buildings

MDPI

Review

Digitisation of Procurement and Information Modelling—Literature Review on e-Procurement †

Eliana Basile [1,*], Francesca Porcellini [1], Enrico Pasquale Zitiello [1], Sonia Lupica Spagnolo [2], Antonio Salzano [1] and Salvatore Antonio Biancardo [1]

1 Department of Civil, Architectural and Environmental Engineering, University of Naples Federico II, 80125 Naples, Italy; francesca.porcellini@unina.it (F.P.); enricopasquale.zitiello@unina.it (E.P.Z.); antonio.salzano@unina.it (A.S.); salvatoreantonio.biancardo@unina.it (S.A.B.)

2 Department of Architecture, Built Environment and Construction Engineering, Politecnico di Milano, Via G. Ponzio 31, 20133 Milan, Italy; sonia.lupica@polimi.it

* Correspondence: eliana.basile@unina.it

† This paper is an extended version of our paper published in Zitiello, E.P.; Porcellini, F.; Basile, E.; Salzano, A.; Nicolella, M. Synergy Between BIM and e-Procurement: A New Paradigm for Digital Procurement Management. In Proceedings of the Computational Science and Its Applications—ICCSA 2025 Workshops; Springer Nature: Cham, Switzerland, 2025; pp. 63–77. https://doi.org/10.1007/978-3-031-97617-9_5.

Abstract

In recent decades, the introduction of e-procurement has profoundly transformed the methods of procuring goods, services, and works, redefining traditional procurement processes and significantly impacting global economic, operational, and regulatory dynamics. The construction sector has also been affected by this transition, which has altered the operating models of public procurement and favoured the adoption of digital tools aimed at more efficient, transparent, and automated process management. This study proposes a systematic literature review based on the analysis of 95 scientific contributions, with the aim of outlining the evolution of the e-procurement paradigm in the construction sector and identifying the main directions for research development. Despite the widespread dissemination of studies on the topic, it emerges that the actual maturity of e-procurement systems is still limited, often resulting in a logic of document dematerialization rather than full process digitalization. In this context, the review critically analyses the role of Building Information Modelling as an enabling factor for the evolution of e-procurement, exploring the potential of its integration into procurement flows. Particular attention is paid to the contribution of the Digital Building Logbook, an information tool capable of extending the value of data generated during the tender phase throughout the building's entire life cycle, supporting advanced management and maintenance strategies. The results highlight how, despite the significant potential of integrating e-procurement and BIM, significant technological, regulatory, and cultural issues persist that limit its large-scale adoption. This underscores the need to develop shared and interoperable methodological approaches capable of transforming procurement from a document-based process to an integrated information system, oriented toward value creation throughout the entire life cycle of projects.

Keywords: e-procurement; BIM; building process optimization; digitalization; public procurement; digital building logbook; review

Check for updates

Academic Editor: Ahmed Senouci

Received: 6 March 2026
Revised: 9 April 2026
Accepted: 22 April 2026
Published: 15 May 2026

1. Introduction

The construction sector has always been one of the driving forces of the economy, a complex ecosystem where engineering skills, financial management and logistics converge. Public spending on civil works is, in fact, one of the key items in the budgets of all global economies [1–3]; all governments or public sectors, in one way or another, engage in public spending through a structured mechanism known as procurement [1,4]. From a legal point of view, a contract is an agreement between two parties in which one, known as the contractor, undertakes to carry out a project or provide a service on behalf of a client (or contracting authority), whether public or private, in exchange for a monetary consideration. In a broader overview, the procurement system is characterised as a mechanism that regulates the meeting of supply and demand, through which costs are defined, execution times are established and, above all, the final quality of the work is guaranteed. However, traditional award procedures, often burdened by analogue bureaucracy and a lack of transparency, have shown their limitations, frequently resulting in inefficiencies, disputes and unacceptable delays in an increasingly dynamic market.

It is precisely in response to these critical issues that e-procurement comes into play as an indispensable element of disruption and innovation. It is not simply a matter of "digitising paper", but of rethinking the entire process of procurement and awarding contracts, becoming the technological bridge that links the operational efficiency requirements of the construction sector with the regulatory rigour of public tender.

Since the advent of the first forms of electronic procurement (EP), the procurement process, as the set of stages and activities that regulate the acquisition of goods, services and works, has undergone a profound transformation, significantly influencing the dynamics of global trade [1], redefining traditional public procurement operating models in the construction sector [2], and paving the way for digital tools for management and execution of procurement activities for infrastructure works [1,3]. The conservative nature of the construction sector [5–7] clashes with the evolution of EP [8], continuing to show some resistance to the adoption of advanced technological solutions [9,10]. Despite this, recent years have seen the growing spread of innovative platforms [11,12] designed to digitise the entire procurement life cycle, to reduce human errors, costs and time, to optimise the traceability of operations [13,14], to improve transparency [15,16] and to increase overall efficiency [13,17]. In this context, digitalization is emerging as the driving force [18–20] behind the need to remain efficient and competitive in a rapidly changing environment [21,22], even though the sector remains less digitised than the rest of the economy [23].

However, it should be emphasised that the current transformation of the sector is in fact limited to the concept of dematerialisation: the advent of the current EP platforms has mainly resulted in a simple transition from paper to digital documentation, thus not leading to a true digitisation process, which would instead require the integration of other innovative technologies. In particular, BIM technology could play a key role. If properly integrated into e-procurement platforms, it could be a fundamental tool for reducing award times and making evaluation processes more transparent.

This study analyses the scientific literature to outline the technological evolution of the e-procurement paradigm. The review of the current state of the art highlights BIM's ability to innovate traditional procurement processes, elevating the information model from a mere documentary output to an operational system for the tendering procedure. The strategy that now links digital procurement to information modelling marks the transition from a document-based approach to a data-driven one, where the modelling itself becomes the cornerstone for structuring all technical and administrative information. This interaction is achieved through the precise alignment of information requirements with the various stages of the tender: initially, the contracting authority defines its requirements in the Information Specifications, using digital methods to create a reference model. In the subsequent tender and bid phase, the process requires bidders not only to submit a financial bid but also a Project Information Model drawn up in an open format; this ensures, on the one hand, that participants can demonstrate the technical quality of their proposals and, on the other, allows for a clear and transparent verification by the contracting authority. In conclusion, the research proposes a methodological framework in which the BIM model serves as an integrated platform for the submission of parameterised tenders by economic operators, enabling the automation of the evaluation and award stages to ensure complete procedural transparency.

In this system architecture, e-procurement does not end with the award of the contract but acts as a catalyst for the creation of the Digital Building Logbook (DBL). The BIM model, enriched by the technical and contractual datasets acquired during the tender process, evolves from an evaluation tool into a dynamic asset repository. This transition ensures data persistence, transforming the specifications provided by economic operators into structured information within the project's digital file. This establishes full traceability of components and materials, which is essential for optimising operational and maintenance phases throughout the entire life cycle of the building.

2. The Digitisation of Procurement: The Evolution of e-Procurement

Public procurement, as a structured mechanism through which public sectors make their financial disbursements for the benefit of the community [4], is a key government function [24,25], accounting for between 20 and 30 per cent of gross domestic product [26]. This complex and wide-ranging process is geared not only towards the timely fulfilment of needs for goods, works and services, but also towards compliance with the fundamental principles of good governance, such as transparency [27,28], accountability and integrity [29,30]; however, the procurement process is globally recognised as the most susceptible to corruption [31,32] with every phase and activity exposed to risks of irregularity [33,34]. In this context, numerous public sector agencies globally have identified e-procurement as a priority objective for e-government [15,35], initiating the implementation of buy-side systems [36].

However, despite the impetus given by governments, the adoption of EP in the public sector has proved to be a slow and obstacle-strewn process, due to the construction sector's tendency to resist the adoption of new technologies [5,37,38].

This conservative tendency is also clearly evident in the implementation of EP [8], despite the fact that procurement activities are particularly frequent and relevant in this area [39]. The concept of procurement supports a delivery relationship between buyers and sellers and can be defined as the search for information on the requirements of goods/services and the willingness to promise, i.e., the flow of information within the quotation and negotiation functions [39]. The traditional process that serves as the basis for current e-procurement consists of a series of well-defined activities [40] that, although autonomous, are interconnected and organised according to a logic determined by the strategy or specific procurement procedure adopted [1]. A study [39] divides procurement into two phases: contracting and settlement. Contracting includes the search for suppliers, the promise of supply and the definition of goods/services requirements, managing the flow of information (availability, shipping) for quotations and negotiations, while settlement includes payment (transaction) and the physical transfer of goods/services (delivery). Other studies [41,42] group procurement activities into four main contractual phases: the pre-contractual phase, the contractual phase, the administrative management phase of the contract, and the post-contractual phase. Procurement can also be classified into two main types: structured and unstructured [43]. Structured procurement processes are highly automated in terms of identifying needs, ordering and fulfilment. In fact, if demand is regular and product specifications do not change over time, transition costs can be reduced by creating an automatic order with minimal human interference [39]. Unstructured procurement occurs when products or services are not suitable for predefined automated procedures. In this case, human intervention is required to search, request, match suppliers and create the order using the best available offers, thus not restricting procurement [39]. In summary, when discussing structured procurement, we refer to goods with well-defined characteristics, as the procurement of such goods is quicker and easier. This is due to the clarity of the technical specifications and the ease of evaluating offers, which reduce decision-making and implementation times. On the other hand, for unstructured goods, there is an evolution that is closer to the construction sector, where it is difficult to parameterise goods and services because they are too variable.

Despite some initial terminological confusion [44], e-procurement is now defined as the use of Internet-based ICTs to perform one or all stages of the procurement cycle, such as search, sourcing, negotiation, ordering, receipt and post-purchase review [45]. From a broader perspective, it can be conceptualised as an end-to-end solution that integrates and optimises purchasing processes at an organisational level through tools such as electronic tendering, electronic requests for quotations, reverse auctions, electronic catalogues and electronic invoicing. E-procurement is therefore defined as business-to-consumer (B2C), business-to-business (B2B), or business-to-government (B2G) purchasing, as well as the sale of goods, services, works, or supplies [46,47] via the Internet and other information and network systems [1]. Such systems include Enterprise Resource Planning (ERP) and Electronic Data Interchange [48,49]. In light of the above, it should be emphasised that, regardless of the variety of systems available, the basic procurement process remains consistent and lends itself to automation using standard technologies [36].

A study conducted by the United Nations Global Marketplace (UNGM) indicates the conceptual origins of e-procurement in the 1960s [50], while other studies demonstrate the technological origins in the 1970s and 1980s, i.e., during the emergence of Electronic Data Interchange (EDI) technologies, which enabled the structured exchange of standardised commercial documents between trading partners via dedicated networks, representing a first significant form of digitisation of B2B transactions, albeit characterised by high implementation complexity and significant costs [36]. B2B electronic marketplaces are essentially web-based supply networks in which one or more companies try to find their suppliers at the lowest possible costs [51]. Previously, most of the relationships between buyer and seller were carried out in an independent and conflictual manner, in the sense that both tried to reach an agreement that was profitable for them at the expense of the other party [52,53].

However, e-procurement in its modern sense, as the pervasive application of technologies based on Internet protocols and web interfaces for the management of purchasing processes, saw its actual genesis and diffusion starting in the second half of the 1990s, coinciding with the commercial expansion of the World Wide Web [54]. This period marked the transition from closed, bilateral systems to more open, accessible and interoperable solutions (often based on client-server or web-based architectures), favouring the development of B2B marketplaces [55] and software platforms dedicated to the automation of the corporate purchasing cycle. The subsequent phase, following the dot-com speculative bubble (early 2000s), saw technological consolidation and a more mature and strategically oriented adoption of these solutions by organisations globally. The development process of e-procurement technologies over time is presented in Figure 1 [1].

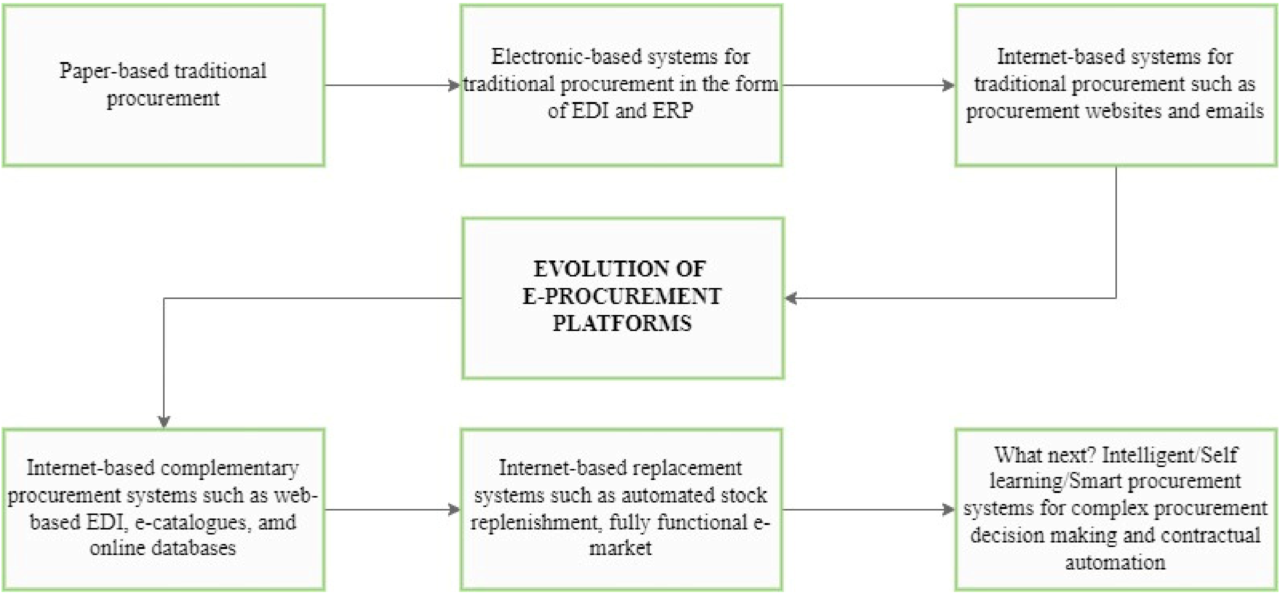


Figure 1. Evolution of e-procurement [1].

