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Building Information Modelling Mandates and Government Efforts: A Systematic Review

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Abstract

While much advocacy has been given to adopting BIM in the built industry, the mandate or effort adopted by the government holds different implications towards disposition to adoption. This is imperative as resistance to change on BIM adoption is hinged by implementation strategies adopted by the government between national contexts. A review of government efforts is important to bring the strength of diverse mandating strategies for future national efforts from governments yet to adopt BIM. Research studies have sought to produce a holistic review of the increasing BIM publications to establish the development trend. The studies have used different Scientometric reviews, bibliometric reviews, or systematic literature reviews (SLR) to show the trends. Although BIM adoption differs acrossfirms and countries, these studies regularly take a global view of development. Few studies use a two-phase literaturereview to look at BIM mandates worldwide. This paper aims to present a two-phase bibliometric analysis and systematic literature review of BIM mandates and government efforts in the construction industry to investigate the current state of BIM across regions. The study used publications made between 2011 and 2022 using the Web of Science. Vosviewer was used to analyse the bibliometric data while AtlasTi was used to analyse and code the SLR data. The review findings revealed that the African continent lags in publications and governments' efforts to make BIM mandatory. The results of this study should be used to establish a BIM mandate roadmap for developing countriesand their governments in the future.

Keywords

Building Information Modelling, Bibliometric Review Government, Mandate, Systematic Literature Review

1. Introduction

Governments have increasingly recognized the potential of BIM in recent years and have implemented related legislation in the worldwide construction industry (Chang *et al* 2017; Liao *et al* 2020). Moreover, governmental efforts are a vehicle for construction stakeholders to take BIM adoption efforts seriously through policies. Furthermore, while the government remains the largest client for projects, it is expected that they will lead the way for other investors to follow (Olanrewaju *et al* 2020). BIM (Building Information Modelling) is a set of technologies and solutions that allows for the three-dimensional (3D) representation of geometric and non-geometric (functional) aspects of building elements (Demian and Walters, 2013; Murphy *et al* 2013; Lee *et al* 2020). According to Bryde et al. (2013), not only does BIM include software that enables geometrical modelling and data entry, but it also incorporates project management tools and processes. It is a centralized platform for integrated design, modelling, asset planning, and collaboration. It offers all stakeholders a digital depiction of a building's attributes over its entire life cycle, promising significant efficiency gains (Miettinen and Paavola, 2014). Its goal is to promote collaboration among many stakeholders in the architectural, engineering, and construction (AEC) industry and productivity and management throughout the life cycle (Jiang *et al* 2021). With the global construction industry's growing needs and the world drive toward BIM adoption and implementation, construction professionals must quickly catch up and begin using BIM in their projects, recognising that BIM adoption benefits all project stakeholders (Mehran, 2016). This is through the implementation of government policies and strategies.

While other studies have examined BIM mandates (Pereira *et al*2021; Hussein *et al*2021; Khan *et al*2021; Mansuri *et al*2021); this study adopts a mixed review through bibliometric and systematic literature review on BIM mandates worldwide to further extend the body of knowledge. A mixed literature review is a traditional method for identifying current trends and research gaps in a body of knowledge. They do not critically analyze the studies making trends on the BIM mandate and the government's efforts. BIM mandates are important as it is an initiative by government to drive industry uptake and implementation of BIM across all levels of the AEC industry (Oti-Sarpong *et al*2020).

This study provides a literature overview of BIM mandates and government efforts worldwide through a literature review. The first phase is a qualitative Scientometric literature review to identify emergent trends of the BIM mandates in this field. The second phase is a quantitative systematic literature review (SLR), which provides a reliable and resilient strategy for selecting the most appropriate contribution across a large field of research. Two phases were employed in the literature review to increase the validity and reliability of the data sources (Alwan *et al* 2017). The rest of this paper is structured as follows. Section 2 elaborates on the research methodology used in this study. Section 3 provides an in-depth analysis of the literature review findings of BIM mandate efforts of the various governments. Finally, section 4 concludes the findings and presents further studies concerning governance issues of BIM mandates.

