

Article

The Influence of Building Information Modelling Adoption in the Viability of Medium, Small and Micro Scale Construction Firms (MSMSCFs)

Olubimbola Oladimeji ^{1,*} , Mohammad K. Najjar ² , Carlos A. P. Soares ³  and Assed N. Haddad ^{4,*} 

¹ Department of Building, Osun State University, Osogbo 210001, Nigeria

² Departamento de Construção Civil, Universidade Federal do Rio de Janeiro, Rio de Janeiro 21941-901, Brazil; mnajjar@poli.ufrj.br

³ Pós-Graduação em Engenharia Civil, Universidade Federal Fluminense, Niterói 24020-141, Brazil; capsoares@id.uff.br

⁴ Programa de Engenharia Ambiental, Universidade Federal do Rio de Janeiro, Rio de Janeiro 21941-901, Brazil

* Correspondence: oladimeji70@yahoo.co.uk (O.O.); assed@poli.ufrj.br (A.N.H.)

Abstract: Identifying factors influencing the viability of medium, small, and micro scale construction firms (MSMSCFs) is a crucial precursor in positioning such firms to aid economic and infrastructural development, especially in developing countries. This article assesses viability factors that are influenced by building information modeling (BIM) in MSMSCFs amidst construction firms' viability factors. Out of a total of 177 workers surveyed from 59 MSMSCFs that were awarded construction project contracts in sampled institutions in Nigeria, 65 staff members from 31 MSMSCFs were accessed. The factors were ranked and reduced to significant ones through principal component analysis. Ten significant factors influence the viability of MSMSCFs and six of them are enhanced by BIM implementations. All eight component factors and 18 of the 27 variables with high factor loadings can be influenced by BIM implementation. BIM can potentially curb corruption in construction projects and enhance MSMSCFs' quality of service, clients' satisfaction, construction management and technology, professional performance, procurement practices, and prompt payment of work certificates. All stakeholders need to pay prompt attention to factors that can be influenced by BIM to improve the viability of MSMSCFs, thereby hastening BIM adoption and utilization, especially in developing countries.

Keywords: medium, small and micro scale construction firms (MSMSCFs); building information modelling (BIM); viability



Citation: Oladimeji, O.; Najjar, M.K.; Soares, C.A.P.; Haddad, A.N. The Influence of Building Information Modelling Adoption in the Viability of Medium, Small and Micro Scale Construction Firms (MSMSCFs). *Buildings* **2023**, *13*, 1087. <https://doi.org/10.3390/buildings13041087>

Academic Editor: Ahmed Senouci

Received: 22 March 2023

Revised: 12 April 2023

Accepted: 17 April 2023

Published: 20 April 2023



Copyright: © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

BIM can be used for many different things, including project management, facilities management, design and construction integration, optimization, risk evaluation, cost estimation, scheduling, communication, coordination, and documentation [1–3]. BIM is widely regarded as a valuable tool for minimizing fragmentation in the construction sector, increasing productivity, and cutting the high costs attributed to poor interoperability [3]. BIM is both a process and a technology. BIM's technological component aids project stakeholders in simulating the construction site and what is to be built to find any potential issues with the design, construction, and future operation. All project stakeholders' functions are integrated through the close collaboration made possible by the BIM process component.

BIM helps with virtually all the processes involved in the construction of building structures. All facets of a building's design, construction, use, and maintenance are covered by BIM [2,4–6]. Due to its potential to improve construction firm performance, BIM has been embraced by the construction industry more frequently in recent years. Although it is generally accepted that greater BIM competency will increase business performance and

subsequently viability, no study has likely been able to determine which factors impacting construction firms' viability are enhanced by the various BIM benefits.

Owing to the strategic benefits of BIM, studies have shown that large firms, especially in developed countries, are increasingly utilizing BIM technology and processes to optimize their building production capacity [7]. On the other hand, micro- and small-scale construction firms in all countries are yet to comprehend and utilize these gains in growing their construction business [7]. Identifying BIM benefit factors in factors influencing the viability of medium-, small-, and micro-scale construction firms (MSMSCFs) is a crucial precursor in positioning such firms to aid the economic and infrastructural development of developing countries. Underutilization of BIM technology is particularly poor in developing countries as there are construction professionals who are not aware of BIM and some who are still making use of traditional drawing tools or at best the popular two-dimensional computer-aided design [8]. Most if not all locally owned construction firms are MSMSCFs. Construction firms that are locally owned in Nigeria are those whose whole monetary resources and any other corporate assets in the business are owned and managed by Nigerian residents or organizations [9]. It is also necessary that Nigerians handle most or all of their technological and management activities [9].

Hinging on the major role of the MSMSCFs in sustaining the economic development of developing countries, we consider it imperative to review and evaluate BIM benefits in factors influencing the viability of MSMSCFs. This is based on a past study on local construction firms' viability and the extant literature on the influence of BIM on construction business performance. This was done to evaluate how the usage of BIM may affect the MSMSCF's viability factors. This analysis predicts a spark in MSMSCFs' interest in taking advantage of BIM's potential benefits for the growth of a profitable construction firm. Find below a conceptual framework for the study (Figure 1).

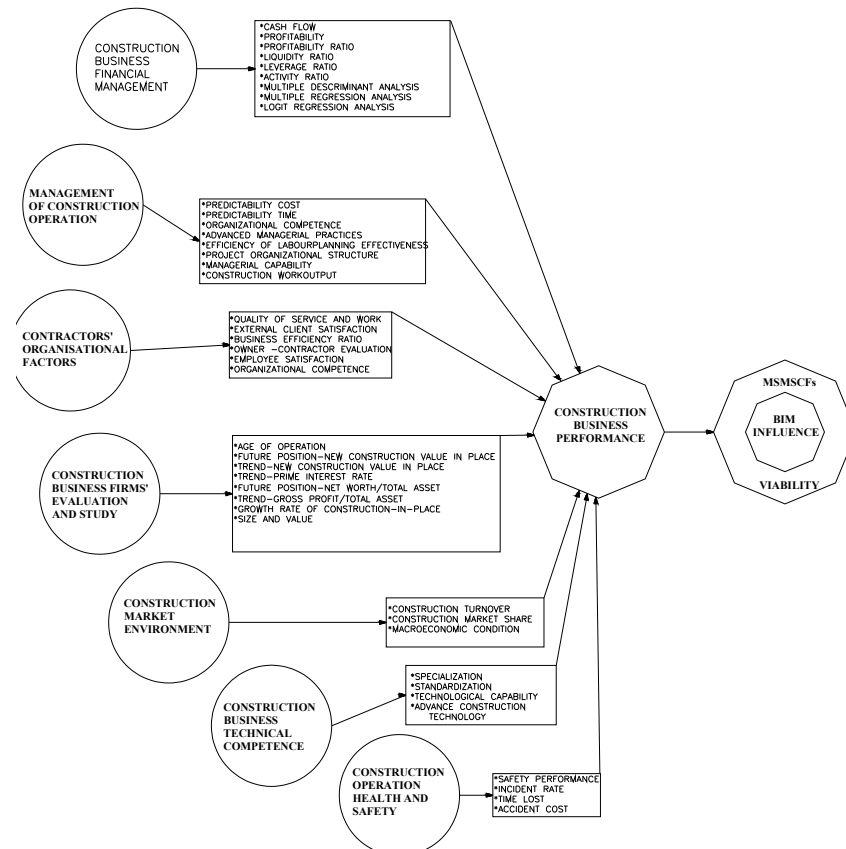


Figure 1. A conceptual model for the study.