In conclusion, the progressive technological advancement of digital tools [56,57] has been the driving force behind the transformation of procurement processes. This has pushed beyond manual methods and it has led to a radical digitisation of purchasing activities [58] both within the public administration and in the private business sector. According to some studies [59,60], the e-procurement process can be described in six different phases:

- E-sourcing: This process involves searching for new potential suppliers via the Internet, both in general and through specific B2B marketplaces. It takes place during the information gathering phase of the procurement process.
- E-tendering: This consists of sending requests for information (RFI), requests for price (RFP) and other requests to suppliers, receiving responses via Internet technologies. The data involved focuses on the product or service. At this stage, initial screening can be carried out to qualify a selected number of suppliers for the negotiation stage (a process that takes place during the supplier contact stage).
- E-informing: This manages information about suppliers, such as quality certifications, financial status and unique capabilities, without involving transactions. The information may come from third-party suppliers or from internal company surveys.
- E-reverse auctions: Electronic reverse auctions allow the purchasing company to obtain goods and services at the lowest price or at a combination of price and other conditions via Internet technologies. Auctions are negotiated in real time and conclude with a final offer between buyer and supplier. (This characterises the negotiation phase.)
- E-MRO and Web-based ERP (Enterprise Resource Planning): These focus on the creation and approval of purchase requests. E-MRO deals with indirect items (maintenance, repair and operating materials), while Web-based ERP deals with product-related items (order fulfilment phase).
- E-collaboration: This manages the collection and dissemination of purchase-related information, such as product versions, designs and sales forecasts, available on the purchasing company's website or extranet. This reduces errors and synchronises suppliers with the purchaser.

However, there are several variations of electronic models. According to Costa and Grilo [61], the e-procurement process consists of ten sequential activities covering the entire procurement cycle:

- Ex ante e-evaluation: I.e., the multi-criteria evaluation of procurement needs and strategies;
- E-notice: Electronic publication of public procurement notices;
- E-submission: Electronic submission of proposals;
- E-decision: Electronic evaluation of proposals, followed by communication of the evaluation results with discussion and analysis of the results;
- E-award: Electronic award of contracts to suppliers with the best proposals;
- E-ordering: Activities that include sending an order document from public purchasers to suppliers and transmitting delivery instructions for the goods and services ordered;
- E-invoicing: I.e., the request for payment for goods and services ordered and delivered under the agreed conditions;
- E-payment: The agreed management of electronic payments and their execution;
- E-contract management: The use of electronic contract management tools to monitor and improve contract performance and document management;
- Ex post e-evaluation: Multi-criteria evaluation of contract performance and generation of KPIs to support future tendering processes.

All these processes should be combined and all relevant information must be available electronically. Only in this way it is possible to achieve a reduction in administrative work and the automation of operational processes [61]. The lack of a standardised or universally recognised framework that brings together all variants of e-procurement under a single source [62] often makes it difficult to accurately identify all the different types of e-procurement actually used to support the activities of the entire electronic procurement process [1]. Despite this, e-procurement can be considered a comprehensive "end-to-end" solution that integrates and optimises numerous procurement processes within an organisation [36,63] to integrate and optimise the numerous activities related to purchasing within the organisation itself [1,61].

2.1. Main Barriers and Potentialities

Analysis of the scientific literature on e-procurement highlights a persistent gap between the potential of the technology and the actual results achieved in the public sector. Despite strong institutional support [12,64], adoption has been a slow process [65], with a success rate described as modest [66] and projects sometimes described as notoriously unsuccessful.

The critical factors slowing down development have been classified into four main categories: organisational, technological, legal and cultural [9]. According to Yevu et al. [9], these obstacles do not operate independently but are linked by multiple interrelationships that amplify their negative impact.

Therefore, the main limitations identified concern [9,67]: inadequate IT infrastructure [10], systems integration, security [68,69] and authentication [70], process re-engineering, top management support [71], performance measurement, change management [72], implementation strategies and technological standards, resistance to change [73], bureaucratic barriers [74], user adoption and training, supplier adoption, and compliance with project management best practices [73,75]. Resistance to change should not be underestimated as it represents one of the most complex challenges in the implementation of new EP technologies and can manifest itself in different forms and at various levels of the organisation, significantly slowing down the adoption of innovations, making a strategic and inclusive approach necessary to overcome cultural and organisational barriers [76].

At the infrastructure level, the lack of adequate IT platforms requires the adoption of implementation strategies and the definition of shared technological standards to ensure full operability [13]. This structural deficit is aggravated by widespread technical unpreparedness among public administration staff [36,77,78], which limits the technological acceptance of such systems and increases resistance to changing established operational processes [36]. The latter is a crucial element, as the success of e-procurement adoption is linked to a thorough review of existing processes. In fact, the most significant benefits derive from the re-engineering of workflows rather than from mere technological implementation [79]. At a technical level, it is also essential to determine the correct level of integration with existing information systems, ensure security and authentication mechanisms to validate transactions, and define common standards for the exchange of information between buyer and supplier systems [36].

In conclusion, the implementation of e-procurement should be conceived not as a technological project, but as a strategic initiative aimed at improving the primary objectives of public procurement: quality, timeliness, cost reduction, risk minimisation and transparency [26]. Therefore, thanks to the automation of routine procurement activities, EP could significantly reduce the time required for procurement processes, also thanks to the use of innovative tools such as BIM. Activities such as supplier selection, order approval and invoice processing are thus simplified, leading to faster procurement cycles and greater operational efficiency [13], which results in a reduction in manual work and paper-based processes, with consequent cost savings. One of the most significant advantages of e-procurement is greater transparency; procurement data is stored digitally, making it accessible and traceable and reducing the possibility of corrupt practices such as bid rigging and favouritism [13,80,81].

2.2. Regulatory Framework

The digitisation of public procurement processes is one of the fundamental guidelines for administrative modernisation in Europe; in fact, the consolidation of e-procurement as a central tool in public procurement management is the result of a multi-level regulatory process, which is based on both European Union law and national legislation. The common goal is the complete digitisation of the public contract life cycle, with a view to transparency, traceability and administrative simplification.

At the European level, the main reference points are:

- Directive 2014/24/EU [82] on procurement in ordinary sectors;
- Directive 2014/25/EU [83] for special sectors;
- Directive 2014/23/EU [84] on the award of concession contracts.

These directives introduce the general obligation to use electronic tools in procurement procedures, requiring the adoption of electronic means for accessing tender documentation (eAccess), submitting tenders (eSubmission) and publishing information on procedures (eNotification) [85].

Specifically, Directive 2014/24/EU on public procurement laid the foundations for the systematic digitisation of the sector through a strategic vision of procurement. In particular, Article 22, Paragraph 4 of the aforementioned directive introduced the possibility, which has been transposed and often made mandatory at the national level, as in the case of Legislative Decree 36/2023 [86] in Italy, to impose the use of specific electronic tools and methodologies such as BIM in award procedures. This provision does not respond exclusively to a need for bureaucratic efficiency but aims to ensure greater transparency and accuracy of information, which must be certain from the tender submission stage onwards. This regulatory development is consistent with the transition to the Most Economically Advantageous Tender (MEAT) criterion, which marks the definitive shift away from the lowest price logic in favour of a holistic assessment based on the best quality/price ratio. As widely documented in the recent literature, the application of the MEAT criterion requires transparent evaluation frameworks capable of integrating and weighting heterogeneous variables, in order to effectively reconcile quality and cost [87]. Empirical evidence demonstrates that the systematic use of Multi-Criteria Decision Analysis (MCDA) techniques is essential to support such evaluative complexity and mitigate the inherent subjectivity in the award phases of public contracts [87,88]. Managing the complexities of the MEAT criterion requires overcoming the limitations of traditional cost–benefit analyses, which are often inadequate and susceptible to optimism bias. To address this, recent studies propose the integration of MCDA frameworks, such as the Decision Support Concept (DSC-CONT) developed by Marović et al. [89]; this approach synergistically combines AHP and PROMETHEE methods to transparently balance conflicting stakeholder demands and ensure effective competition during the public procurement phase [89]. In this context, BIM is a key tool for objectifying technical quality, as it allows the winning bid to be determined in a transparent, objective and automatic manner through objective and measurable parameters introduced into the model, thereby also reducing the time required for awarding contracts.

Once acquired and validated during the tender process, these parameters constitute the essential information core that the DBL will subsequently inherit and monitor over time, ensuring that the performance promises made during the procurement phase translate into efficient and sustainable operational management. However, the real push towards information integration lies in the recent Directive (EU) 2024/1275 (EPBD IV) [90], which identifies the DBL as the key tool for continuous monitoring of asset performance. The directive promotes the adoption of DBLs to collect data on consumption, energy certifications and renovation works and introduces a related tool that plans long-term building interventions, integrating perfectly with the preventive maintenance logic previously mentioned, such as the Building Renovation Passport (BRP). Europe is also introducing the Digital Product Passport (DPP), Regulation (EU) 2024/1781, known as ESPR [91], which will require manufacturers to provide standardised digital data on materials.

Although this regulatory framework pushes for harmonised codification at the EU level, there is still an operational shortfall in the definition of tender requirements that link the award phase to the useful life of the asset. It is therefore essential that the procurement process does not end with the evaluation of models but becomes the trigger for the creation of a DBL. Furthermore, only by structuring the data in accordance with European interoperability standards can the DBL be transformed from a simple documentary obligation into a preventive and predictive maintenance tool, capable of ensuring the resilience of the work and the achievement of the decarbonisation targets set by the European Green Deal [92].

Regulation (EU) No 910/2014 (eIDAS) [93] has also defined the legal framework for electronic identification and trust services, ensuring the legal validity of digital signatures and electronic seals.

A key element of the European design is the introduction of the European Single Procurement Document (ESPD) [94], which allows economic operators to self-certify their participation requirements, reducing the documentary burden and promoting greater uniformity between national legal systems. In 2025, the ESPD was updated in the Italian regulatory context with new technical specifications and taxonomies as a result of the regulatory changes introduced by Legislative Decree 209/2024 [95]. It is accompanied by e-Certis, an information system that allows the identification of the various certificates required in procurement procedures throughout the EU. In addition, Directive 2014/55/EU requires the use of electronic invoicing by public administrations, based on a common standard, promoting interoperability through the PEPPOL infrastructure [96].

https://doi.org/10.3390/buildings16101969

The evolution of public procurement in Italy has taken shape through a gradual development of regulatory and technical frameworks, the legal basis for which lies in the Digital Administration Code (Legislative Decree 82/2005) [97], which laid down the requirements for the digitisation of procedures, such as digital identity, digital domicile and the validity of electronic documents. Although Legislative Decree 50/2016 initiated the transposition of European directives through the introduction of electronic platforms, the definitive systematisation of e-procurement as an integrated regulatory framework was enshrined in Legislative Decree 36/2023 [98] by introducing the concept of the digital life cycle of public contracts and mandating the exclusive use of certified electronic ecosystems for the management of every stage of the award procedure.

The regulatory framework was further supplemented by Legislative Decree 209/2024, which extended the deadlines for assessing the technical capacity of economic operators, whilst operational support is provided by Ministerial Decree 148/2021 [99] and the related AgID Guidelines [100] on the certification and traceability of digital flows.

With the transition set to be fully operational by 2025, digitalisation has ceased to be a mere functional tool and has become a fundamental pillar of legality and transparency, steering administrative action towards models of efficiency and simplification designed to safeguard competition within the single market. This transition is not merely a technological adaptation, but rather a profound cultural and organisational transformation that requires the full implementation of technical rules through strategic investment in staff training, the enhancement of digital infrastructure and the monitoring of the platforms themselves.

3. Optimising e-Procurement Processes Through the Integration of BIM and the Digital Building Logbook

The current paradigm of digitalisation in the AECO sector requires a rethinking of procurement models towards advanced e-procurement systems capable of integrating complex information flows. The optimisation of these processes finds a key strategic driver in the convergence of Building Information Modelling and the Digital Building Logbook.

3.1. Building Information Modelling: Potential and Barriers

The adoption of information modelling, as a design methodology [101], has radically transformed the Architecture, Engineering, Construction and Operation sector (AECO) sector [102], consolidating performance optimisation and management efficiency as key drivers for systemic progress in the sector [103]. Technological evolution has marked the transition from traditional 3D drawings and paper documentation, historically used for infrastructure design and maintenance, to computer-aided design (CAD) systems, and finally to BIM models [104–106].