2. Methodology

Figure 1 depicts the research approach used in this study. Bibliometric analysis and SLR were used in combination. The first phase was conducting a bibliometric analysis. Bibliometric analysis is one technique for visualising bibliometric networks to synthesise science mapping, which identifies unique disciplines, scientific domains, and research frameworks using large bibliographical datasets and large bodies of literature (Chen and Song, 2019). The Web of Science Core Collection database is recognised as the most valuable and high-impact data collection and the most dependable database for bibliometric studies (Rojas-Sola and Aguilera-García, 2020). Vosviewer, a text-mining tool, explored a wide range of bibliometric networks for bibliometric analysis (Morelli and Ignacio, 2021). The tool includes citation relationships between publications, co-authorship networks between scholars, and keyword co-occurrence relationships (Safura Zabidin *et al* 2020; Turatto *et al* 2021).

The second phase was conducting the SLR from the final 16 documents used in the bibliometric analysis manual selection and elimination. SLR was used to undertake critical analysis and objective appraisal of the literature by methodically searching, sorting, and finding articles (Palka *et al* 2018). This included determining and choosing the right search keywords and discovering and extracting relevant research studies based on the inclusion and extraction criteria (Rashmi and Kataria, 2021). Any article not written in English was excluded. This is because English is one of the most spoken languages worldwide and is used for communication in the business, policy and academic world (Nunan, 2003; Jenkins, 2013). The classification and coding approach of the SLR of the articles was conducted using Atlas.ti These reviews are especially useful for doing in-depth analyses of cutting-edge research and integrating the findings into a specific topic (Abu *et al* 2021).

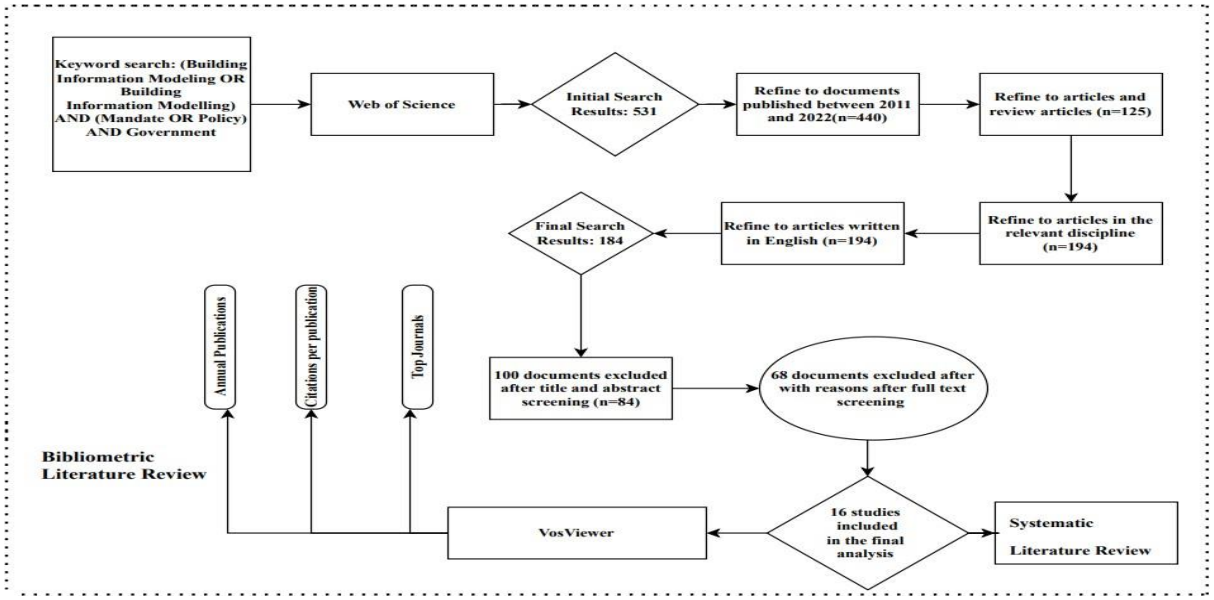

Fig. 16. Research Methodology.

3. Results

The bibliometrics analysis is results are shown in the section below. The current state and evolution of knowledge surrounding the issues of BIM, government, and mandates were examined using several bibliometric features of all the publications acquired.

3.1 Bibliometric Analysis

3.1.1 Annual Publication and Citations

Figure 2 below depicts the annual evolution of publications and citations. Between 2011 and 2021, the number and kind of publications were evaluated. This topic's relevant publications were published in 2017. There is an upward trend in studies related to BIM mandates and policies. In 2021, the highest number of publications was found, with six totalling 149 citations. Therefore, the subjects under analysis in the current paper are of current and high interest in the scientific community. This could indicate that a large amount of the data acquired is trustworthy, enhancing the quality of the analysis performed in this research. Similarly, between 2015 and 2021, there was a noticeable increase in citations.