2. Factors Influencing the Viability of MSMSCFs in the Literature

Research has shown that viability in the construction contracting industry goes beyond financial profitability, even though financial profitability is a critical performance indicator that determines a company's viability [10,11]. Factors that affect a contractor's viability, aside from financial factors, include quality of service and work [12]; cash flow [13]; and growth and financial stability [10]. Numerous studies on how construction enterprises operate, forecasting failures and losses, macroeconomic policies, important success and failure criteria, and similar topics have emphasized and reached conclusions on numerous factors determining the viability of construction businesses. Numerous studies on how construction enterprises operate, forecasting failures and losses, macroeconomic policies, important success and failure criteria, and similar topics have emphasized and reached conclusions on numerous factors determining the viability of construction businesses [11,14]. Studies on construction businesses' financial management have identified several factors that place a strong emphasis on managing the organization's financial activities in the realization of the business's overall strategy as well as on achieving the strategic plans and objectives of such organizations. Such factors include construction profit margin [15]; building construction loan accessibility [16]; Cash for construction work [10]; credit purchase of construction materials [16]; interest on loans [17]; cost of plant and equipment purchase, maintenance, and hiring [18]; cost of construction labor [19]; prompt payment of work certificates [20,21]; and cost of construction materials [22].

Construction firms' success and failure are best assessed over time, according to studies on construction business evaluation and market environment, by factors such as successful tender rates and construction work turnover [23]; firm size [24]; bad weather and natural disaster [25]; tax [26]; inflation [27]; tendering practices [23]; corruption [28]; government policy [29]; the firm's impact on the community [30], and the age of the operation [31].

Technical capability, depth, structure, and robustness are all hallmarks of technical competence in the construction industry. High-performance contractors are known for having a lot of expertise, which reduces technical risk and allows them to handle the only remaining risk that can reduce their profit. Due to their technical knowledge, they provide high quality at the lowest possible price. The technical viability of a construction firm is influenced by the following factors: specialization of construction work [32]; availability of skilled craftspeople [33]; use of cutting-edge technology in building [34]; technical know-how in construction [35]; and availability of high-performing personnel [36].

The significance of managerial ability and competence within the construction industry has been highlighted in studies on construction operations and company organization. Employee contentment [37]; credibility of good client-contractor relationships [38], management of construction site materials [39]; reliability of construction cost and time [40]; organizational competency customer satisfaction [35]; the quality of service and work [40]; and factors related to labor, plant, and equipment management on construction sites [41,42] were identified.

The number of accidents and fatalities in the construction sector is incredibly high around the world and construction safety has become a major concern [43]. When compared to other industries, the construction sector has a six-fold higher risk of workplace fatalities [43]. The viability of the health and safety of the construction sector is influenced by these performance factors and metrics [44]: accessibility to safety gear; rate of accident; and accident cost.

Recent research suggests that psychosocial- and organizational culture, professional ethics and conduct, and the COVID-19 epidemic are amidst factors influencing the viability of construction enterprises [45–47]. Psychosocial- and organizational culture have a significant impact on the growth and financial performance of construction enterprises [48]. To promote greater construction business performance, Goulding et al. [49] advocated for the integration of psychosocial diffusion indicators into the Turkish construction industry. Previously, Takim et al. [50] assessed psychological environmental factors in the context

of private construction businesses in the event of disasters. All these studies considered various influencers of construction firms' viability.

Recently, the COVID-19 pandemic's effect on all sectors of the local and world economy is being researched, and micro-, small-, and medium-scale enterprises (MSMEs), of which MSMSCFs are a significant part [51], were among the hardest hit [52]. Findings revealed the strategic role of digital activities in various firms' marketing and operations to improve their performance and by implication their viability in the COVID-19 pandemic era [53]. Coincidentally, the drive and call for the adoption of BIM had occurred before the outbreak of the pandemic. BIM Open Source software facilitates access to a common data environment in the construction sector and it is expected to be established at the outset of the construction project, following international standards. This can aid in successful project management by giving quick insights into the performance of construction projects and by removing wasteful activities such as rework and defects [54]. The great benefits of the digitization of construction activities offered by the adoption of BIM can be received at no better time than now given the threats to public health. To this end, it is important to emphasize and elaborate the benefits of BIM and evaluate its place in the viability of MSMSCFs.

3. Materials and Methods

3.1. Sampling Method and Response Rate

For this study, registered local construction firms were chosen. This was to assure data quality and uniformity in the profiles of the construction firms under study. These are local construction firms that have been registered with the Nigerian Corporate Affairs Commission, have been prequalified by the Bureau of Public Procurement in Nigeria, and have had their financial statements audited regularly as required by the Bureau. Before bidding on any construction contract, all firms awarded construction contracts by federal institutions are supposed to have met these conditions. Because they do not meet all of these requirements, construction companies that work only with state governments and private entities are excluded from the study.

Three employees from each of the 59 local construction companies that received contracts for building projects at universities and teaching hospitals of universities in South-West Nigeria owned by the federal government between 2005 and 2015 were among the study's 177 respondents. During this era, the government significantly expanded funding for educational infrastructure, including major construction projects, which influenced the years and institutions chosen [55]. The three states in South-West Nigeria were picked in order of contiguousness since it is one of the most developed sections of Nigeria's six geopolitical zones. Lagos was chosen over Ogun state because of its extensive physical development and significant concentration of construction firms' headquarters. Ondo state was picked to represent one of Nigeria's oldest founded states, and to represent one of Nigeria's most recently created states, Osun state was preferred to Oyo state.

Out of a total of 177 employees from the 59 construction firms sampled, 65 employees from 31 companies responded. Osun, Ondo, and Lagos were represented by 16, 10, and five of the total 31 firms surveyed, respectively. 36.7 percent of employees in 53% of firms responded to the survey. In construction management, several studies considered the number of responses of this kind appropriate [13,30].

3.2. Questionnaire Design

To get the most responses feasible, questionnaires were given out via human contact interviews and, later, drop-and-collect methods at the respondents' convenience. The first half of the questionnaires asked for general information on the respondents, while the second section included an outline of 37 characteristics affecting the viability of local construction firms, which were to be scored on a Likert scale of 5 points, as presented in Appendix A.

On a Likert scale of 1 to 5, respondents were asked to check the appropriate column to indicate how essential they believed each of the listed variables was to the viability of their companies. Responses ranged from 1—“not important” to 5—“extremely significant”. Mean scores were obtained, and each of the 37 variables was evaluated on the scale range.

4. Data Analysis

4.1. Methods of Data Analysis

The data were analyzed using descriptive and inferential statistics, which were supported by a statistical application software (SPSS 15). Cronbach's alpha values were examined, using a cutoff of 0.7. Cronbach's alpha values were expected to range from 0.70 to 0.95 [56]. To ensure that the factors are significantly reliable, this study used a factor loading value of 0.47 or above. Kaiser-Meyer-Olkin (KMO) test values of above 0.6 and Bartlett's sphericity test (β) of $p < 0.05$ were used to verify the validity of principal component analysis (PCA) for the investigation. These tests show that there are sufficient correlations between variables [57]. PCA aids the reduction of a large number of factors by grouping them based on shared traits into a few group factors called component factors. This allows the trend of inter-correlation between the variable factors to be assessed as desired in this study [58,59].

4.2. Local Construction Firms' Characteristics

Local construction firms surveyed employ 65 people, including 24 (36.9%) construction experts, 13 (20%) contract managers, 19 (29.2%) site managers, and nine (13.8%) unclassified employees. More than half of the firms had completed more than eleven building projects, and 70% of them had been in business for at least ten years. More than 80% of firms are based in Nigeria, with over 70% having annual revenues of less than 150 million Naira (\$391,100). More than 85 percent of them employed fewer than 50 people permanently. These firms' features are typical of medium-, micro-, or small-scale business enterprises, especially firms' yearly turnover, and permanent workforce strength characteristics [45].