Building Information Modelling (BIM), whose roots lie in the development of the first CAD software in the 1970s, is defined as a methodology aimed at the digital representation of the structural and functional characteristics of a building [107], whose core operation lies in the optimisation of the design, construction and management processes of the building [108,109], pursued through the centralisation of information and the enhancement of collaboration between the various stakeholders [110–113]. In this context, the adoption of open and customisable standards such as IFC (Industry Foundation Classes) has enabled the integration of a wide range of external data, although this flexibility entails a degree of unpredictability in the management of the types of data acquired [102].

In addition to three-dimensional modelling, BIM is now used in crucial areas such as cost control, time planning, sustainability, site management and safety [114–118]. The integration of this approach into the construction production cycle and e-procurement offers multiple advantages, including: superior communication coordination; greater speed and operational accuracy; and high-quality documentation that reduces errors and costs [119], enables strict budget control [120–122], and allows for faster visualisation of the work [105,123,124]. However, although the implementation of BIM is in the process of consolidation, its diffusion remains conditioned by numerous challenges and structural obstacles [125].

According to several studies [13,105,126], the main obstacle to the integration of BIM into e-procurement processes is the high economic commitment required. This barrier manifests itself, specifically, in the high costs of purchasing and updating dedicated software [127,128], the expense of training experts [129], in resistance to change within organisations [111,130], and the costs associated with acquiring and sharing information flows [131,132].

In addition to these critical issues, there is limited awareness of the potential of BIM and its benefits, often accompanied by a lack of technical skills and qualified personnel, all aggravated by the lack of government support, clear regulations and specific incentives [105]. No less significant are technical and technological barriers, such as interoperability and compatibility issues [133], the absence of adequate technological infrastructure, and difficulties relating to systematic data management [105].

With regard to data management, the main concerns relate to privacy, security and the risk of information alteration [134]. An effective response to these issues is offered by the integration of BIM and Blockchain, which is one of the most advanced frontiers of digitalisation in the AEC sector. In this technological combination, while BIM coordinates the creation and sharing of digital information about an asset, Blockchain guarantees its immutability, traceability and security.

Finally, the picture of barriers is completed by the psychological resistance to change on the part of stakeholders and the current absence of a clear legal and contractual framework to regulate its application.

3.2. Synergy Between e-Procurement and BIM

The tender phase is a crucial step for the success of a project in the Architecture, Engineering, Construction and Operation (AECO) sector, where selecting the most qualified bidder is difficult because information is unstructured and poorly defined [135,136]. The limited adoption of Building Information Modelling [137] and the prevalence of paper-based documentation lead to inadequate data transfer and misinterpretation, making procedures prone to design negligence, conflicts, errors and documentary inconsistencies [136,138,139]. Added to this is the difficulty for contracting authorities to define clear and easily verifiable requirements, an attitude that often leads to delays, disputes and increased costs [138,140].

In response to these critical issues, the sector is undergoing a profound process of digitalisation, driven by two innovations: e-procurement and BIM. E-procurement, through the use of telematic platforms, enables the dematerialisation of transactions, the automation of workflows and the rationalisation of administrative processes, increasing management efficiency [141]. At the same time, BIM is establishing itself as a standardised [142] and incentivised methodology for the digital management of project information [143].

However, analysis of the literature and current operating practices reveals a clear dichotomy in the integration of these two technologies [141]. While there is growing adoption of the BIM model as an integral part of tender documentation [144], there is a significant gap in the definition of standardised operating procedures for its effective use during the procurement process [141]. In fact, there is no established methodological framework governing how the model should be actively used by parties within e-procurement platforms.

Consequently, although BIM is present as an information artefact, its transformative potential on the procurement process remains largely unexpressed, relegating it to a static support role rather than a dynamic and central management tool. Factual confirmation of this dissociation is provided by the "Report on digitisation and BIM tenders 2023" [145]. This document, edited by OICE, lists the public procurement procedures that refer to BIM and, while noting an overall upward trend in the period 2015–2023, confirms the fragmentation of its use, classifying references to BIM in distinct ways for the tender access phase and the bid evaluation phase. This shows that the synergistic integration between e-procurement platforms and the potential offered by the BIM model, although promising, still needs a methodological and procedural bridge to be fully realised.

With regard to the tender access phase:

- BIM is referred to in the context of the assessment of technical capacity and linked to the competitor's previous experience;
- BIM is required as a professional suitability requirement (often under penalty of exclusion), with regard to individual professional figures and linked to the possession of organisational skills, the tools necessary to carry out the required activity, and any BIM certifications.

In addition to these references to BIM, there are a number of tenders relating to a generic request for BIM design; in these cases, BIM is mentioned in general terms, i.e., as a method of performing the service, but without this profile being subject to a specific score in the evaluation of the bid, or qualification, as a minimum level for access to the tender [145], as best highlighted in Figure 2.

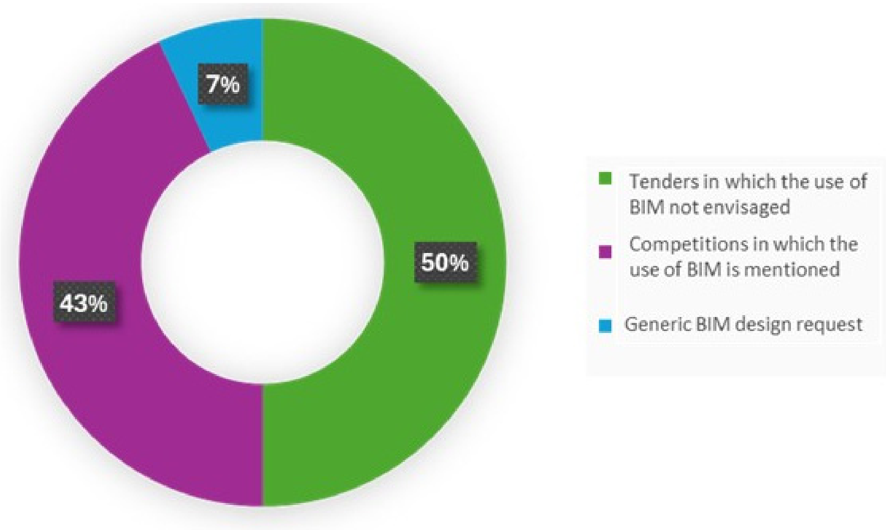


Figure 2. Pie chart identifying the percentage of BIM use in tenders carried out in 2023 [145].

Specifically, 50% of the tenders issued in Italy in 2023 relate to tender procedures in which the use of BIM is not required; conversely, 43% of the procedures include explicit references to the BIM methodology. Only in 7% of cases was a general requirement for BIM-based design identified, demonstrating a lack of digital maturity.

As can be seen in Figure 3, in 2023 only 14.8% of total procurement mentioned the use of BIM as a generic method, i.e., without assigning specific scores, but only considering it as a contractual element of the service, recording a decrease compared to 2022. The decrease in the percentage of total tenders with a "generic request for BIM design" shows that contracting authorities are slowly developing a real awareness of the use of BIM, consequently publishing detailed tenders and comprehensive annexes. In fact, in 29.4% of cases, contracting authorities attach the specifications to the tender. Going into more detail and considering the contents of the tender specifications, sub-classes have been identified according to the type of reference adopted, which can be divided into two macro-categories: specific reference to BIM (BIM is mentioned independently of the criteria) and non-specific reference to BIM (BIM is mentioned together with other criteria). These sub-categories are: BIM process management, BIM software, experience of other projects already completed in BIM, and the presence of BIM experts in the working group.

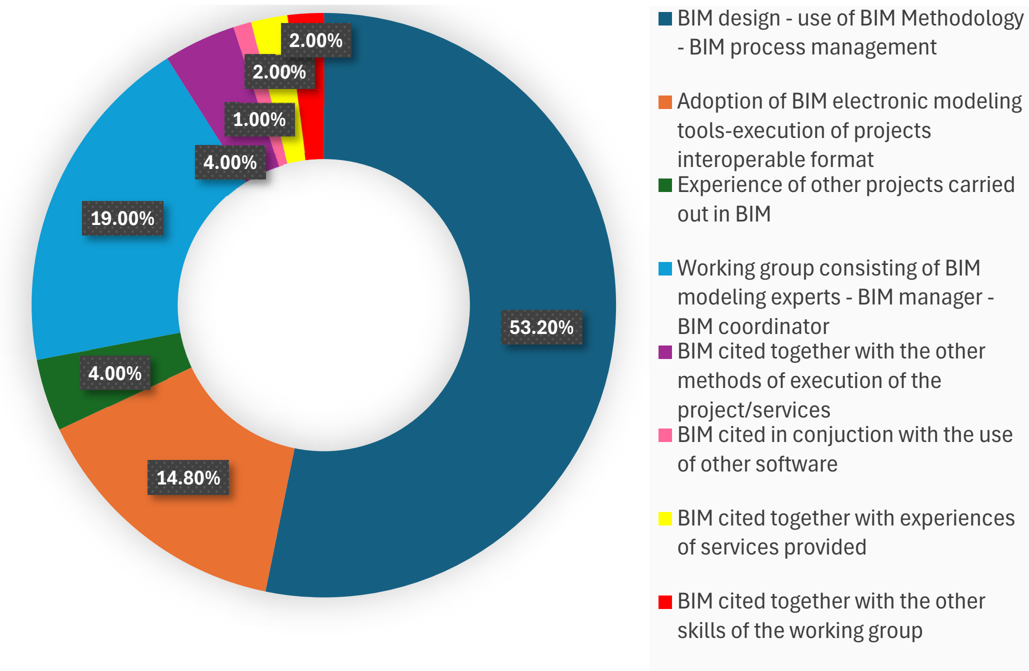


Figure 3. Identification of subclasses with a focus on the specific distribution of BIM requirements in tenders carried out in 2023 [145].

By analysing the weighting within the BIM field, using data from the 7th OICE Report on digitisation and BIM tenders [145], a clear hierarchy emerges that favours evaluative and methodological aspects over purely technological ones.

The predominant factor, as can be seen from Figure 4, which alone accounts for more than half of the total, or 53% of tenders, is the specific score attributed to BIM. This clearly indicates that the most critical aspect is not the tool itself, but rather the evaluation criterion adopted. This perspective finds solid support in the analysis of decision-making models applied to public procurement; indeed, some studies point out [87] how the weighting of criteria must be supported by rigorous methodologies to avoid allocative distortions. However, data in the literature indicate a structural criticality: only in a minority of cases are adequate sensitivity analyses or judgement standardisation procedures implemented, thereby introducing a significant risk in terms of the robustness and transparency of the award. Therefore, the adoption of BIM must proceed in close synergy with the application of standardised MCDA approaches, capable of translating information requirements into traceable and verifiable evaluation matrices [87]. In second place in terms of importance is methodology, which accounts for 37%. This means that more than a third of the result depends on how information flows and organisational processes are managed. Good management is almost as important as the evaluation itself.

Finally, the component with the least impact is that relating to electronic modelling tools, which accounts for only 10% of the total tenders carried out in 2023. This significantly reduces the role of the software itself; although it is a necessary operational tool, it is considered marginal compared to the strategic importance of process management and the overall evaluation of the project.

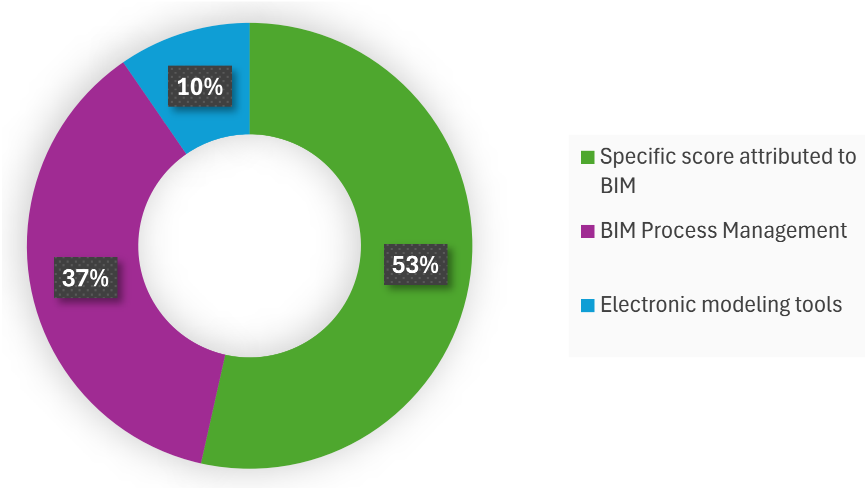


Figure 4. Identification of subclasses in percentage of use in tenders carried out in 2023 [145].

In conclusion, the empirical evidence provided indicates that, although there is a growing awareness of the importance and key role that BIM could play in public procurement, even today, a portion of public clients still hold the mistaken belief that the adoption of BIM is equivalent to the mere use of application tools or primarily as a factor in the attribution of technical scores in tenders, rather than as a methodological paradigm for the integrated management of the information life cycle of the work.

One of the best examples of this paradigm is the link between the tender phase and the management phase: the shift from a model based on technical scoring to a continuous monitoring tool. From this perspective, the process of integrating BIM information modelling and DBL is an automated workflow that transforms complex three-dimensional data into concise, dynamic and easily accessible documentation. It should be borne in mind that data extrapolation and entry require rigorous data management, the criticality of which lies in the transition from a purely geometric data structure to a relational database logic, ensuring that the information is accessible, queryable and durable over time for the building manager.