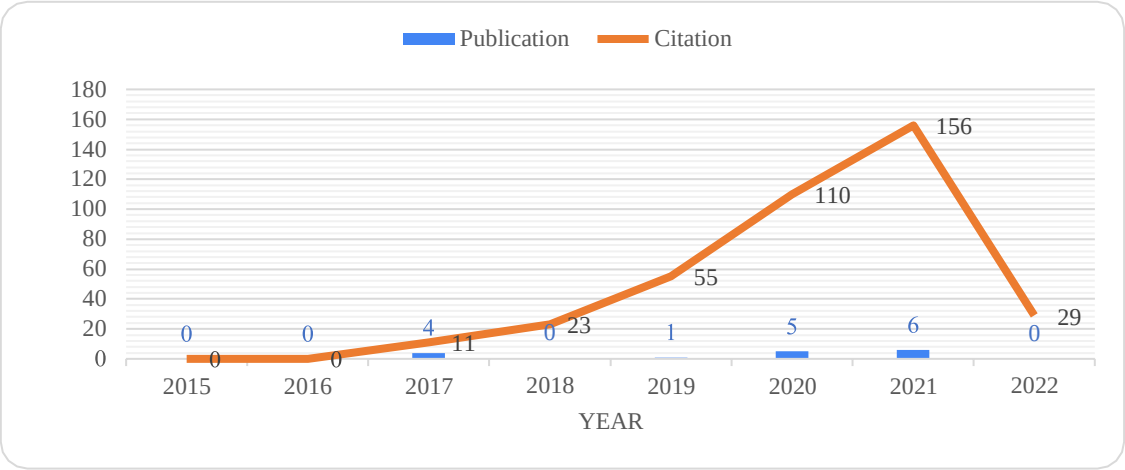

Fig. 2. A number of publications and citations.

3.1.2 Citations per publication

A researcher's influence in an area is measured by the number of citations they receive. Table 2 lists the top 10 publications from the identified 16 in government efforts in BIM mandates and policies with the most citations, according to data extracted from the Web of Science database. Li et al's publication had the most citations (106) and the most average citations (26.5). The publication looks at the BIM and Blockchain intergration in the built environment and the construction industry.

Table 2. Top ten contributing publications in the relevant field

Authors	Total Citations	Average citations per year
Li *et al*	106	26.5
Alwan *et al*	94	18.8
Dainty *et al*	75	12.5
Chang *et al*	31	6.2
Juan et al	26	5.2
Babatunde *et al*	15	7.5
Qin *et al*	11	3.67
Doan et al	12	4
Liao *et al*	6	2
Bouguerra *et al*	2	1

3.1.3 Citations per Journal

Journals are publicly accessible and provide a platform for publishing research. Peer-reviewed journal papers are likely to continue as an important means of disseminating research findings. Table 3 shows the journals with the most prestigious publications. The most cited journal is the Journal of Cleaner Production and Automation in Construction (94 citations), followed by Building Research and Information (68 citations), and the Journal of Civil Engineering and Management (68 citations) (35). The journals with the most documents (2) are the Journal of Civil Engineering and Management, Journal of Construction Engineering and Management, and Sustainability, while the others only have one publication.