4.3. Ranking of Factors Influenced by BIM Amidst Factors Influencing the Viability of MSMSCFs

The mean score for each variable component was calculated by summing up the scores the respondents' assigned to each variable and dividing it by the total number of respondents. This operation resulted in the obtaining of the mean scores and ranking of the 37 factors. All Cronbach's alpha values are greater than 0.7, indicating acceptable internal consistency. The obtained KMO of 0.551 and $p < 0.0001$ is statistically acceptable when compared to the recommended KMO and β of above 0.05 and $p < 0.05$ [58,59].

All factors have MS greater than 2.90, with the average mean being 3.72. This implied that all 37 factors are “important factors” (≥ 2.61 and ≤ 3.40). As noted in the literature review, these 37 factors were adjudged as factors known to influence the viability of MSMSCFs. Going further to identify an MSMSCF's viability factors that can be influenced by BIM based on extant literature, 24 factors of the 37 factors were obtained. The first twelve are (1) organizational competence/client satisfaction; (2) quality of work and services; (3) quality of construction work and services; (4) prompt payment of work certificate; (5) prompt payment of work certificate; (6) employee satisfaction; (7) reputation and good client/contractor relationships; (8) management of construction site material; (9) management of construction site labor, plant, and equipment; (10) government policy; (11) construction technical enterprise; and (12) procurement practices. The remaining twelve are (1) the cost of construction labor; (2) several high-performance professionals; (3) project organization structure; (4) predictability of construction cost and time; (5) construction profit margin; (6) advanced construction technology; (7) tax implementation; (8) bad weather and natural disaster; (9) corruption; (10) incident rate; (11) accident cost; and (12) firm size. This means that 64.86% of factors influencing the viability of MSMSCFs can be enhanced by the adoption of BIM by MSMSCFs. This inference corroborates the

findings of various studies that stressed the importance of BIM in all facets of building construction processes and delivery [2,3,60].

Ten significant factors influenced the viability of MSMSCFs and six of them were enhanced by BIM adoption and implementations in building construction processes by construction firms. These factors are: organizational competence/client satisfaction [60]; quality of work, construction work, and services [60]; prompt payment of work certificates [2]; employee satisfaction [61]; and a reputation of good client-contractor relationships [62]. Construction clients are in the position to benefit most from the use of BIM leading to improved construction customer relationship germane to MSMSCFs' viability [11]. This is due to the substantial potential impact that BIM can have on construction project performance [63].

4.4. Principal Factor Analysis of Factors Influenced by BIM

With the aid of principal component analysis, a set of reduced components was created by grouping the 37 variables into categories based on their shared traits. This process allowed for the trend of inter-correlations between the variables to be assessed. The PCA produces outcomes including the factor of extraction, correlations, Eigenvalues, and interpretations. After 11 iterations of the PCA and the exclusion of 10 variables, based on Eigenvalues greater than the statistically required cut-off, eight component factors explained 70.41% cumulative variance. Based on the following considerations, each of the 11 variables was deleted one at a time: Three variables should be eliminated: (1) those with loadings below 0.4 [64]; (2) those with cross-loadings below the established threshold of 0.47; and (3) one variable component since such factors are considered unfit. Using the 0.47 cut-off value about the sequential information given above, a strong valid interpretable factor structure emerges. In determining the optimal sequence, Henson and Roberts [65] suggested that thoughtful scholars use their judgment.

The usage of the highest one or two loading item names for each factor is a common component name approach for properly labeled components that accurately describe the underlying variables [66]. This strategy was used to name the various underlying variable factors into eight components, as shown in Table 1. The components were named (1) "Quality of services and client satisfaction"; (2) "Seasoned professionals and advanced construction"; (3) "Resources management and firm structure"; (4) "Credit and loan"; (5) "Construction hazard and cost"; (6) "Procurement practices and government policy"; (7) "Tax and inflation"; and (8) "Construction cash and payment". The first, second, and third components had five, four, and five variable factors while the fourth to the eighth factors had three, three, two, three, and two variable factors consecutively. It can be observed in Table 1 that components six and eight have two variable factors each; meanwhile, two variable factors are deemed unacceptable by several authors but an exemption was given for factor variables that are closely related in practice [64]. Consequently, the two variables in components six and eight have two variables each that are acceptable since they relate logically to reality (see Table 1).

Eight component factors shown in Table 1 have been based on the body of existing knowledge, 18 of the 27 variables with factor loadings of at least 0.5 were considered to be BIM influenced. The top three of the five variables loaded on the first component are factors that can be impacted by BIM adoptions. This demonstrated the importance of BIM in the viability of MSMSCFs even more. A comprehensive achievement of the study set objective requires that only factors in Table 1 influenced by BIM adoption based on extant literature need to be discussed below. These factors are shown in bold and italicized text in Table 1.

Table 1. The eight named component factors showing variables that can be influenced by BIM adoption in MSMSCFs.

No.	Component	Factors	Loadings	% of Variance Explained
1.	Quality of service and client satisfaction	<i>Organizational competence/client satisfaction</i> <i>Quality of service and works</i> <i>Employee satisfaction</i> Availability of skilled labor Availability of artisan and craftsmen	0.791 0.870 0.701 0.611 0.592	25.10
2.	Seasoned professionals and advanced construction	Firm's impact on the community Specialization of construction work <i>Advanced construction technology</i> <i>Number of high performance professionals</i>	0.478 0.778 0.838 0.815	10.11
3.	Resource management and firm structure	<i>Project organization structure</i> <i>Management of construction site Material</i> <i>Management of construction site labor, plant, and equipment</i> <i>Firm Size</i> Availability of safety equipment	0.773 0.641 0.801 0.585 0.588	9.90
4.	Credit and loan	Accessibility to loan Credit purchase of material <i>Corruption</i>	0.716 0.781 0.634	5.85
5.	Construction hazard rate and cost	<i>Bad weather and Natural disaster</i> <i>Incident rate</i> <i>Accident cost</i>	0.596 0.742 0.809	5.59
6.	Procurement practices and government policy	<i>Procurement practices (The way contract is awarded)</i> <i>Government policy</i>	0.789 0.782	5.03
7.	Tax and inflation	Inflation Tax <i>Construction work turnover/successful tender rate</i>	0.556 0.828 0.499	4.57
8.	Construction cash and payment	Cash for construction work <i>Prompt payment of work certificate</i>	0.874 0.509	4.26

Note: factors in embolden and italicized text are factors that can be influenced by BIM adoption in MSMSCFs.

Component 1—Quality of service and client satisfaction

BIM achieves its goal in most design and construction phases, culminating in better-quality construction products. The quality management process is necessary for engineering and construction projects to be successful. It takes a lot of time and is inefficient for many quality management techniques used in construction projects to be paper-based. The next iteration of BIM is called the BIM-cloud. The BIM-cloud can assist construction firms to improve the efficiency of their quality management process while also saving time and money. This software is used to collect, monitor, and control the quality of management data [67]. Another quality management application provides immediate feedback on inspection results so that appropriate action can be taken. The application makes sure that every step of the process is recorded, establishing a system for managing knowledge that can access and evaluate quality-related metrics, giving insight into present processes, revealing inefficiencies, and setting the stage for quality management plan upgrades [68]. These benefits have a substantial impact on the construction business' service and job quality, and they tend to increase construction firms' competency and client satisfaction. Great challenges and concerns in detecting a defect in concrete, iron, and other structural elements in high construction volume vertical building projects and horizontal construction

projects are readily being solved by the utilization of BIM for quality management [7,69]. Construction clients are maximally benefiting from the use of BIM and are hence satisfied and motivated to derive more benefits from its use. Dakhil et al. [62] listed numerous benefits most clients derive from BIM adoption. These include improved information control, project planning, communications, decision-making process, and project quality. Such client satisfaction is a significant indicator for assessing construction firms' competence in the delivery of quality construction products.