At the heart of this procedure lies the implementation of a bidirectional synchronisation architecture that connects the BIM authoring environment with an advanced reporting engine. The protocol begins with the structuring of property sets within the information model, where each component of the building is associated with specific metadata through shared parameters that comply with international standards. This step is facilitated by the creation of the parametric BIM model already developed during the tender phase, where the subject of the contract was digitised in such a way as to create a parametric BIM model that complies with the technical and economic feasibility of the project. The model incorporates objective and measurable parameters and properties that directly translate the evaluation criteria and sub-criteria set out for the tender, which are modified by the various economic operators during the submission of bids and guide the selection committee in identifying the winner of the tender through automated comparison of the model parameters and the assignment of scores according to a predefined grid. The extraction of parameters from BIM models provides a structured database that can seamlessly feed advanced decision-making models; for example, contractor evaluations can be mathematically optimised by integrating BIM datasets with outranking methods such as PROMETHEE [89]. This has proven highly effective in ranking alternatives by simultaneously processing quantitative parameters (e.g., BIM-extracted costs and expected durations) and qualitative assessments (e.g., past relationships and whole-life costs) in order to improve the consistency and legitimacy of the final award within e-procurement ecosystems [89].

Instead of manually extracting the BIM model to create the DBL, the system uses application programming interfaces (APIs), such as those provided by cloud-based platforms, which monitor in real time any geometric or alphanumeric changes made to the model. When an operator modifies an instance in the Common Data Environment (CDE), whether it be the replacement of a boiler or a change in the material of an envelope, a webhook mechanism detects the event and queries the database to extract the new information package.

This raw data, generally structured in JSON or XML formats, is processed by a transformation engine that normalises the information according to the schema required by the DBL; to meet the need for a constantly updated and easily accessible PDF document, a server-side document rendering service is activated at this point and a predefined graphic template is applied to the extracted data, instantly generating the PDF file each time a change in the model is validated. This file is not a simple static printout, but an intelligent digital document that contains all the information relating to the building, such as archived technical documents, construction and renovation costs, a history of maintenance work carried out on the building, a list of all the parties involved in the building, embedded 3D views and references to unique spatial coordinates, and a PDF that always reflects the latest approved status of the As-Built or As-Maintained model. In order to guarantee the persistence of the data, it is also necessary to archive previous versions of the DBL to ensure that stakeholders can trace the history of changes, while presenting the end user with only the latest synchronised instance of the building system. This ensures that the time discrepancy between the design/maintenance reality and the official documentation is eliminated, transforming the DBL from a static tool into an active monitoring tool.

3.3. Digital Building Logbook

E-procurement plays a crucial role in the creation of the Digital Building Logbook as it acts as a trigger for the systematic collection of data throughout the entire life cycle of the building. Digitising the procurement phase allows for the acquisition of granular and certified information, such as technical specifications of materials, sustainability certifications, costs and supplier references, which, if collected systematically, could generate a building information system capable of guiding not only the end user but all stakeholders who will come into contact with the building itself. Without this upstream integration, the DBL would risk being an incomplete collection of posthumous documents; on the contrary, thanks to BIM-powered e-procurement, it becomes a dynamic and reliable repository, ensuring the correct use of every component installed in the building and optimising its future management and maintenance.

The transformative potential of digitalisation lies mainly in its ability to optimise property management, acting as a support for improving the efficiency of building performance. This aspect of digitalisation is analysed in the report by the Buildings Performance Institute Europe (BPIE) report "The European Renovation Wave: From Words To Action" [146], which highlights information management, through a more organised and precise structure, as one of the main advantages of digital solutions. Rigorous information management appears, in fact, to be indispensable for governing the huge and diverse amount of data produced during the entire life cycle of a building [147]. This excessive proliferation of data and documents contributes to the fragmentation of information, complicating the processes of collecting, archiving, sharing and updating it and, at the same time, making its proper management essential [148]. It should also be considered that the acquisition of data by the various stakeholders involved in one or more phases of the building's life cycle is often inconsistent, leading to decisions based on the mere availability of the data rather than on its completeness or accuracy [19]. In addition, the elements collected and stored by a single entity may not be easily accessible or available to all actors involved in the building process [20]. These problems persist and intensify during the use phase of the asset, where the collection, management and use of information can be complex [149,150]. All this can lead to data compromise and incompatibility with the systems used by other stakeholders, creating information asymmetry, reducing transparency and significantly complicating the decision-making process [151,152]. In this context, DBL is an essential tool for the digital management of real estate assets, as it collects information relating to a specific building system [153]; a common repository for all relevant building data that facilitates transparency, trust, decision-making and information sharing between owners, building occupants, financial institutions and public authorities [154–156], capable of improving building efficiency [157] by supporting maintenance strategies to preserve the economic value of the property [158,159] and increase the performance of components throughout the entire life cycle of the building [160]. This tool also reduces the time and costs associated with retrieving missing information [19,151].

In line with European policy [161,162], the DBL is intended as a digital archive of all relevant data on a building, collected throughout its life cycle, including information from energy performance certificates, to achieve the climate objectives set by the European Union.

The concept of a Digital Building Logbook has only recently been introduced and remains an optional tool within the European AECO sector [19]; however, the idea of a tool for collecting and displaying building information by construction industry stakeholders to increase awareness and improve the quality of the built environment [163] has been discussed for decades in Europe [164,165]; therefore, there are several national versions of the Building Passport (BP) with different stakeholders, requirements and characteristics depending on the country in question [151,157,163]. Although there are a respectable number of national initiatives aimed at defining the concept and characteristics of the DBL [163,166,167] across Europe, there is no uniform and common archive, resulting in discrepancies in its organisation and the data required [160], although a unified European framework is being developed [168], finding recent and solid regulatory confirmation in EU Directive 2024/1275 (EPBD recast) [90], which promotes its systematic adoption to harmonise Building Renovation Passports.

Considering the above, the implementation of the DBL is a priority for Europe to promote the renovation of the building stock necessary to achieve the climate targets set. In fact, in 2016, the Building Renovation Passport (BRP) was defined by the BPIE [169] as "a document, in electronic or paper format, outlining a long-term (up to 15 or 20 years) step-by-step renovation roadmap for a specific building, resulting from an on-site energy audit that meets specific criteria and quality indicators established during the design phase and in dialogue with the building owners". The BRP was first introduced in an official document with Directive (EU) 2018/844 [170], as part of the long-term strategies that European Member States were required to design to promote the renovation of their building stock, and was conceived as a natural, more comprehensive and user-friendly evolution of the Energy Performance Contract (EPC) [163,171,172].

The operational effectiveness of DBL finds its main technological enabler in BIM. If DBL is the strategic container of information, BIM is its technical engine: it provides the structured and standardised information model needed to feed it with accurate and up-to-date data. The link between the two tools ensures continuity and acts as a guide for the various design choices both during construction and maintenance of the asset, ensuring greater traceability of materials and greater knowledge of the asset.

This data structuring is of fundamental importance in the context of e-procurement. The integration between DBL and e-procurement platforms allows for more transparent and efficient management of tenders, enabling contracting authorities to define requirements based on real data and measurable performance by implementing preventive maintenance based on real knowledge of the asset and the performance of its components.

In conclusion, the synergy between Digital Building Logbook, BIM and e-procurement could transform the construction sector into an integrated industrial process, but to achieve this, it is necessary to view these three elements as components of a single digital ecosystem that accompanies the building from the tender phase to operational management.

4. Methodology

To outline a comprehensive framework of e-procurement, studies concerning its implementation, public contract management, and the use of innovative platforms designed to digitalize the entire procurement process were analysed. These platforms aim to minimise human interaction to optimise operational traceability, ensure time reduction, and guarantee greater transparency.

Given the breadth and heterogeneity of the existing scientific literature on e-procurement within the civil construction sector, the methodological approach adopted required the definition of specific parameters to rigorously circumscribe the research field. For the general setup of the review, the methods utilised by Lopez et al. [173] and Yao et al. [174] were considered, alongside the publication sorting method proposed by Jang et al. [175]. To ensure transparency and repeatability, the conduct and reporting of this systematic review follow the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [176], in line with validated approaches in the literature, such as that of Regona et al. [177].

The literature retrieval process was conducted in February 2026 using the Scopus (Elsevier) bibliographic database, recognised by the bibliometric community for its advanced indexing, citation tracking, and metric analysis capabilities [107,178–180]. The search strategy employed a formal string based on Boolean operators, applied to the title, abstract, and keyword fields (TITLE-ABS-KEY). The complete search string used was as follows:

TITLE-ABS-KEY ("E-procurement" AND ("Digitalization" OR "Public Procurement" OR "Technology" OR "Methodology" OR "BIM"))

To rigorously select the sources, the following inclusion and exclusion criteria were defined a priori:

- Inclusion Criteria: (I) Peer-reviewed scientific publications (limited to Articles and Reviews); (II) English language; (III) relevance to the "Engineering" and "Computer Science" thematic macro-areas; (IV) publication in scientific journals with a SCImago Journal Rank (SJR) ≥ 0.5, to ensure proven scientific impact.
- Exclusion Criteria: (I) Conference proceedings, book chapters, and entire monographs; (II) documents in languages other than English; (III) studies not focused on the civil construction sector or considered "false positives" (marginal use of search terms); (IV) articles published in journals with SJR < 0.5 or lacking metric indexing.

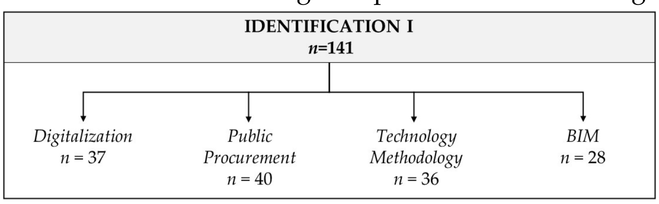
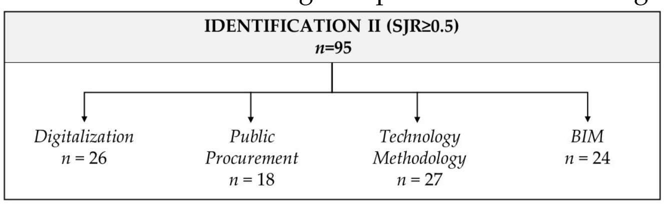
The protocol for filtering identified records (detailed in Table 1) was structured into the four standard phases of the PRISMA framework:

- Phase 1—Identification: The application of the initial search string returned 1810 articles. The application of automatic database filters (inclusion by language, document type, and subject area; exclusion of books and conference proceedings) reduced the sample to 361 articles.
- Phase 2—Screening and Transparent Manual Selection: The 361 resulting articles underwent manual screening. This phase involved a critical and independent reading of titles and abstracts to evaluate actual adherence to the theme of e-procurement in construction. Residual false positives and duplicates were manually removed. To

ensure transparency, doubtful cases were resolved through discussion and consensus, bringing the number of potentially relevant articles to 141.

- Phase 3—Eligibility: The editorial quality criterion (Identification II) was applied to the 141 selected articles. Only studies from journals with an SJR $\geq$ 0.5 were admitted for full-text analysis. This metric, derived from Scopus citation analysis, assigns a weighted value to journal prestige, further refining the sample.
- Phase 4—Inclusion: The rigorous application of these criteria generated a final corpus of 95 publications deemed suitable for full-text analysis.

Table 1. Methodology flow diagram.

Phases and Filters	Results
Recounts data extracted to 2025	E-procurement (only title, keywords and abstract) ↓ *n* = 1810
Specific range	2010–2025 ↓ *n* = 1222
Language text	English text ↓ *n* = 1200
Type research	Scientific article and review ↓ *n* = 617
Subject area	Engineering and computer sciences ↓ *n* = 361
Manual check Duplication check	Not-relevant topics Duplicates deleted ↓ *n* = 141
Identification I Main topic *n* = 141	Articles identified through Scopus database searching 
Identification II Main topic *n* = 95	Articles identified through Scopus database searching 
Full text analysis	Reviewed publications ↓ *n* = 95

These studies underwent a clear coding and classification procedure: each document was read in its entirety and assigned, based on its primary focus, to one of the four thematic categories derived from the original keywords.

The distribution of the 95-article corpus is as follows:

- Digitalization: 26 articles (focused on the dematerialization of processes).
- Public Procurement: 18 articles (centred on regulatory and management aspects).
- Technology and Methodology: 27 articles (concerning system architectures and operational frameworks).
- BIM: 24 articles (specific to the integration of information models in procurement).

This classification phase enabled the systematic collection of relevant data, facilitating the interpretation of results, critical discussion, and the proposal of directions for future research [102,181,182].

The proposed search method has certain limitations. Firstly, there is a risk of linguistic bias, as the review includes only studies in English, thereby risking the omission of significant findings documented in other languages [102,183]. Secondly, the decision to limit the search to the Scopus database alone and to use an SJR threshold of $\geq$0.5 as a strict eligibility criterion, whilst ensuring the high editorial validity of the included sources, may have excluded a priori relevant studies published in emerging journals or those not yet fully indexed.