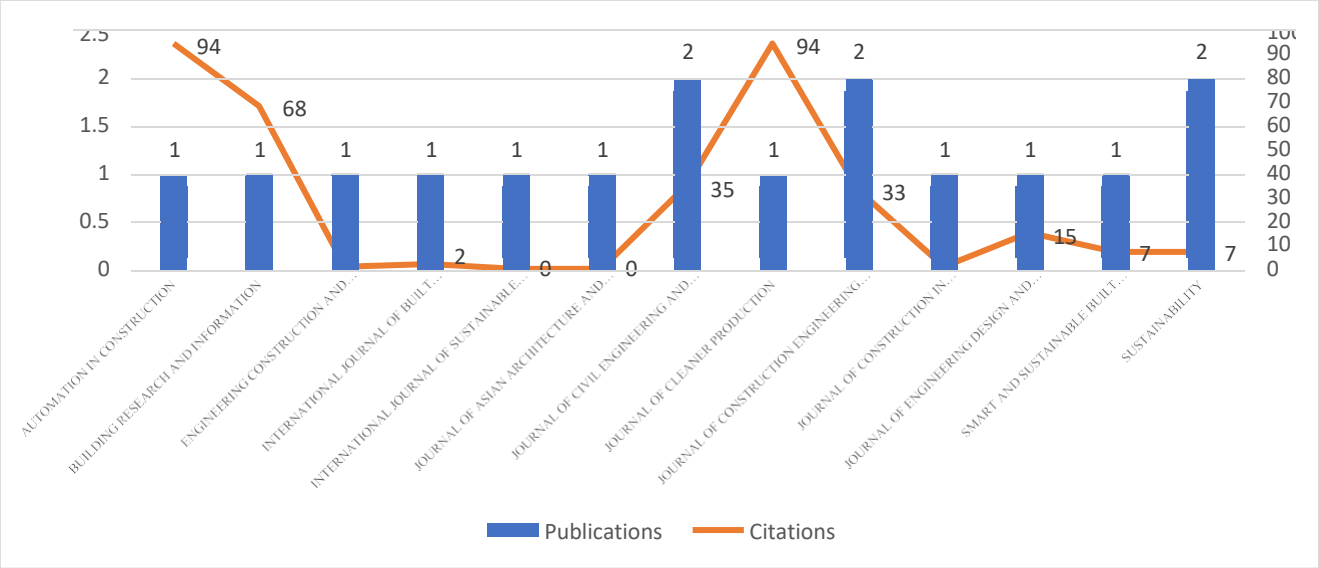

Table 3. Contributing journals having maximum publications

4. Discussion and Conclusion

This study presented a two-phase bibliometric review and systematic literature review of BIM mandates using BIM publications from the Web of Science. The bibliometric overview identifies the publication trend, country, author, and journal source. The SLR identified the mandates around the world. Table 4 is a literature review summary of the various governments' BIM mandates and policies. Table 4 shows a summary of BIM mandates and policies.

Table 4. BIM Mandates and policies

Country	Government Effort	Source
Australia	The government has mandated BIM for all government-funded projects, resulting in a major increase in BIM usage in Australia. Currently, as of 2021, BIM is being widely used on projects in Australia and by Australian consultants working on overseas projects	Babatunde *et al*2020; Bouguerra *et al*2020; Karampour *et al*2021; Jiang *et al*2021
Brazil	Government to mandate BIM in the year 2021. On April 3, 2020, decree 10.306 / 2020 was finally issued, requiring the mandatory use of BIM in the construction of direct or indirect work by entities or bodies belonging to the federal public administration	Jiang *et al*2021
Canada	To maintain consistency in the BIM implementation process, a national BIM strategy, standards, guidelines, protocols, and technical codes were planned to be developed. According to the NATSPEC report 2021, the Canadian government is now considering whether to mandate or encourage BIM processes in public procurement procedures and is polling industry players	Doan *et al*2020
China	Governments and the private sector in China have promoted BIM heavily. In May 2015, the government published standards for BIM usage and adoption. Every year china holds seminars to train industry players on BIM.	Chang *et al*2017; Qin *et al* 2020; Wang *et al*2021
Colombia	The government is working on BIM-adoption strategies for public construction. The Colombian government is also part of the Latin America BIM network since 2019, which aims to increase productivity under BIM	Murguia *et al*2021
Denmark	The Industry Foundation Classes (FC) certification provided the foundation for BIM implementation. Denmark was a pioneer in defining BIM classification standards, which helped boost BIM adoption across Europe. In 2007, the Danish government launched a digital construction programme requiring BIM in all public building projects.	Karampour *et al*2021; Jiang *et al*2021