Component 2—Seasoned professionals and advanced construction

Advances in construction technology through BIM adoption has triggered various interoperable platforms and processes to facilitate the phases of design and construction along with efficient model and code checking, as well as four dimensional BIM analysis of the construction phase. Semi-automatic validation techniques needed the addition of alphanumeric attributes to architectural, structural, mechanical, electrical, and plumbing models. Auto-matching and integration between BIM objects and construction activities are being achieved in conjunction with other smart technological applications. A few examples of such are BIM and the delivery of modular integrated construction projects [70]; BIM and robotic construction through concrete and construction component three dimensional printing [71,72]; BIM and Internet of Things smart steel bridge construction and on-site assembly services of prefabricated construction [73]; BIM and the creation of a module system that determines the true volume of the earth and produces a triangular irregular network surface for the machine to follow [74]. These and many other BIM-driven advances in construction management and technology have birthed increasingly high-performing construction professionals. A good example is open-source application software. Open-source applications can effectively manage and modify different BIM models, they are a potent tool that could make construction professionals more effective and open the construction sector to a more advanced digitization process. A ready example is the TUM Open Infra Platform which supports visualizing, navigation, reading, analyzing, and handling of industry foundation classes (IFC), models and point cloud data [75]. Open-source applications can effectively manage and modify different BIM models and area potent tool that could make construction professionals more effective and open the construction sector to a more advanced digitization process.

Professionals have begun implementing BIM software solutions and modifying their current delivery methods to meet the dynamics of the construction industry. Universities are attempting to include BIM in their courses to meet market demand for these professionals, particularly in the domains of architecture, construction management, and civil engineering. Open-source terrestrial laser scanners were proposed for use in construction base university courses for the visualization of common but accurate geometrical shapes in lecture theatres [76]. Succar et al. [77] identified BIM competency items and generated assessment tools, learning modules, and processes workflows for professional performance improvement. Construction professionals who are slow or unwilling to improve the services that they traditionally offered will soon be forced to adapt or die [78].

Component 3—Resource management and firm structure

A real hurdle for construction companies is to increase the logistical efficiency of transporting materials and machinery from the manufacturing site to the place of use. The use of integrated construction supply chain logistics using four dimensional BIM is proven to effectively manage construction material, site labor, plant, and equipment by drastically reducing or eliminating workforce, materials, and equipment clashes [79]. Three dimensions of visualizing through BIM tools can be used to effectively develop a site layout model (SLM). A well-developed SLM has been regarded as having a beneficial impact on workers and the workplace [80], as well as having a direct impact on project productivity and success [81]. A specialized type of construction project such as the engineer-to-order prefabricated modular system that requires a special product to satisfy the requirements for peculiar needs requires the management of aggregated principles of lean building production and BIM concepts [82]. Material on such specialized projects

and on other types of construction project require prompt material delivery. BIM and scheduling software have been developed to select reliable material vendors and generate quantities of material and its required delivery time. This is expected to improve the flow process and reduce related delays and productivity losses on construction sites due to idle and non-productive equipment and labor.

The benefits of BIM with regard to firm size is noteworthy; the association between construction firm size and BIM benefits was found to be significant for data standardization and stakeholder management [83]. Sadeh et al. [84], while writing on BIM implementation for micro-, small-, and medium enterprises (MSMEs) inferred that supply-chain responsiveness and bureaucracy reduction were the most important benefits of BIM to MSMEs. Meanwhile, most, if not all, MSMSCFs are MSMEs [14,45]. It is important to sustainably adopt BIM in MSMEs by identifying various drivers that can be adapted by MSMEs' managers and policymakers [85].

Component 4—Credit and loan

Corruption is a major viability factor that can influence BIM use. As a result of BIM's explicit generation of accurate information and easy access to a variety of information sources, information transparency throughout the facility's lifecycle is greatly encouraged. By prohibiting some unethical but profitable acts from taking place, information openness has many positive effects [83]. The most susceptible processes to unethical behavior during the design, tendering, and construction stages were found to include estimates, tender document preparation, construction material appraisal, quality control, and supplementary work orders. Project audits can be passively automated, and project information can be monitored throughout the project's value chain if BIM's current dimensional capabilities are used. This will thereby enhance transparency and reduce the likelihood of information falsification [85].

Component 5—Construction hazard rate and cost

The Project's use of BIM during the design and completion phases is associated with safety management and accident prevention, and its use from the beginning of the project's lifecycle is associated with lower accident rates and costs [86]. Specifically, a proactive construction management system based on five dimensional BIM can assist in identifying sources of potential hazards to on-site personnel and send out proactive notifications to prevent terrible accidents brought on by falling or being struck by moving objects [87]. There is a push to build construction projects using BIM, as well as to incorporate occupational health and safety into BIM-based projects [88]. To effectively manage bad weather and natural disaster, the application of block chain technology can be incorporated within the BIM process [89]. There is another BIM-based tool for quick rehabilitation of affected areas when there is a disaster and the constructed facilities are entirely demolished [90]. This prompt tool could assist policy-makers, authorities, and construction managers with immediate decisions by providing more accurate economic insight that will aid reconstruction.

Component 6—Procurement practices and government policy

Current government policy strategy is being influenced by BIM as firms are mandated to use BIM for government projects. This is a method of integrating the design, building, and maintenance of financed public structures. Governments from around the world are pushing for BIM to be used widely in the construction sector. This drive is being influenced by governments in developed countries through offsetting firms' setup costs [91]. This government subsidy is expected to hasten and BIM adoption efficiency. Atkinson et al. [92] concluded that governments' engagement has caused a sector that has historically been quite fragmented to respond in a coordinated manner and has provided a significant push for changing the way the construction industry operates and embraces digital technology. In the construction sector, the digitization of procurement is a cutting-edge approach to e-procurement that makes use of BIM to facilitate the procurement process. As a result, a comprehensive, electronic, integrated tool that can perform advanced operations as well as improve supply chain collaboration and transaction linkages has been created [93]. Kuiper

and Holzer [94] explained how the development of contract delivery methods will be fueled by BIM and other enabling technologies.

Component 7—Tax and inflation

BIM can be linked to a variety of relevant code lists for building quality and other features that are prescribed by national regulations and used to calculate tax. The tax computation procedure would be faster and more automated in this way since data from the project documentation would be imported from BIM rather than manually entered [95]. Another major aspect determining the viability of MSMSCFS is the influence of BIM on successful tender rates. The success of a firm's tender will have an impact on its construction work turnover. Majzoub and Eweda [96] observed that using BIM when submitting a bid for a contract could boost a construction firm's chances of winning by up to 9.42% in a quality-based selection and by up to 5.5% in a cost-based selection process.

Component 8—Construction cash and payment

Delayed payment of work certificates has been fingered as one major cause of construction cost and time overrun [97]. The autonomous administration of construction progress payments is made possible by BIM, which fills the gap between the evaluation of the work completed on project sites and the payment for that evaluated activity. Through content addressable file sharing, as-built BIM, and reality capture data, construction progress is distributed, saved, and broadcasted to a smart contract that automates on-chain payment settlements [98]. By eliminating third-party involvement and manual signing, in the traditional payment procedure, BIM and intelligent contract features would increase efficiency and cut down on time [99].