5. Data Analysis

The methodological approach described above is not merely a procedural step but represents the logical and qualitative foundation on which the entire data analysis is based. The systematic methodology, based on the PRISMA protocol and stringent quality criteria (such as the SJR threshold $\geq$ 0.5), made it possible to transform the initial heterogeneous bibliographic landscape into a granular and coherent corpus of 95 publications. Furthermore, the choice of Scopus as the primary source made it possible to apply the analytical capabilities of the database in the subsequent scientometric analysis, allowing the data thus obtained to be transformed into impact and global production indicators that justify the trends found, as will be seen below. The systematic screening was specifically designed to move beyond a frequency-based analysis, aiming to map the functional interplay between procurement administrative frameworks and technical modelling tools.

Similarly, the use of network visualisation software, such as VOSviewer (version 1.6.19), allowed for the analytical extension of the filtering criteria and conceptual categories identified during the manual screening phase into an easier-to-read graphical representation. Temporal fluctuations and peaks of interest for e-procurement were therefore identified, as well as correlations between keywords that emerged in the analysis.

The following study of the data, therefore, is not limited to describing the literature but processes it, producing an analysis that is not simply a descriptive review but a critical synthesis that traces all empirical evidence back to the robustness of the methodology applied, allowing the evolution of the e-procurement sector to be outlined with scientific precision.

As mentioned, following a systematic review of the literature, identified as a powerful research approach to investigate both past and present theories [184–186], whose methodology has been outlined above, this study adopted an integrated approach based on bibliometric, scientometric, thematic and content analysis techniques, aimed at the systematic examination of data extracted from a corpus of 95 articles from which the temporal distribution of publications, the geographical origin and the scientific journals involved, as well as the identification of peaks associated with specific keywords.

Table 2 shows the scientific journals, the main topics covered, the impact factor and the number of articles resulting from the detailed selection of each journal.

Table 2. Publish workflow.

Source Title	Main Topic	SJR	Articles
Sustainability (Switzerland)	Sustainability and environment	0.672	7
Journal Of Enterprise Information Management	Information & knowledge management	1.648	5
International Journal Of Production Research	Computer science & supply chain	2.668	5
International Journal Of Production Economics	Computer science & supply chain	3.074	5
Computers In Industry	Computer science	2.453	5
Automation In Construction	Building and construction	2.626	10
Transforming Government People Process And Policy	Transforming government	0.661	4
Journal Of Organizational Computing And Electronic Commerce	Computer science and information system	0.523	4
Journal Of Engineering Design And Technology	Computer science and construction management	0.6	4
International Journal Of Logistics Research And Applications	Supply chain and supply chain management	1.322	4
International Journal Of Construction Management	Computer science and construction management	1.085	5
Expert Systems With Applications	Computer science and fuzzy logic	1.875	4
Electronic Commerce Research And Applications	Internet and computer science	1.338	4
Telecommunications Policy	Competition (economics) and computer science	1.647	3
Production Planning And Control	Supply chain and computer science	2.02	3
Production And Operations Management	Computer science and supply chain	3.035	3
Electronic Journal Of Information Technology In Construction	Construction management and Building Information Modelling	0.733	5
Computers And Industrial Engineering	Computer science and supply chain	1.701	3
Journal Of Theoretical And Applied Electronic Commerce Research	Computer science and E-commerce	0.892	2
Journal Of Information Technology In Construction	Information system and Engineering	0.733	2
Journal Of Information Technology	Strategic information system and nformation system	1.443	2
Journal Of Global Information Management	Computer science and information system	0.838	2
Information Technology For Development	Information and communications technology and information technology	1.249	2
Information Technology And People	Computer science and originality	1.244	2
Information Systems Frontiers	Computer science and information system	1.577	2
IEEE Transactions On Engineering Management	Technology and engineering management	1.201	2
Construction Innovation	Computer science and construction management	0.754	2
Buildings	Construction activities	0.575	6

Table 2. *Cont.*

Source Title	Main Topic	SJR	Articles
Australasian Journal Of Information Systems	Information system and engineering	0.582	2
Advanced Engineering Informatics	Computer science and biology	1.731	2
Vine Journal Of Information And Knowledge Management Systems	Computer science and originality	0.53	1
Transportation Research Part E Logistics And Transportation Review	Civil and structural engineering	2.884	1
Telematics And Informatics	Social impacts of new technologies	1.827	1
Technovation	Entrepreneurship and technology management	2.593	1
Operations Management Research	Operations management	1.377	1
Operational Research In Engineering Sciences Theory And Applications	Management and engineering	0.801	1
Ksce Journal Of Civil Engineering	Civil and structural engineering	0.534	1
Knowledge Based Systems	Artificial intelligence	2.219	1
Journal Of Simulation	Theory and application of simulation modelling	0.621	1
Journal Of Operations Management	SI operations research and management science	3	1
Journal Of Internet Commerce	Internet electronic commerce in businesses	1.338	1
Journal Of Information Technology And Politics	Impacts of politics and government of IT	1.107	1
Journal Of Hospitality And Tourism Technology	E-commerce in tourism	1.285	1
Journal Of Emerging Technologies In Accounting	Computer science and audit	0.559	1
Journal Of Decision Systems	Systems development	0.746	1
Journal Of Cleaner Production	Environmental science	2.058	1
Journal Of Civil Engineering And Management	Civil and structural engineering	0.737	1
International Journal Of Systems Science	Intelligence and autonomy of general system level	1.851	1
International Journal Of Information Management	Facility management	5.775	1
International Journal Of Industrial Engineering And Management	Industrial engineering	0.519	1
International Journal Of Enterprise Information System	Enterprise Resource Planning and information system	0.5	1
International Journal Of Computer Integrated Manufacturing	Computer science	0.987	1
Information Systems And E Business Management	Information systems applications	0.604	1
Information Systems	Information systems applications	1.201	1
Information And Management	Information systems applications	2.594	1
Industrial Management And Data Systems	Computer science and supply chain	1.207	1

https://doi.org/10.3390/buildings16101969

Table 2. *Cont.*

Source Title	Main Topic	SJR	Articles
IEEE Systems Journal	Computer science and engineering	1.402	1
IEEE Access	Computer science	0.96	1
Future Internet	Internet technologies	0.808	1
Operational Research in Engineering Sciences: Theory and Applications	Engineering sciences	0.801	1
Engineering Construction And Architectural Management	Engineering	0.896	2
Energies	Engineering	0.651	1
Computers In Human Behavior	Psychological perspective	2.641	1
Computer Law And Security Review	Technology law	0.847	1
Applied Sciences Switzerland	Facility management	0.508	3
Journal of Construction Engineering and Management	Facility management and engineering	1.071	5
Journal of Infrastructure Systems	Civil and structural engineering	0.584	1
Journal of Management in Engineering	Facility management	1.475	1

Figure 5 shows the trend of publications, from 2010 to 2025, divided into four thematic areas.

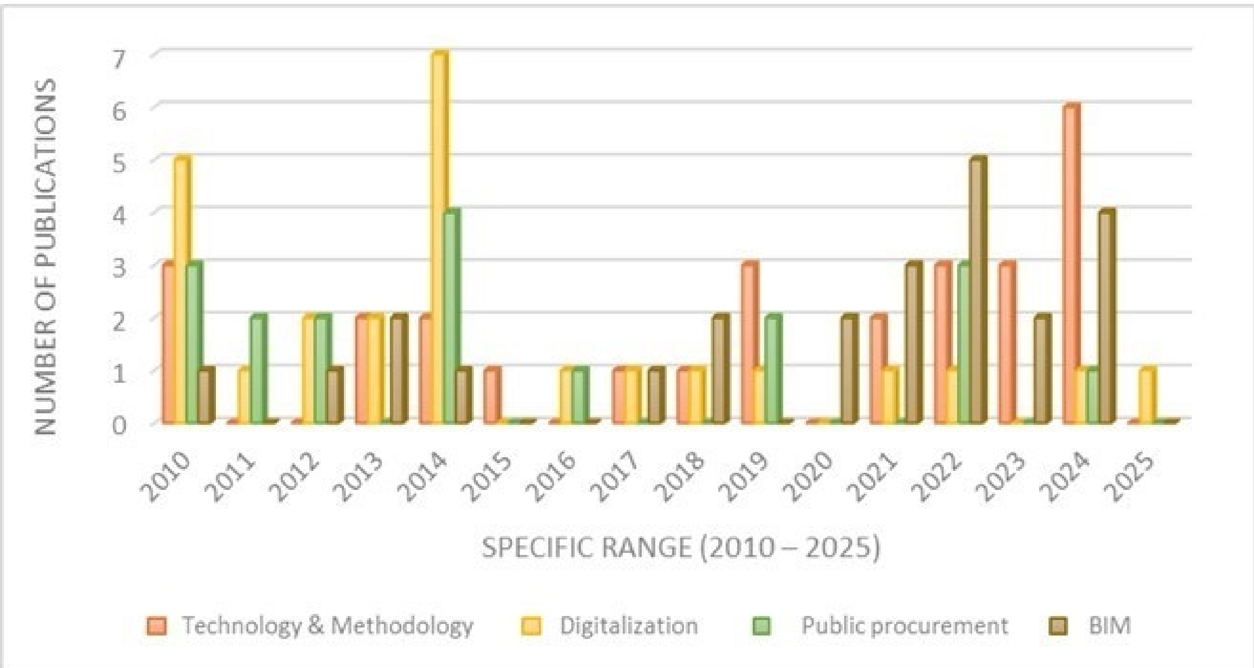


Figure 5. Trend of publications (from 2010 to 2025) for four main topics.

Looking at the general trend, there has been a fluctuation in scientific interest in these issues over the fifteen-year period. While the evolution of the EP and associated platforms has been promising over the last ten years [57], with significant developments and updates, scientific contributions on the subject have been declining, with a slight recovery in recent years. In particular, 2014 was a period of high editorial productivity, with a large number of publications concentrated in the categories “Digitalisation” and “Public procurement”, followed by years of low literary production. The most recent period, between 2022 and 2024, shows a marked increase in interest in BIM-related topics along with significant scientific production on the evolution of innovative technologies and methodologies in the AECO sector, while 2020 stands out for a decline in publishing activity, likely due to the global crisis.

In terms of the number of contributions, twenty-seven countries have published on the subject, with a concentration of productivity (minimum five articles) in six countries: Australia, Hong Kong, Malaysia, Nigeria, the United States and the United Kingdom. On the other hand, the citation index shows that high productivity does not necessarily translate into greater impact. A case in point is Sweden, which, despite limited production, has published over 100 exceptionally influential articles, surpassing the impact of some of the most active national contexts [1].

Analysis of the volume of production and citation impact of research on e-procurement reveals a heterogeneous picture at the global level [1] (Figure 6).

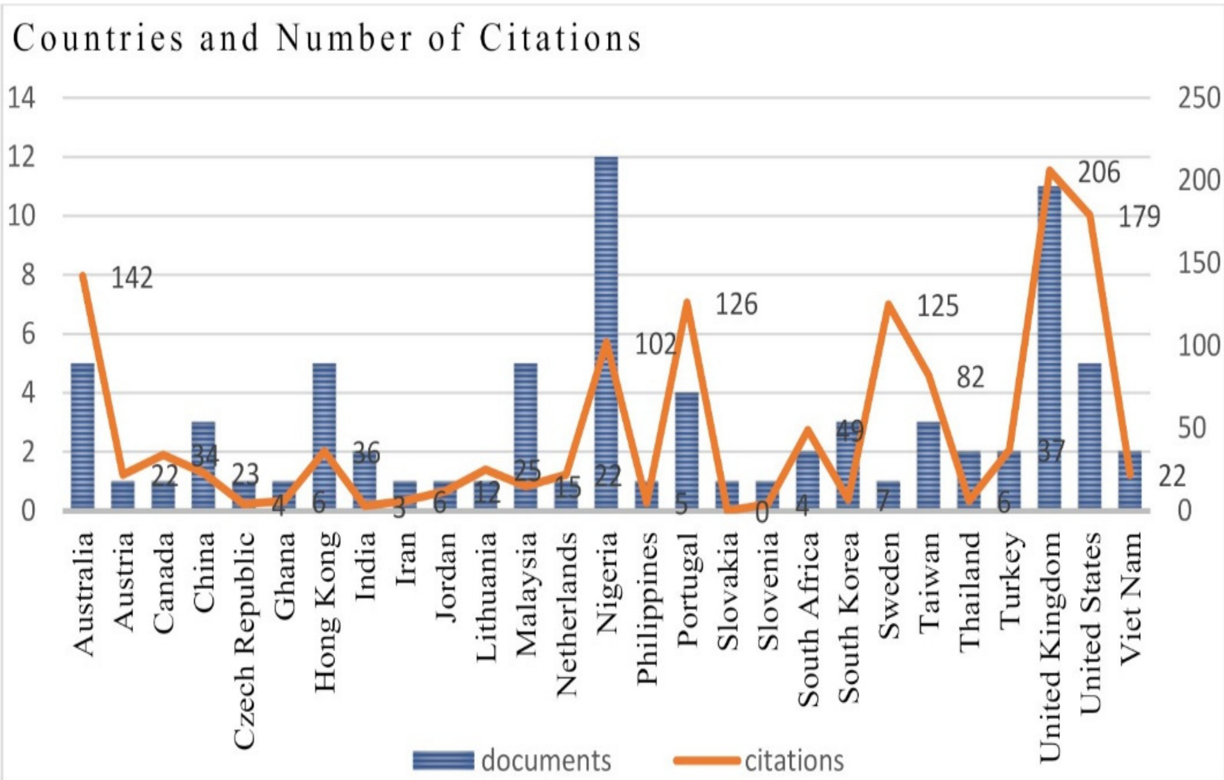


Figure 6. Distribution of manuscripts by country [1].

