai, R. (2020), "4D BIM models for smart utility relocation management in urban infrastructure projects", *Facilities*, Vol. 39 Nos 1-2, pp. 50-63, doi: 10.1108/F-08-2019-0091.

Wang, J., Shou, W., Wang, X. and Chi, H.L. (2015), "An integrated approach for progress tracking in liquefied natural gas construction", *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, Vol. 9320, pp. 259-267, doi: 10.1007/978-3-319-24132-6_33.

Wang, Z., Zhang, N. and Wang, S. (2022), "Geometry control of special-shaped arch pylon considering seasonal temperature changes during construction", *Structures*, Vol. 36, pp. 416-427, doi: 10.1016/J.ISTRUC.2021.12.022.

Won, J., Lee, G., Dossick, C. and Messner, J. (2013), "Where to focus for successful adoption of building information modeling within organization", *Journal of Construction Engineering and Management*, Vol. 139 No. 11, 04013014, doi: 10.1061/(ASCE)CO.1943-7862.0000731.

Wong, J.K.W., Zhou, J.X. and Chan, A.P.C. (2018), "Exploring the linkages between the adoption of bim and design error reduction", *International Journal of Sustainable Development and Planning*, Vol. 13 No. 1, pp. 108-120, doi: 10.2495/SDP-V13-N1-108-120.

Yan, L., Lavin, V.A., Moser, L.R., Cui, Q., Kanies, C. and Yang, E. (2008), "PP2A regulates the pro-apoptotic activity of FOXO1", *Journal of Biological Chemistry*, Vol. 283 No. 12, pp. 7411-7420, doi: 10.1074/jbc.M708083200.

Yaseen, Z.M., Ali, Z.H., Salih, S.Q. and Al-Ansari, N. (2020), "Prediction of risk delay in construction projects using a hybrid artificial intelligence model", *Sustainability*, Vol. 12 No. 4, p. 1514, doi: 10.3390/SU12041514.

Young, N.W, Eastman, C., Teicholz, P., Sacks, R. and Liston, K. (2008), "BIM handbook A guide to building information modeling for owners, managers, designers, Engineers, and contractors BIM handbook: a guide to building informationn n modeling for owners, managers", available at: www.wiley.com/go/permissions (accessed 27 April 2020).

Zhang, L. and Liu, H. (2021), "Research on application strategy of BIM technology in construction project management", *E3S Web of Conferences*, EDP Sciences. doi: 10.1051/e3sconf/202123605002.

Further reading

Egwim, C.N., Egunjobi, O.O., Gomes, A. and Alaka, H. (2021), "A comparative study on machine learning algorithms for assessing energy efficiency of buildings", *Communications in Computer and Information Science*, Springer, Cham, pp. 546-566, doi: 10.1007/978-3-030-93733-1_41.

Supplementary material

The supplementary material for this article can be found online.

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