5. Conclusions and Recommendation

The various factors determining the viability of construction firms have been defined and documented in existing construction management literature, but the current digital divide in terms of its relevance to the design, construction, and post-construction activities of MSMSCFs is obvious. This growing concern instills the need to assess the effect of BIM on MSMSCFs. It was observed that about 70% of the factors influencing the viability of MSMSCFs are influenced by BIM and other accompanying digital applications. BIM has been used to effectively manage construction materials, site labor, plant, and equipment by drastically reducing or eliminating workforce, materials, and equipment clashes. BIM can potentially curb corruption in construction projects and enhance MSMSCFs quality of service, clients' satisfaction, construction management and technology, professional performance, procurement practices, and prompt payment of work certificates.

The inability to conduct close contact interviews with the MSMSCFs to get their opinions on how BIM has affected the different identified factors determining their viability is a constraint of this study. The reason for this is the inadequacy of respondents to appropriately assess the benefits of BIM due to scarce access to BIM digital facilities and functional internet access. This is the digital bottleneck in most developing countries' MSMSCFs. In addition, most construction professionals, especially in micro- and small-scale construction firms, have little or no exposure and training in the use of the trendy BIM tools and facilities. This will invariably make them incapable of appropriately laterally responding to questions on the place of BIM in the viability of MSMSCFs. However, this shouldn't reduce the quality of findings in this study as it rather achieved its objective on how BIM can enhance MSMSCFs' viability based on the present reality of its uses in various developed countries. The adoption and adaption of BIM by MSMSCFs is one novel idea that will enhance engagement with clients online and more organized methods for carrying out construction activity. This was prescribed as a necessary firm survival strategy during the COVID-19 era [47]. Government and private enthusiast interventions in formulating digitization policy that will enhance wide internet coverage and digital application packages access that will enhance faster and easier adoption of BIM by MSMSCFs are necessary. This is one major growth and development drive in nations of the world and developing countries especially need to pay attention to this digital divide.

Author Contributions: Conceptualization, O.O. and A.N.H.; methodology, O.O., M.K.N., C.A.P.S. and A.N.H.; software, O.O., M.K.N. and A.N.H.; validation, O.O., C.A.P.S. and A.N.H.; formal analysis, O.O., M.K.N. and A.N.H.; investigation, O.O.; data curation, O.O.; writing—original draft preparation, O.O.; writing—review and editing, O.O., M.K.N., C.A.P.S. and A.N.H.; visualization, O.O. and M.K.N. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: Not applicable.

Acknowledgments: Assed Haddad would like to thank the National Council for Scientific and Technological Development—CNPq—Brazil and FAPERJ (Fundação de Amparo à Pesquisa do Estado do Rio de Janeiro) for supporting his research. The authors also thank the editor and anonymous reviewers for their comments and suggestions.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A Questionnaire for Contractors and Their Construction Professional Representative

(Please Companies' Name Not Required)

Section A

Q1: Designation of person completing the questionnaire?

☐Contract manager ☐Construction professional ☐Site manager/Project manager ☐Others
(please specify)

Q2: Years of experience in construction? *(Please specify and also tick below)*

☐0–5 years ☐6–10 years ☐11–15 years ☐16–20 years ☐21–25 years ☐Over 25 years

Q3: Years of Construction Company's Operations. *(please specify only)*

Q4: In how many projects have you been involved in the past? *(please specify and also tick below)*

☐1–5 projects ☐6–10 projects ☐11–15 projects ☐16–20 projects ☐Over 20 projects

Q5: Number of permanent staff (foreman and above) in 2015? *(please specify and also tick below)*

☐less than 5 ☐5 to 50 ☐Over 50

Q6: Annual Turnover (in Million Naira) in 2014? *(please specify and also tick below)*

☐less than N10 million ☐N10 to N50 million ☐N50 to N150 million ☐Over N150 million

Q7: Registration Grade (A, B, C, D, E or ____ etc.)

☐General building ☐Civil engineering

Q8: Is your company based in Nigeria or Abroad? *(please Tick)* Nigeria Abroad

Q9: Is your Company carrying out construction work in other countries apart from Nigeria? *(please Tick)*

☐Yes ☐No

Q10: If Yes, is it a **major or minor** construction work in comparison to the work done in Nigeria? *(please Tick)*

☐Major ☐Minor

Q11: Who are your major Client? *(please Tick)*

☐Government ☐Others ☐Both

Section B

How important are the following factors to the viability of locally owned construction firms using the rating of 1 to 5 in the table below?

S/N	Factors Influencing the Viability of Indigenous Construction Contractors' Business. (Survival of Contractors' Business)	(1) Not Important	(2) Fairly Important	(3) Important	(4) Very Important	(5) Extremely Important
1.	Cash for construction work					
2.	Construction profit margin					
3.	Accessibility to loan					

4.	Interest on loan
5.	Credit purchase of material
6.	Prompt payment of work certificate
7.	Cost of plant and equipment purchase maintenance and hiring
8.	Cost of construction labour
9.	Cost of construction material
10.	Project organization structure
11.	Management of construction site Material
12.	Predictability of construction cost and time
13.	Management of construction site labour, plant and equipment
14.	Organizational competence/client satisfaction
15.	Quality of service and works
16.	Employee Satisfaction
17.	Reputation of good client-contractor's relationship
18.	Age of operation
19.	Firm Size
20.	Firm's Impact on the community
21.	Inflation
22.	Tax
23.	Corruption
24.	Construction work turnover/successful tender rate
25.	Availability of Skilled labour
26.	Availability of Artisan and craftsmen
27.	Procurement practices (The way contract is awarded)
28.	Government policy
29.	Bad weather and Natural disaster
30.	Construction technical expertise
31.	Quality of construction work and services
32.	Specialization of construction work
33.	Advanced construction technology
34.	Number of high performance professionals
35.	Incident rate
36.	Accident cost
37.	Availability of safety equipment
Please, Itemize and rate other factors you know that are not stated above in the space below	
41.	
42.	
43.	
44.	
45.	