Based on the above, this literature review is structured in several stages of identification and manual checking based mainly on three fixed parameters:

- Specific time frame (2010–2025);
- Articles in scientific journals;
- Articles written in English.

Analysis of the corpus of publications led to the identification of the most frequently used keywords, searched for in the title, abstract, and author keywords, and summarised in Table 3. This allowed the corpus to be categorised into three main topics.

Table 3. Keywords for the main e-procurement topics.

Main Topic	Keywords
Digitalization	E-procurement, E-tendering, E-marketplaces, E-commerce, Sustainable procurement, E-business, E-government, Procurement Process, Tendering Process, Efficiency, Optimization, Performance, Implementation, Economics, Supply Chain, Sustainable Development, Industry 4.0
Public Procurement	Transparency, Procurement, Corruption, Public Sector, Local Government, Governance, Construction Procurement, Construction Industry, Construction Projects, Building Industry
Technology & Methodology	Information Technology, Information use, Websites, Artificial Intelligence, Machine Learning, Big Data Analytics, Electronic Data Interchange, Internet, Planning Method, Cloud computing, Factor Analysis
BIM	Technology Adoption, Language processing, Data visualization, Design/methodology/approach, Decision Making, Project Management, Economics, Costs, Supply Chain Performance, Agent-based Model

An increase in the use of certain keywords was observed, which were subsequently grouped into prevalent thematic areas. To corroborate this analysis, bibliographic data extracted from Scopus was processed using VOSviewer. This tool made it possible to create visualisation maps (network, overlap, density; Figures 7–9) that graphically represent research dynamics over the last fifteen years, highlighting the co-occurrences of keywords selected by authors in scientific publications.

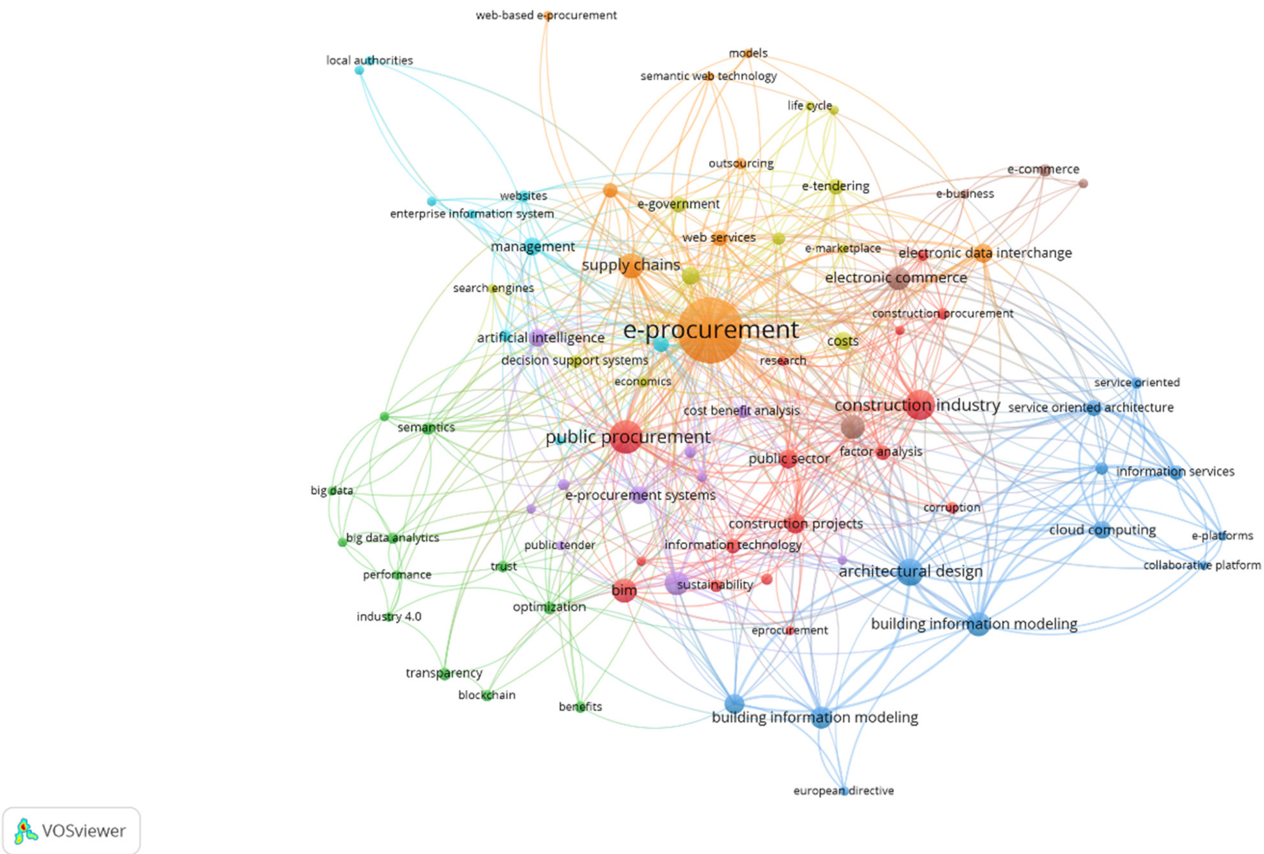


Figure 7. Analysis of keyword co-occurrences with network visualisation.

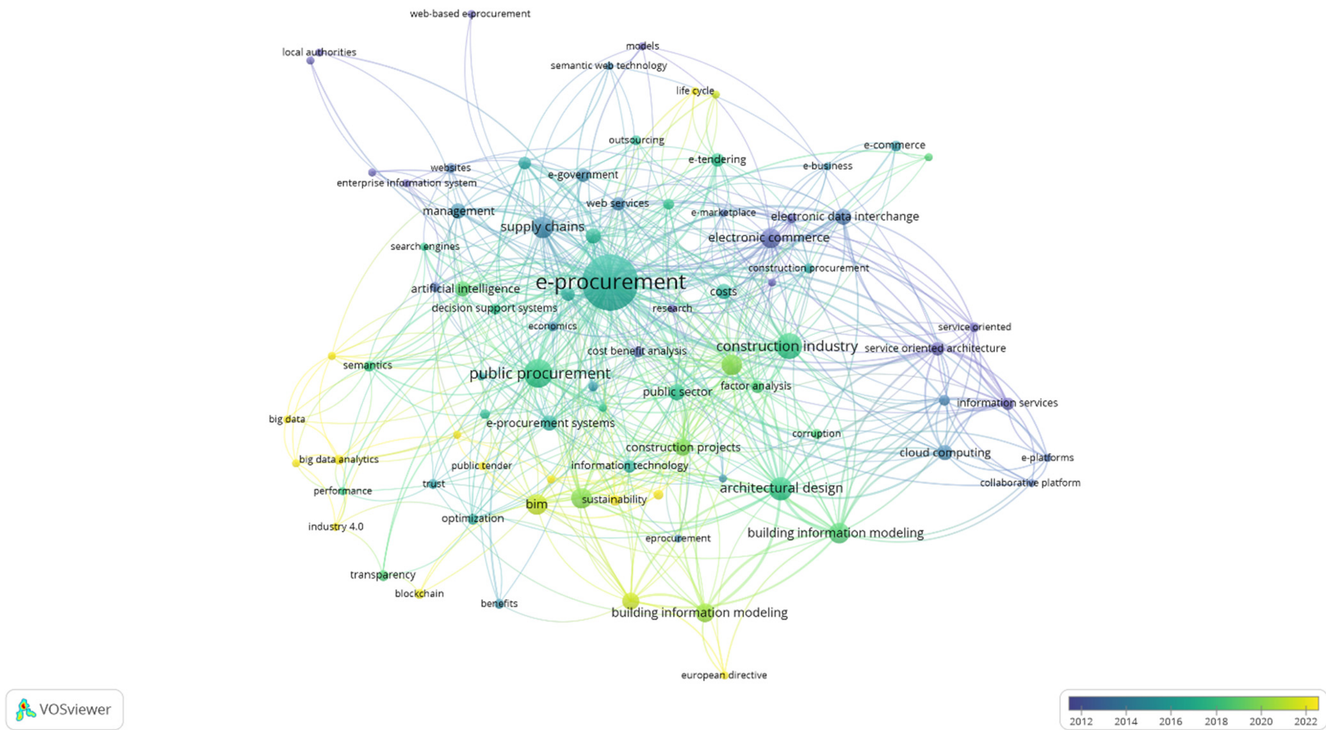


Figure 8. Analysis of keyword co-occurrences with overlay visualisation.

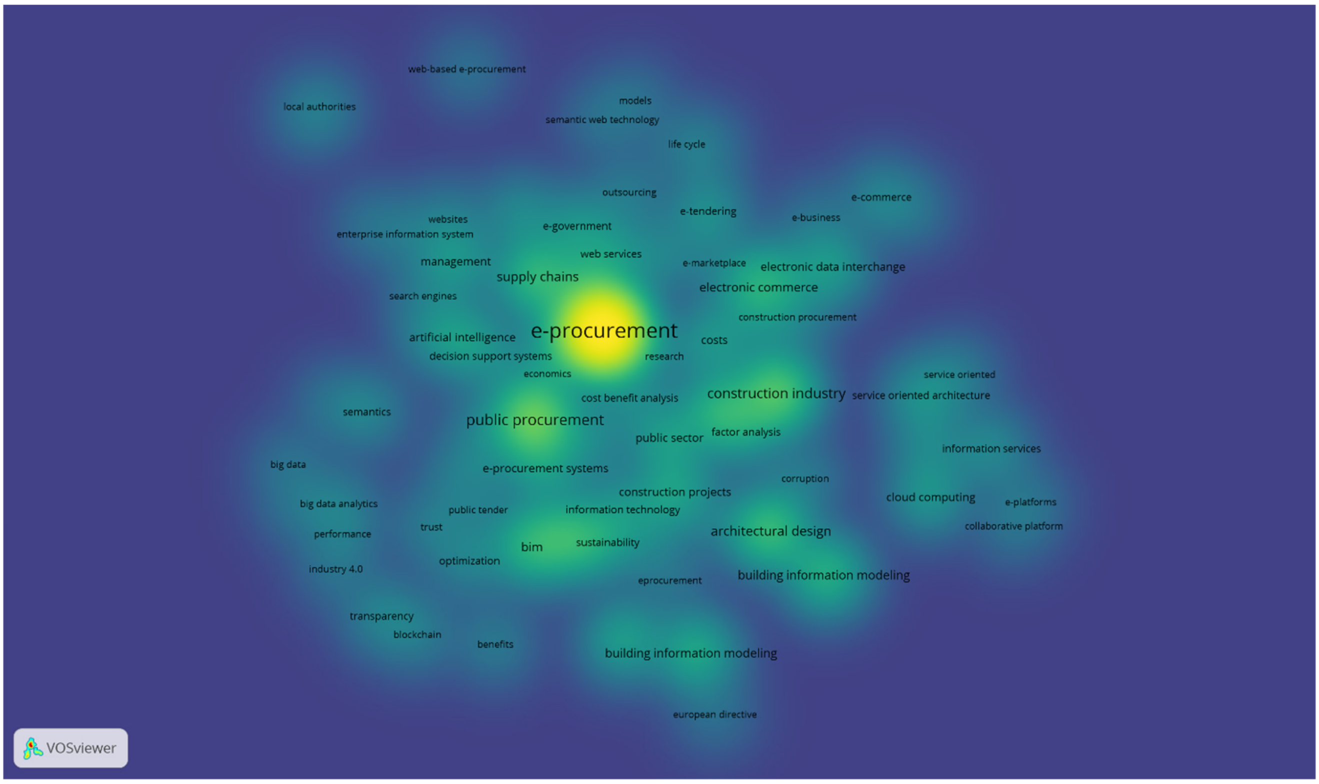


Figure 9. Analysis of keyword co-occurrences with density display.

Figure 7 reveals a complex ecosystem in which electronic procurement is no longer an isolated element, but the hub of a transformation involving technologies, administrative processes and specific industrial sectors. At the centre of the network is the infrastructural and theoretical core (orange cluster), dominated by the concept of e-procurement and supply chain management. This cluster represents the backbone of the system, connecting basic web technologies to e-government services and electronic markets, and acts as the main hub for all other issues.

Closely linked to this central core is the application context of public procurement (red cluster), focused specifically on the construction industry. The modernisation of this sector is made possible by technology and design (blue cluster), which is deeply intertwined with the construction industry; this cluster demonstrates that the evolution of procurement necessarily involves the adoption of advanced digital tools such as Building Information Modelling (BIM), cloud computing and service-oriented architectures; this strong interconnection (between the red and blue clusters) suggests that digitalisation is not only a support but a structural component of architectural design and modern construction management.

At the same time, there is a shift towards advanced innovation and decision-making (green cluster). This thematic area introduces the use of cutting-edge technologies such as Artificial Intelligence, Big Data and Blockchain.