Finland	In 2007 the government-mandated BIM adoption to all construction projects. Currently, BIM is at 100% uptake in Finland. In addition, BIM sessions (training) for specific usage are scheduled regularly, based on the profession and activity.	Jiang *et al* 2021
France	Since 2017, the government has mandated BIM in all public-sector projects. Because of the fragmentation of the player types, primarily SME's, the construction sector in France remains quite heterogeneous in terms of digital technology and BIM integration. Thus, in 2019, BIM reached 66% of overall adoption in France. More specifically, 42% of architectural agencies are implementing BIM practices in 2020.	Liao *et al* 2020b ; Jiang *et al* 2021
Germany	Since 2015, a policy has been in place to manage the digital design, construction, operation, and maintenance activities across all project types. BIM was only mandated in all public infrastructure projects in 2019.	Liao *et al* 2020b; Jiang *et al* 2021
Hong Kong	It is required as from 2018 BIM on capital work projects.	Jiang *et al* 2021
Italy	The Italian government financed a project to create a standardised national BIM library that included Italy's construction companies, three universities, and building component manufacturers' groups. This was implemented in 2019.	Karampour *et al* 2021; Jiang *et al* 2021
Japan	The government published BIM guidelines in 2013. This was first done in government projects as a pilot then gradually infiltrated into the industry. However, the private sector is currently the driver for BIM adoption in Japan.	Juan *et al* 2016 ; Bouguerra *et al* 2020 ;Jiang *et a l*2021
Mexico	The government is developing BIM adoption strategies for the construction of public infrastructure.	Murguia *et al* 2021
Netherlands	In 2011, the government mandated that all central government departments implement BIM.	Jiang *et al* 2021
Norway	Following the government's commitment to BIM adoption in 2010, a slew of public-sector initiatives were launched in its support. Statsbygg, a Norwegian key adviser and public administration company, authorised the usage of BIM, and by 2010, all of its projects were using BIM models based on IFC and IFD.	Karampour *et al* 2021; Jiang *et al* 2021
Peru	The government created a national BIM Steering Committee for BIM usage in public projects	Murguia *et al* 2021
Singapore	The government put in place mandatory BIM submission. The mandate came into place in 2015. The government is using a top-down approach to enforce organisations to use BIM	Juan *et al* 2016; Bouguerra *et al* 2020; Liao *et al* 2020a ; Qin *et al* 2020; Liao *et al* 2020b ; Jiang *et al* 2021
South Korea	The government has included BIM adoption in all public sector projects since 2016	Liao *et al* 2020b; Jiang *et a l*2021
Spain	The government has included BIM adoption in all public sector projects since 2018	Liao et al, 2020b; Jiang *et al* 2021
Sweden	In 2015 the government-mandated BIM was used in all investment projects	Jiang *et al* 2021
Taiwan	The Taiwan government is planning to enact a BIM-based submission model for building permits specifically for architectural firms	Juan *et al* 2016
United Kingdom	In 2011, the government issued a mandate. BIM was made mandatory on all public-financed projects under the Government Construction Strategy, resulting in a major increase in BIM usage in those countries. The UK government developed the UK BIM Task Group to support clients and the supply chain through active collaboration between government departments, business, academia, and real estate clients, which is why the UK government encouraged client usage of BIM. This was a top-down approach that resulted in widespread adoption. Since 2016, all government-funded public projects must use at least Level 2 collaborative BIM on a four-level scale.	Alwan *et al* 2017; Chang *et al* 2017; Dainty *et al* 2017; Babatunde *et al* 2020; Liao *et al* 2020b; Qin *et al* 2020; Karampour *et al* 2021; Jiang *et al* 2021; Li *et al* 2019
United States	the government mandated in 2007 a BIM-adoption policy for public construction through the National BIM policy, which has led to a significant increase in BIM adoption in those countries. The implementation of policies was largely driven by other players in the industry, which is a bottom-up approach.	Bouguerra *et al* 2020; Babatunde *et al* 2020; Juan *et al* 2016; Liao *et al* 2020b; Karampour *et al* 2021; Jiang *et al* 2021
Vietnam	Government BIM roadmap in 2014 to improve efficiency in the construction industry	Nguyen and Nguyen, 2021

From the Systematic Literature Review, Denmark and Finland were the first countries to implement BIM mandates in 2007. Furthermore, the only African country cited was Nigeria as a case study in both analyses. This is in terms of research and not BIM mandate. As a result, government encouragement might stimulate BIM innovation in the African AEC industry, as seen in industrialised countries. The African AEC sector and government must accept and adopt technologies such as BIM to address infrastructural gaps and prepare for the continent's population growth. The AEC industry will be in greater demand than ever to offer infrastructure facilities.

The analysis was conducted using a dataset collected from the Web of Science search database; as a result, the study may be influenced by the coverage of publications. Furthermore, only records published in English were evaluated; other documents may have been published in other languages. These restrictions may provide fruitful ground for future research. Furthermore, future research should consider using the findings to create a roadmap for BIM mandates in developing countries.

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