References

1. Woo, J.; Wilsmann, J.; Kang, D. Use of as-built building information modeling. In Proceedings of the Construction 1 Research Congress 2010: Innovation for Reshaping Construction Practice 2010, Banff, AB, Canada, 8–10 May 2010; pp. 538–548.
2. Azhar, S. Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. *Leadersh. Manag. Eng.* **2011**, *11*, 241–252. [\[CrossRef\]](#)
3. Eastman, C.; Teicholz, P.; Sacks, R.; Liston, K. *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors*; John Wiley & Sons: Hoboken, NJ, USA, 2011; Volume 2, pp. 147–150.
4. Meadati, P. BIM extension into later stages of project life cycle. In Proceedings of the Associated Schools of Construction 45th Annual International Conference, Gainesville, FL, USA, 1–4 April 2009; pp. 121–129.
5. Getuli, V.; Ventura, S.M.; Capone, P.; Ciribini, A.L. BIM-based code checking for construction health and safety. *Procedia Eng.* **2017**, *196*, 454–461. [\[CrossRef\]](#)
6. Olugboye, O.; Windapo, A. Framework for managing BIM benefits: A benefits breakdown hierarchy approach. In Proceedings of the 2018 Conference: 10th SACQSP International Research Conference, Johannesburg, South Africa, 30 September–1 October 2018; pp. 68–82.
7. Cheng, Y.M. Building Information Modeling for Quality Management. In Proceedings of the 20th International Conference on Enterprise Information Systems (ICEIS 2018), Funchal, Portugal, 21–24 March 2018; pp. 351–358.
8. Sistani, N.S.; Rezaei, A. BIM implementation in developing countries. In Proceedings of the 10th International Congress on Advances in Civil Engineering, Ankara, Turkey, 17–19 October 2012.
9. Olateju, B. *Enhancing the Contract Management Capabilities of the Indigenous Contractors: Effective Contract Management in the Construction Industry*; Publication of the Nigeria Institute of Building: Lagos, Nigeria, 1991; pp. 132–142.
10. Makori, D.M.; Jagongo, A. Working capital management and firm profitability: Empirical evidence from manufacturing and construction firms listed on Nairobi securities exchange, Kenya. *Int. J. Account. Tax.* **2013**, *1*, 1–4.
11. Hany Abd Elshakour, M.A.; Al-Sulaihi, I.A.; Al-Gahtani, K.S. Indicators for measuring performance of building construction companies in Kingdom of Saudi Arabia. *J. King Saud Univ.-Eng. Sci.* **2013**, *25*, 125–134.
12. Leong, T.K.; Zakuan, N.; Saman, M.Z.M.; Ariff, M.S.M.; Tan, C.S. Using project performance to measure effectiveness of quality management system maintenance and practices in construction industry. *Sci. World J.* **2014**, *2014*, 591361. [\[CrossRef\]](#)
13. Oladimeji, O.; Aina, O.O. Cash flow management techniques practices of local firms in Nigeria. *Int. J. Constr. Manag.* **2021**, *21*, 395–403. [\[CrossRef\]](#)
14. Oladimeji, O.; Aina, O.O. Financial performance of locally owned construction firms in southwestern Nigeria. *J. Financ. Manag. Prop. Constr.* **2018**, *23*, 112–128. [\[CrossRef\]](#)
15. Ho, P.H. Analysis of competitive environments, business strategies, and performance in Hong Kong's construction industry. *J. Manag. Eng.* **2016**, *32*, 04015044. [\[CrossRef\]](#)
16. Peterson, S.J. *Construction Accounting and Financial Management*; Pearson: Upper Saddle River, NJ, USA, 2013.
17. Harymawan, I. Why do firms appoint former military personnel as directors? Evidence of loan interest rate in militarily connected firms in Indonesia. *Asian Rev. Account.* **2018**, *26*, 2–18. [\[CrossRef\]](#)
18. Peurifoy, R.L.; Schexnayder, C.J. *Construction Planning, Equipment, and Methods*; McGraw-Hill Education: New York, NY, USA, 2018.
19. El-Gohary, K.M.; Aziz, R.F. Factors influencing construction labor productivity in Egypt. *J. Manag. Eng.* **2014**, *30*, 1–9. [\[CrossRef\]](#)
20. Badroldin, M.K.; Hamid, A.R.; Raman, S.A.; Zakaria, R.; Mohandes, S.R. Late payment practices in the Malaysian construction industry. *Malays. J. Civ. Eng.* **2016**, *28*, 149–162.
21. Haron, R.C.; Arazmi, A.L. Late payment issues of subcontractors in Malaysian construction industry. *Plan. Malays.* **2020**, *18*. [\[CrossRef\]](#)
22. Wahab, A.B.; Lawal, A.F. An evaluation of waste control measures in construction industry in Nigeria. *Afr. J. Environ. Sci. Technol.* **2011**, *5*, 246–254.
23. El-khalek, H.A.; Aziz, R.F.; Morgan, E.S. Identification of construction subcontractor prequalification evaluation criteria and their impact on project success. *Alex. Eng. J.* **2019**, *58*, 217–223. [\[CrossRef\]](#)
24. Ozcan, I.S.; Unal, E.A.; Yener, U.N. The effect of firm size on profitability: Evidence from Turkish manufacturing sector. *J. Bus. Econ. Financ.* **2017**, *6*, 301–308.
25. Akomah, B.B.; Jackson, E.N. Contractors Perception of Factors Contributing to Road Project Delay. *Int. J. Constr. Eng. Manag.* **2016**, *5*, 79–85.
26. Matarirano, O.; Makina, D.; Chiloane-Tsoka, G.E. Tax compliance costs and small business performance: Evidence from the South African construction industry. *S. Afr. J. Bus. Manag.* **2019**, *50*, 9. [\[CrossRef\]](#)
27. Jaya, I.; Alaloul, W.S.; Musarat, M.A. Role of inflation in construction: A systematic review. In *ICCOEE2020: Proceedings of the 6th International Conference on Civil, Offshore and Environmental Engineering (ICCOEE2020)*; Springer: Singapore, 2021; pp. 701–708.
28. Boudreaux, C.J.; Nikolaev, B.N.; Holcombe, R.G. Corruption and destructive entrepreneurship. *Small Bus. Econ.* **2018**, *51*, 181–202. [\[CrossRef\]](#)
29. Deng, X.; Pheng, L.S. Understanding the critical variables affecting the level of political risks in international construction projects. *KSCE J. Civ. Eng.* **2013**, *17*, 895–907.