Figure 8 reveals, through the actual absence of a link, the need to focus on the main issues relating to EP, namely the development and application of dynamic tools and innovative techniques capable of guiding the entire operational process relating to procurement.

Thanks to the analysis of the content of the 95 articles and the adoption of the research method described above, we have arrived at a comprehensive critical review of EP and innovative techniques for public procurement management. The aim is to provide an interpretative framework for the constructs developed, enabling an in-depth discussion of the conceptual dimensions that have emerged and contributing to the definition of the existing field of research. The theoretical integration emerging from this study suggests that the development trend is moving toward a 'Unified Digital Lifecycle'. In this model, information modelling tools and e-procurement platforms are no longer parallel silos but integrated nodes where the digital twin of the building directly informs the legal and economic workflow of the tender, reducing information asymmetry and enhancing process transparency.

Furthermore, analysis of the literature revealed that there is no actual link between EP and DBL, as shown in the figure below (Figure 10).

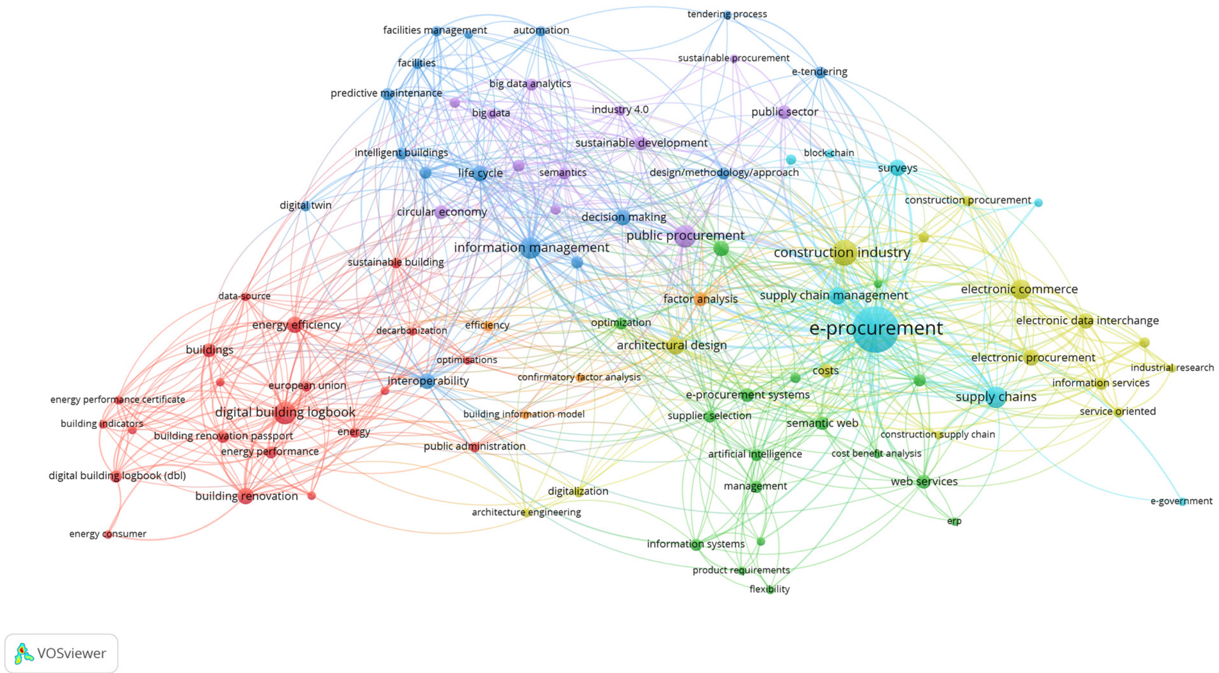


Figure 10. Link analysis between EP and DBL themes identified through keyword mapping and network visualization.

As can be seen from the image, e-procurement is at the centre of this scenario (light-blue cluster). This area of the map shows a dense network of connections with supply chain management and e-commerce.

The red cluster focuses on DBL; this cluster closely links digital information management to environmental sustainability. As can be seen from the figure above, the two clusters are not directly linked but are connected by the digitalisation process that is sweeping through the AECO sector (green-yellow cluster).

Bridging the gap between digital procurement administration and physical building management is the vast area dedicated to information management and Industry 4.0 (blue cluster). The purple cluster representing sustainable public procurement links the theme of public procurement with sustainable development and tendering procedures.

In summary, the map describes a sector undergoing a profound metamorphosis, namely an interconnected system where the digitalisation of administrative processes meets environmental responsibility through the intelligent use of information.

6. Discussion

Analysis of the literature has revealed the numerous advantages offered by the use of e-procurement in public administration, such as process automation, which minimises the likelihood of human error and ensures faster delivery times by optimising overall operational efficiency, and the increased competition between suppliers offered by these systems, as they enable the creation and use of transparent platforms that promote competition for the award of contracts and enable data-driven decision-making processes, allowing the available information to be exploited to improve strategic choices.

Despite these obvious benefits, however, there are still significant difficulties associated with the effective implementation of such procedures within public administrations. These problems are mainly related to inadequate infrastructure, insufficient staff training and resistance to change [13,187,188]. Furthermore, as discussed in the previous section, there is a lack of a real link between electronic procurement procedures and BIM [189,190]; although it is used as an information tool in tenders, its transformative potential in the procurement process remains largely untapped, often relegating the model to a simple information support role rather than a central and dynamic tool in the award procedure. As argued by Costa and Grilo [61], the application of BIM in the context of e-procurement is an enabling factor for the optimisation of electronic procurement systems, allowing for the adoption of more advanced approaches; furthermore, this synergy promotes the development of large electronic and interoperable networks that interact dynamically, strengthening the automation of many operational activities and improving information and knowledge management. In fact, BIM brings to e-procurement the possibility of building, within the various activities of the process, a more cooperative working relationship between all specialities, allowing for a more efficient use of resources, a consequent reduction in time and errors due to lack of information and communication [61,191], and an increase in transparency.

With BIM-based e-procurement, information can effectively flow more smoothly through the application of various agents within the procurement processes [61]. The synergy between e-procurement and BIM, therefore, represents a strategic solution for addressing the main issues in the public procurement sector. In fact, ANAC data, based on the European TED platform, show that Italy has significantly longer award times than France, Germany and Spain, both for MEAT contracts (279 days) and for those at the lowest price (195 days) [192]; this slowness entails high costs for both the public administration and businesses, negatively affecting the quality of services. Another limitation of traditional procurement, which can be easily overcome through the use of BIM methodology, is the lack of transparency in the procurement system, which encourages corruption [33] and undermines competition and public trust. e-procurement supported by BIM methodologies digitises and tracks the entire life cycle of the contract and, therefore, thanks to greater accessibility to information and strengthened control by stakeholders, it can contribute to a more efficient, fair and responsible system, reducing timeframes and ensuring clearer decision-making processes.

In conclusion, the integration of BIM into EP represents a qualitative leap for electronic procurement in the AEC sector and shifts the focus from simple digital management of documents and procedures to digital management of integrated and structured project information, thus achieving a more intelligent, accurate, transparent and collaborative procurement process, capable not only of optimising the tender phase but also of laying the foundations for more efficient management of the entire life cycle of the project [141].

7. Conclusions

7.1. Presentation of Results

The research highlights the transition of e-procurement from an isolated function to an integrated digital ecosystem based on web technologies for e-government services and electronic markets, allowing the identification of critical variables for the public construction sector such as transparency, technical and economic sustainability, and cost flow optimisation.

https://doi.org/10.3390/buildings16101969

From the study of the various articles, it can be deduced that there is a strong push towards the modernisation of this sector, made possible by the development of design-related technology; the evolution of procurement necessarily involves the adoption of advanced digital tools such as Building Information Modelling, which determines digitisation, not as a mere support, but as a structural component of the design and management of works. It has been highlighted that the digitisation of procurement, driven mainly by e-procurement and BIM, is a key factor in improving efficiency, transparency and traceability in public procurement. However, the integration between e-procurement and BIM is still partial and uneven across the different stages of the contract life cycle. On the one hand, e-procurement systems have been shown to reduce transaction times and costs, promoting process automation and the use of data to support decision-making; on the other hand, technological, organisational and cultural obstacles remain that slow down their dissemination, such as infrastructure deficiencies, poor system interoperability and limited availability of digital skills. As far as BIM is concerned, although it is increasingly mentioned in calls for tenders, its use often appears to be limited to a documentary function, without any real operational use in digital flows. This highlights the need for a shared methodological framework that clearly defines its role and application criteria within procedures. The regulatory framework, which in recent years has progressively introduced increasingly stringent digital obligations and standards, now also requires substantial alignment of practices and greater attention to the quality of data and processes.

From a methodological point of view, the analysis of the literature has made it possible to trace the main research trends, while identifying significant gaps to be filled. The priorities that emerge include: the adoption of open and interoperable approaches to tender information requirements, the definition of common standards for data integration, the introduction of performance indicators that allow for objective monitoring of results, and investment in training and change management programmes for contracting authorities.

In this context, the contribution of this research lies in highlighting the need to move beyond the current fragmented approach, promoting an integrated vision in which e-procurement, BIM and advanced information systems operate as components of a single digital ecosystem. Only through such integration will it be possible to achieve tangible benefits in terms of efficiency, transparency and the quality of decision-making processes, radically transforming the public procurement paradigm in the AECO sector.

7.2. Future Developments

The findings that have emerged point to numerous avenues for future research, focusing on both methodological development and practical experimentation. Firstly, it appears to be a priority to define shared operational models for the integration of BIM and e-procurement, based on OpenBIM approaches and interoperable standards, to ensure technological neutrality, inclusivity and maximum participation by economic operators. In this context, BIM can evolve from an information tool into a genuine decision-making engine for the tender process, through the definition of parametric models in which evaluation criteria are translated into automatically measurable and verifiable variables. The adoption of automation tools, such as advanced scripts and standards like IFC, enables the development of automated tender evaluation systems, reducing discretionary decision-making and increasing transparency. Such approaches pave the way for procurement models based on computational logic, in which tender selection takes place through objective and replicable processes. A further area of development concerns the integration of emerging technologies.

The use of blockchain can ensure the immutability and traceability of tender data, whilst the application of artificial intelligence and machine learning algorithms can support the automatic verification of the regulatory and technical compliance of bids, enabling automated compliance checking systems capable of operating in real time. At the same time, there is a growing need to strengthen the link between e-procurement and the Digital Building Logbook (DBL), which is currently still weak. The integration of these tools would allow the informational value of the tender phase to be extended to the entire life cycle of the project, transforming project data into a continuous and dynamic information asset. From this perspective, the DBL can evolve into a Decision Support System (DSS), capable of guiding building management, maintenance and monitoring activities through data-driven predictive models. Finally, a further area of research concerns the integration between BIM and Green Public Procurement (GPP) practices.

Author Contributions: Conceptualisation, E.B., F.P., E.P.Z., S.L.S., A.S. and S.A.B.; methodology, E.B. and A.S.; software F.P. and E.P.Z.; validation, E.B., F.P., E.P.Z., S.L.S. and A.S.; formal analysis, E.B. and A.S.; investigation, E.B. and E.P.Z.; resources, E.B. and F.P.; data curation, E.B.; writing—original draft preparation, E.B.; writing—review and editing, E.B., S.L.S. and A.S.; visualisation, E.B., F.P., E.P.Z., S.L.S. and A.S.; supervision, S.L.S. and A.S.; project administration, S.L.S. and A.S.; funding acquisition, S.L.S., A.S. and S.A.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Italian Ministry of University and Research grant number E53C24002940001. And the APC was funded by the University of Naples Federico II.

Data Availability Statement: The data presented in this study are available within the article. All analyzed documents and literature sources are properly cited in the reference list.

Acknowledgments: This article was produced as part of the digITER project (Digital Information Technologies for Life-cycle Management of E-permit Requirements), funded by the Italian Ministry of University and Research (MUR) under the National Research Programme and Projects of Significant National Interest (PRIN)—ref. 2022ZMY5SN—ERC sector PE8_3, developed in collaboration between the Politecnico di Milano, the University of Brescia, the University of Naples Federico II and the Politecnico di Bari. This project aims to define requirements, rules and methods for the application of Information and Communication Technologies (ICTs) and BIM for the semi-automatic control of data during the definition, control, review and approval processes in the case of new constructions, retrofitting and renovations, for both public and private works. Furthermore, the project focuses on the approval and acquisition of documentation relating to public works, as well as on identifying appropriate methods for archiving, controlling and retrieving the data necessary to validate and manage contracts.