30. Bala, K.; Bello, A.; Kolo, B.A.; Bustani, S.A. Factors inhibiting the growth of local construction firms in Nigeria. In Proceedings of the 25th ARCOM Conference, Nottingham, UK, 7–9 September 2009; pp. 351–359.
31. LiPuma, J.A.; Newbert, S.L.; Doh, J.P. The effect of institutional quality on firm export performance in emerging economies: A contingency model of firm age and size. *Small Bus. Econ.* **2013**, *40*, 817–841. [[CrossRef](#)]
32. Sundquist, V.; Gadde, L.E.; Hulthén, K. Reorganizing construction logistics for improved performance. *Constr. Manag. Econ.* **2018**, *36*, 49–65. [[CrossRef](#)]
33. Oke, A.; Aigbavboa, C.; Khangale, T. Effect of skills shortage on sustainable construction. In *Advances in Human Factors, Sustainable Urban Planning and Infrastructure, Proceedings of the AHFE 2017 International Conference on Human Factors, Sustainable Urban Planning and Infrastructure, 17–21 July 2017, The Westin Bonaventure Hotel, Los Angeles, CA, USA*; Springer International Publishing: Cham, Switzerland, 2018; pp. 303–309.
34. Zhong, R.Y.; Peng, Y.; Xue, F.; Fang, J.; Zou, W.; Luo, H.; Ng, S.T.; Lu, W.; Shen, G.Q.; Huang, G.Q. Prefabricated construction enabled by the Internet-of-Things. *Autom. Constr.* **2017**, *76*, 59–70. [[CrossRef](#)]
35. Lawson, M.; Ogden, R.; Goodier, C. *Design in Modular Construction*; CRC Press: Boca Raton, FL, USA, 2014.
36. Ramírez, R.R.; Alarcón, L.F.; Knights, P. Benchmarking system for evaluating management practices in the construction industry. *J. Manag. Eng.* **2004**, *20*, 110–117. [[CrossRef](#)]
37. Nudurupati, S.; Arshad, T.; Turner, T. Performance measurement in the construction industry: An action case investigating manufacturing methodologies. *Computers in Industry. Comput. Ind.* **2007**, *58*, 667–676. [[CrossRef](#)]
38. Chinyio, E.A.; Olomolaiye, P.O.; Kometa, S.T.; Harris, F.C. A needs-based methodology for classifying construction clients and selecting contractors. *Constr. Manag. Econ.* **1998**, *16*, 91–98. [[CrossRef](#)]
39. Gulghane, A.A.; Khandve, P.V. Management for construction materials and control of construction waste in construction industry: A review. *Int. J. Eng. Res. Appl.* **2015**, *5*, 59–64.
40. Aje, O.I.; Odusami, K.T.; Ogunsemi, D.R. The impact of contractors' management capability on cost and time performance of construction projects in Nigeria. *J. Financ. Manag. Prop. Constr.* **2009**, *14*, 171–187. [[CrossRef](#)]
41. Alaghbari, W.; Al-Sakkaf, A.A.; Sultan, B. Factors affecting construction labour productivity in Yemen. *Int. J. Constr. Manag.* **2019**, *19*, 79–91. [[CrossRef](#)]
42. Parchami Jalal, M.; Shoar, S. A hybrid framework to model factors affecting construction labour productivity: Case study of Iran. *J. Financ. Manag. Prop. Constr.* **2019**, *24*, 630–654. [[CrossRef](#)]
43. Liang, K.; Fung, I.W. The impact of macroeconomic and industrial fluctuation on fatalities of construction workers in China. *J. Saf. Res.* **2019**, *70*, 149–158. [[CrossRef](#)]
44. Onyebeke, L.C.; Papazaharias, D.M.; Freund, A.; Dropkin, J.; McCann, M.; Sanchez, S.H.; Hashim, D.; Meyer, J.D.; Lucchini, R.G.; Zuckerman, N.C. Access to properly fitting personal protective equipment for female construction workers. *Am. J. Ind. Med.* **2016**, *59*, 1032–1040. [[CrossRef](#)] [[PubMed](#)]
45. Oladimeji, O. Factors influencing professionalism and the viability of local firms in Nigeria. *Acta Structilia* **2019**, *26*, 104–136. [[CrossRef](#)]
46. Oladimeji, O. Psychosocial construction work and wellbeing in the viability of indigenous construction firms. *J. Eng. Proj. Prod. Manag.* **2020**, *10*, 187–199.
47. Oladimeji, O. Influence of COVID-19 pandemic on local construction firms' viability. *J. Eng. Des. Technol.* **2022**, *20*, 201–221. [[CrossRef](#)]
48. Lenin, J.N. Guest editorial on special issue: Psychosocial and Organisational-Cultural influences on Construction Stakeholders' Financial Performance. *J. Financ. Manag. Prop. Constr.* **2018**, *23*, 2–5. [[CrossRef](#)]
49. Goulding, J.S.; Ezcan, V.; Sutrisna, M. Securing the embeddedness of psychosocial diffusion indicators into the Turkish construction industry: Silence is no longer golden. *J. Financ. Manag. Prop. Constr.* **2018**, *23*, 90–111. [[CrossRef](#)]
50. Takim, R.; Abu Talib, I.F.; Nawawi, A.H. Quality of life: Psychosocial environment factors (PEF) in the event of disasters to private construction firms. *Soc. Behav. Sci.* **2016**, *234*, 28–35. [[CrossRef](#)]
51. European Commission 2015. Enterprises and Industry: SME Definition, Archived from the Original on Available 8 February. Available online: <http://europa.eu.int/comm/enterprise/enterprisepolicy/smedefinition/index.htm> (accessed on 29 May 2017).
52. Ahmad, I. COVID-19 and Labour Law: Pakistan Italian Labour Law. *E-J.* **2020**, *1*, 1–11. [[CrossRef](#)]
53. Zamani, H.; Rahman, R.A.; Fauzi, M.A.; Yusofs, I.M. Effects of COVID-19 on building construction projects: Impact and response mechanism, 4th National Conference on Wind and Earthquake Engineering. *IOP Conf. Ser. Earth Environ. Sci.* **2021**, *682*, 012049. [[CrossRef](#)]
54. Özkan, S.; Seyis, S. Identification of common data environment functions during construction phase of BIM-based projects. In Proceedings of the CIB W78-LDAC 2021, Luxembourg, 11–15 October 2021.
55. Famade, O.A.; Omiyale, G.T.; Adebola, Y.A. Towards improved funding of tertiary institutions in Nigeria. *Asian J. Humanit. Soc. Sci.* **2015**, *3*, 83–90.
56. Tavakol, M.; Dennick, R. Making sense of Cronbach's. *Int. J. Med. Educ.* **2011**, *2*, 53–55. [[CrossRef](#)] [[PubMed](#)]
57. Field, A. *Discovering Statistics Using SPSS for Windows*; Publications: Thousand Oaks, CA, USA, 2000.
58. Cheng, T.C.; Choy, P.W. A study of the relationships between quality management practices and organizational performance in the shipping industry. *Marit. Econ. Logist.* **2013**, *15*, 1–31. [[CrossRef](#)]

59. Cheng, T.E.; Choy, P.W. Measuring success factors of quality management in the shipping industry. *Marit. Econ. Logist.* **2007**, *9*, 234–253. [[CrossRef](#)]
60. Hamada, H.M.; Haron, A.; Zakiria, Z.; Humada, A.M. Benefits and barriers of BIM adoption in the Iraqi construction firms. *Int. J. Innov. Res. Adv. Eng.* **2016**, *3*, 76–84.
61. Ma, P.; Zhang, S.; Hua, Y.; Zhang, J. Behavioral perspective on BIM postadoption in construction organizations. *J. Manag. Eng.* **2020**, *36*, 04019036. [[CrossRef](#)]
62. Dakhil, A.; Underwood, J.; Al Shawi, M. BIM benefits-maturity relationship awareness among UK construction clients. In Proceedings of the First International Conference of the BIM Academic Forum, Glasgow, UK, 13–15 September 2016; pp. 13–15.
63. Khanzadi, M.; Sheikhhoshkar, M.; Banihashemi, S. BIM applications toward key performance indicators of construction projects in Iran. *Int. J. Constr. Manag.* **2020**, *20*, 305–320. [[CrossRef](#)]
64. Maskey, R.; Fei, J.; Nguyen, H.O. Use of exploratory factor analysis in maritime research. *Asian J. Shipp. Logist.* **2018**, *34*, 91–111. [[CrossRef](#)]
65. Henson, R.K.; Roberts, J.K. Use of exploratory factor analysis in published research: Common errors and some comment on improved practice. *Educ. Psychol. Meas.* **2006**, *66*, 393–416. [[CrossRef](#)]
66. O’Neil, J.M. Summarizing 25 years of research on men’s gender role conflict using the Gender Role Conflict Scale: New research paradigms and clinical implications. *Couns. Psychol.* **2008**, *36*, 358–445. [[CrossRef](#)]
67. Nguyen, P.T.; Vo, K.D.; Phan, P.T.; Huynh, V.D.B.; Nguyen, T.A.; Cao, T.M.; Nguyen, Q.L.H.T.T. Construction project quality management using building information modeling 360 field. *Int. J. Adv. Comput. Sci. Appl.* **2018**, *9*, 228–233. [[CrossRef](#)]
68. Achkar, E. A BIM-Integrated Approach to Construction Quality Management. Enabling Information and Knowledge Management during the Execution Phase of a Project Life Cycle. Eindhoven University of Technology Graduation Program: Master of Construction Management and Engineering. Master’s Thesis, Eindhoven University of Technology, Eindhoven, The Netherlands, 8 December 2016.
69. Lee, N.; Salama, T.; Wang, G. Building information modeling for quality management in infrastructure construction projects. In *Computing in Civil and Building Engineering (2014)*; American Society of Civil Engineers: Reston, VA, USA, 2014; pp. 65–72.
70. Zhai, Y.; Chen, K.; Zhou, J.X.; Cao, J.; Lyu, Z.; Jin, X.; Shen, G.Q.; Lu, W.; Huang, G.Q. An Internet of Things-enabled BIM platform for modular integrated construction: A case study in Hong Kong. *Adv. Eng. Inform.* **2019**, *42*, 100997. [[CrossRef](#)]
71. Davtalab, O.; Kazemian, A.; Khoshnevis, B. Perspectives on a BIM-integrated software platform for robotic construction through Contour Crafting. *Autom. Constr.* **2018**, *89*, 13–23. [[CrossRef](#)]
72. Wang, K.C.; Skibniewski, M.J. Feasibility study of integrating BIM and 3D printing to support building construction. In *Creative Construction Conference*; Budapest University of Technology and Economics: Budapest, Hungary, 2019; pp. 845–850.
73. Ding, K.; Shi, H.; Hui, J.; Liu, Y.; Zhu, B.; Zhang, F.; Cao, W. Smart steel bridge construction enabled by BIM and Internet of Things in industry 4.0: A framework. In Proceedings of the 2018 IEEE 15th International Conference on Networking, Sensing and Control (ICNSC), Zhuhai, China, 27–29 March 2018; pp. 1–5.
74. Jeonghwan, K.; Heeyeon, K.; Arshad, T.W.; Jongwon, S. 3D earthwork BIM design and its application in an advanced construction equipment operation. *Archit. Eng.* **2019**, *4*, 22–26.
75. Jaud, Š.; Hecht, H.; Schlenger, J.; Amann, J. TUM Open Infra Platform: An open source package for simultaneous viewing and analysis of digital models in the civil engineering domain. *J. Open Source Softw.* **2022**, *7*, 3061. [[CrossRef](#)]
76. Ramonell, C.; Chacón, R. Open—Source terrestrial laser scanner for the virtualization of geometrical entities in AEC classrooms. *Comput. Appl. Eng. Educ.* **2022**, *30*, 1009–1021. [[CrossRef](#)]
77. Succar, B.; Sher, W.; Williams, A. An integrated approach to BIM competency assessment, acquisition and application. *Autom. Constr.* **2013**, *35*, 174–189. [[CrossRef](#)]
78. Haupt, T.C.; Hefer, E. Adapt or die! Building information modelling (BIM). In Proceedings of the Tenth Built Environment Conference, Port Elizabeth, South Africa, 31 July–2 August 2016.
79. Magill, L.J.; Jafarifar, N.; Watson, A.; Omotayo, T. 4D BIM integrated construction supply chain logistics to optimise on-site production. *Int. J. Constr. Manag.* **2020**, *22*, 2325–2334. [[CrossRef](#)]
80. Sadeghpour, F.; Andayesh, M. The constructs of site layout modelling: An overview. *Can. J. Civ. Eng.* **2015**, *42*, 199–212. [[CrossRef](#)]
81. Krepp, S.; Jahr, K.; Bigontina, S.; Bügler, M.; Borrmann, A. BIMsite—towards a BIM-based generation and evaluation of realization variants comprising construction methods, site layouts and schedules. In Proceedings of the EG-ICE Workshop on Intelligent Computing in Engineering, Krakow, Poland, 29 June–1 July 2016.
82. Bortolini, R.; Shigaki, J.S.; Formoso, C.T. Site Logistic planning and control using 4D Modelling: A Study in a Lean Car Factory Building Site. In Proceedings of the 23rd Annual Conference of the International Group for Lean Construction, Perth, Australia, 28–31 July 2015; pp. 361–370.
83. Sadeh, H.; Mirarchi, C.; Shahbodaghlou, F.; Pavan, A. BIM feasibility for small and medium-sized contractors and subcontractors. *Int. J. Constr. Manag.* **2021**, *23*, 999–1008. [[CrossRef](#)]
84. Sadeh, H.; Mirarchi, C.; Pavan, A. BIM implementation for micro, small and medium-sized enterprises. In Proceedings of the 2021 European Conference on Computing in Construction, Online, 19–28 July 2021; pp. 1–7.
85. Saka, A.B.; Chan, D.W.; Siu, F.M. Drivers of sustainable adoption of building information modelling (BIM) in the Nigerian construction small and medium-sized enterprises (SMEs). *Sustainability* **2020**, *12*, 3710. [[CrossRef](#)]

86. Martinez Aires, M.D.; Rubio Gamez, M.C.; Gibb, A. Prevention through design: The effect of European directives on construction workplace accidents. *Saf. Sci.* **2010**, *48*, 248–258. [[CrossRef](#)]
87. Wong, J.K.W.; Li, H.; Chan, G.; Wang, H.; Huang, T.; Luo, E. An integrated 5D tool for quantification of construction process emissions and accident identification. In Proceedings of the 31st International Symposium on Automation and Robotics in Construction and Mining, ISARC 2014, Ultimo, Australia, 1 January 2014; pp. 393–397.
88. Cortés-Pérez, J.P.; Cortés-Pérez, A.; Prieto-Muriel, P. BIM-integrated management of occupational hazards in building construction and maintenance. *Autom. Constr.* **2020**, *113*, 103115. [[CrossRef](#)]
89. Nawari, N.O.; Ravindran, S. Blockchain and building information modeling (BIM): Review and applications in post-disaster recovery. *Buildings* **2019**, *9*, 149. [[CrossRef](#)]
90. Kermanshachi, S.; Rouhanizadeh, B. Feasibility analysis of post disaster reconstruction alternatives using automated BIM-based construction cost estimation tool. In *Proceeding of the CSCE 6th International Disaster Mitigation Specialty Conference*; Canadian Society of Civil Engineering: Montreal, QC, Canada, 2018; pp. 13–16.
91. Yuan, H.; Yang, Y. BIM adoption under government subsidy: Technology diffusion perspective. *J. Constr. Eng. Manag.* **2020**, *146*, 04019089. [[CrossRef](#)]
92. Atkinson, L.; Amoako-Attah, J.; B-Jahromi, A. Government's influence on the implementation of BIM. In *Computing in Civil and Building Engineering*; American Society of Civil Engineers: Reston, VA, USA, 2014; pp. 520–527.
93. Aguiar Costa, A.; Grilo, A. BIM-based e-procurement: An innovative approach to construction e-procurement. *Sci. World J.* **2015**, *2015*, 905390. [[CrossRef](#)]
94. Kuiper, I.; Holzer, D. Rethinking the contractual context for Building Information Modelling (BIM) in the Australian built environment industry. *Australas. J. Constr. Econ. Build.* **2013**, *13*, 1–17. [[CrossRef](#)]
95. Radulović, A.; Sladić, D.; Govedarica, M.; Raičević, D. LADM based taxation model in Montenegro: Using BIM in taxation process. In *Proceeding of the 7th International FIG Workshop on 3D Cadastres*, New York, NY, USA, 11–13 October 2021.
96. Majzoub, M.; Eweda, A. Probability of Winning the Tender When Proposing Using BIM Strategy: A Case Study in Saudi Arabia. *Buildings* **2021**, *11*, 306. [[CrossRef](#)]
97. Fatoye, E.O. Contributing factors of delay in the Nigerian construction industry: A comparative analysis with other selected countries. In *Proceedings of the 4th West Africa Built Environment Research (WABER) Conference*, Abuja, Nigeria, 24–26 July 2012; pp. 575–587.
98. Hamledari, H.; Fischer, M. Construction payment automation using blockchain-enabled smart contracts and robotic reality capture technologies. *Autom. Constr.* **2021**, *132*, 103926. [[CrossRef](#)]
99. Salleh, R.M.; Mustafa, N.E.; Rahiman, N.A. The adoption of building information modelling and intelligent contract to payment process in Malaysian conventional contract. *J. Comput. Theor. Nanosci.* **2020**, *17*, 1378–1387. [[CrossRef](#)]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.