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

Abbreviations

The following abbreviations are used in this manuscript:

EP	Electronic Procurement
BIM	Building Information Modelling
DBL	Digital Building Logbook
ICT	Information and Communication Technology
B2C	Business to Consumer
B2B	Business-to-business
B2G	Business to Government
EDI	Electronic Data Interchange
RFI	Request For Information
RFP	Request for Proposal
E-MRO	Electronic Maintenance, Repair and Operations

ERP	Enterprise Resource Planning
KPI	Key Performance Indicator
BPIE	Buildings Performance Institute Europe
AECO	Architecture, Engineering, Construction and Operation
BP	Building Passport
BRP	Building Renovation Passport
EPC	Energy Performance Contract
CAD	Computer-Aided Design
IFC	Industry Foundation Classes
OICE	Organizzazioni di Ingegneria e di Consulenza (Tecnico-Economica)
IT	Information Technology
eIDAS	electronic IDentification, Authentication and trust Services
DGUE	Documento di Gara Unico Europeo
AGID	Agenzia per l'Italia Digitale
ANAC	Autorità Nazionale Anticorruzione
TED	Technology, Entertainment, Design
MEAT	Most Economically Advantageous Tender
MCDA	Multi-Criteria Decision Analysis
DSC	Decision Support Concept
DPP	Digital Product Passport
DSS	Decision Support System

References

1. Chan, A.P.C.; Owusu, E.K. Evolution of Electronic Procurement: Contemporary Review of Adoption and Implementation Strategies. *Buildings* **2022**, *12*, 198. [CrossRef]
2. Matei, L.; Lazar, C.G. Quality Management and the Reform of Public Administration in Several States in South-Eastern Europe. Comparative Analysis. *Theor. Appl. Econ.* **2011**, *18*, 65–98.
3. Mavidis, A.; Folinas, D. From Public E-Procurement 3.0 to E-Procurement 4.0; A Critical Literature Review. *Sustainability* **2022**, *14*, 11252. [CrossRef]
4. Owusu, E.K.; Chan, A.P.C.; Wang, T. Tackling corruption in urban infrastructure procurement: Dynamic evaluation of the critical constructs and the anti-corruption measures. *Cities* **2021**, *119*, 103379. [CrossRef]
5. Laryea, S.; Ibem, E.O. Patterns of Technological Innovation in the use of e-Procurement in construction. *J. Inf. Technol. Constr.* **2014**, *19*, 104–125.
6. Taher, G. Industrial Revolution 4.0 in the Construction Industry: Challenges and Opportunities. *Manag. Stud. Econ. Syst.* **2021**, *6*, 109–127. [CrossRef]
7. Oesterreich, T.D.; Teuteberg, F. Understanding the implications of digitisation and automation in the context of Industry 4.0: A triangulation approach and elements of a research agenda for the construction industry. *Comput. Ind.* **2016**, *83*, 121–139. [CrossRef]
8. Issa, R.R.; Flood, I.; Caglasin, G. A survey of e-business implementation in the US construction industry. *J. Inf. Technol. Constr.* **2003**, *8*, 15–28.
9. Yevu, S.K.; Yu, A.T.W.; Darko, A. Barriers to electronic procurement adoption in the construction industry: A systematic review and interrelationships. *Int. J. Constr. Manag.* **2021**, *23*, 964–978. [CrossRef]
10. Toktaş-Palut, P.; Baylav, E.; Teoman, S.; Altunbey, M. The impact of barriers and benefits of e-procurement on its adoption decision: An empirical analysis. *Int. J. Prod. Econ.* **2014**, *158*, 77–90. [CrossRef]
11. Hong, Y.; Shao, B.B.M. On Factors that Moderate the Effect of Buyer-Supplier Experience on E-Procurement Platforms. *Prod. Oper. Manag.* **2021**, *30*, 1034–1051. [CrossRef]
12. Seri, P.; Bianchi, A.; Matteucci, N. Diffusion and usage of public e-services in Europe: An assessment of country level indicators and drivers. *Telecommun. Policy* **2014**, *38*, 496–513. [CrossRef]
13. Egwim, P.; Dike, B.U.; Nmecha, M.I. Adapting the e-procurement process from the private and public sector: A comprehensive overview. *Soc. Sci.* **2024**, *1*, 1–15. [CrossRef]
14. Aduwo, E.; Ibem, E.O.; Afolabi, A.O.; Oluwnmi, A.O.; Tunji-Olayeni, P.F.; Ayo-Vaughan, E.A.; Uwakonye, U.O.; Oni, A.A. Exploring anti-corruption capabilities of e-procurement in construction project delivery in Nigeria. *Constr. Econ. Build.* **2020**, *20*, 56–76. [CrossRef]
15. Neupane, A.; Soar, J.; Vaidya, K. An Empirical Evaluation of the Potential of Public E-Procurement to Reduce Corruption. *Australas. J. Inf. Syst.* **2014**, *18*, 21–44. [CrossRef]

16. Sanchez-Graells, A. Procurement Corruption and Artificial Intelligence. In *Routledge Handbook of Public Procurement Corruption*; Routledge: London, UK, 2024; pp. 29–41. [CrossRef]
17. Salvalai, G.; Sesana, M.M.; Dell'Oro, P.; Brutti, D. Open Innovation for the Construction Sector: Concept Overview and Test Bed Development to Boost Energy-Efficient Solutions. *Energies* **2023**, *16*, 5522. [CrossRef]
18. Tanoli, W.A. Assessing Drivers, Barriers and Policy Interventions for Implementing Digitalization in the Construction Industry of Pakistan. *Buildings* **2025**, *15*, 2798. [CrossRef]
19. Signorini, M.; Dejaco, M.C.; Spagnolo, S.L. The Evolution of Digital Building Logbook: Exploring Building Information Gathering Systems to Boost Building Maintenance and Renovation. *Appl. Sci.* **2025**, *15*, 771. [CrossRef]
20. Volt, J.; Toth, Z.; Glicker, J.; De Groote, M.; Borragan, G.; De Regel, S.; Dourlens-Quaranta, S.; Carbonari, G. Definition of the Digital Building Logbook-Report 1 of the Study on the Development of a European Union Framework for Buildings. In *Digital Logbook*; Publications Office of the European Union: Luxembourg, 2020.
21. Chen, X.; Chang-Richards, A.; Ling, F.Y.Y.; Yiu, T.W.; Pelosi, A.; Yang, N. Developing a readiness model and a self-assessment tool for adopting digital technologies in construction organizations. *Build. Res. Inf.* **2022**, *51*, 241–256. [CrossRef]
22. Naji, K.K.; Gunduz, M.; Alhenzab, F.H.; Al-Hababi, H.; Al-Qahtani, A.H. A Systematic Review of the Digital Transformation of the Building Construction Industry. *IEEE Access* **2024**, *12*, 31461–31487. [CrossRef]
23. Aghimien, D.; Aigbavboa, C.; Oke, A.; Thwala, W. Digitalisation in construction. In *Construction Digitalisation*; Routledge: London, UK, 2021; pp. 64–112. [CrossRef]
24. Knight, L.; Harland, C.; Telgen, J.; Thai, K.V.; Callender, G.; McKen, K. (Eds.) *Public Procurement: International Cases and Commentary*; Routledge: New York, NY, USA, 2012.
25. Zouhar, Y. *Public Expenditure and Inclusive Growth—A Survey*; IMF Working Papers: Washington, DC, USA, 2021; Volume 2021, p. 1. [CrossRef]
26. Thai, K.V.; Grimm, R. Government procurement: Past and current developments. *J. Public Budg. Account. Financ. Manag.* **2000**, *12*, 231–247. [CrossRef]
27. Chan, A.P.C.; Owusu, E.K. Corruption Forms in the Construction Industry: Literature Review. *J. Constr. Eng. Manag.* **2017**, *143*, 04017057. [CrossRef]
28. Le, Y.; Shan, M.; Chan, A.P.C.; Hu, Y. Investigating the Causal Relationships between Causes of and Vulnerabilities to Corruption in the Chinese Public Construction Sector. *J. Constr. Eng. Manag.* **2014**, *140*, 05014007. [CrossRef]
29. Wittig, W.A. *Public Procurement and the Development Agenda*; International Trade Centre: Geneva, Switzerland, 2000.
30. Callender, G.; Schapper, P. Public Procurement Reform in Australia: A Federal-State Evaluation. International Research Study of Public Procurement. In Proceedings of the International Research Study of Public Procurement, Budapest, Hungary, 10–12 April 2003.
31. Schoeni, D. Corruption in Defense Procurement. In *Routledge Handbook of Public Procurement Corruption*; Routledge: London, UK, 2024; pp. 113–129. [CrossRef]
32. Iqboljon o'g'li, R.Z. The Impact of Corruption on the Public Procurement System: The Experience of Uzbekistan and Estonia. *Int. J. Law Criminol.* **2025**, *5*, 10–13. [CrossRef]
33. Tabish, S.Z.S.; Jha, K.N. Analyses and evaluation of irregularities in public procurement in India. *Constr. Manag. Econ.* **2011**, *29*, 261–274. [CrossRef]
34. Thio-ac, A.; Domingo, E.J.; Reyes, R.M.; Arago, N.; Jorda, R., Jr.; Velasco, J. Development of a Secure and Private Electronic Procurement System based on Blockchain Implementation. *Int. J. Adv. Trends Comput. Sci. Eng.* **2019**, *8*, 2626–2631. [CrossRef]
35. Chawala, E.; Maagi, B. The Effect of E-Procurement Risk Mitigation Strategies on Prevention of Corruption in Public Procurement in Tanzania. *Afr. J. Appl. Res.* **2025**, *11*, 110–124. [CrossRef]
36. Vaidya, K.; Sajeev, A.S.M.; Callender, G. Critical factors that influence e-procurement implementation success in the public sector. *J. Public Procure.* **2006**, *6*, 70–99. [CrossRef]
37. Eadie, R.; Perera, S.; Heaney, G. Analysis of the use of E-Procurement in the Public and Private Sectors of the UK construction Industry. *J. Inf. Technol. Constr.* **2011**, *16*, 669–686.
38. Soliman, K.S.; Janz, B.D. An exploratory study to identify the critical factors affecting the decision to establish Internet-based interorganizational information systems. *Inf. Manag.* **2004**, *41*, 697–706. [CrossRef]
39. Grilo, A.; Jardim-Goncalves, R. Challenging electronic procurement in the AEC sector: A BIM-based integrated perspective. *Autom. Constr.* **2011**, *20*, 107–114. [CrossRef]
40. Vitkauskaitė, E.; Gatautis, R. E-procurement perspectives in construction sector SMES/E. Pirkimų perspektyvos smulkiose ir vidutinėse statybų sektoriaus įmonėse. *J. Civ. Eng. Manag.* **2008**, *14*, 287–294. [CrossRef]
41. Owusu, E.K.; Chan, A.P.C.; Ameyaw, E. Toward a cleaner project procurement: Evaluation of construction projects' vulnerability to corruption in developing countries. *J. Clean. Prod.* **2019**, *216*, 394–407. [CrossRef]
42. Ruparathna, R.; Hewage, K. Sustainable procurement in the Canadian construction industry: Challenges and benefits. *Can. J. Civ. Eng.* **2015**, *42*, 417–426. [CrossRef]

43. Subramaniam, C.; Shaw, M.J. The Effects of Process Characteristics on the Value of B2B E-Procurement. *Inf. Technol. Manag.* **2004**, *5*, 161–180. [CrossRef]
44. Vaidya, K.; Yu, P.; Soar, J.; Turner, T. Measuring the Performance of e-Procurement Implementations in the Australian Public Sector. In *Building Society Through e-Commerce: E-Government, e-Business and e-Learning*; Cerpa, N., Bro, P., Eds.; University of Talca: Talca, Chile, 2003; pp. 47–61.
45. Croom, S.; Brandon-Jones, A. E-Procurement: Key issues in e-Procurement implementation and operation in the public sector. In Proceedings of the 13th International Purchasing & Supply Education & Research Association (IPSERA) Conference, Catania, Italy, 4–7 April 2004.
46. Choe, J. The Classification of Types of Business-to-Business Electronic Commerce. *J. Inf. Organ. Sci.* **2017**, *41*, 1–20. [CrossRef]
47. Eom, J.; Kim, S.-C.; Jang, W.-S. Paradigm shift in main contractor-subcontractor partnerships with an e-procurement framework. *KSCE J. Civ. Eng.* **2015**, *19*, 1951–1961. [CrossRef]
48. Cheng, C.-B. Solving a sealed-bid reverse auction problem by multiple-criterion decision-making methods. *Comput. Math. Appl.* **2008**, *56*, 3261–3274. [CrossRef]
49. Farzin, S.; Nezhad, H.T. E-procurement, the golden key to optimizing the supply chains system. *Int. J. Econ. Manag. Eng.* **2010**, *4*, 837–843.
50. United Nations Global Market Place. *The UN Procurement Practitioner's Handbook*; United Nations High Level Committee on Management Procurement Network: New York, NY, USA, 2020; Available online: https://www.ungm.org/Shared/KnowledgeCenter/Pages/PPH2 (accessed on 5 March 2026).
51. Ong, D. *Putting B2B Hype in Perspective*; Business Times: Singapore, 2000; Volume 8, pp. 5–8.
52. Chang, S.-C.; Yang, C.-L.; Cheng, H.-C.; Sheu, C. Manufacturing flexibility and business strategy: An empirical study of small and medium sized firms. *Int. J. Prod. Econ.* **2003**, *83*, 13–26. [CrossRef]
53. Robaty Shirzad, S.; Bell, D. A Systematic Literature Review of Flexible E-Procurement Marketplace. *J. Theor. Appl. Electron. Commer. Res.* **2013**, *8*, 9–10. [CrossRef]
54. Alvarez-Rodríguez, J.M.; Labra-Gayo, J.E.; de Pablos, P.O. New trends on e-Procurement applying semantic technologies: Current status and future challenges. *Comput. Ind.* **2014**, *65*, 800–820. [CrossRef]
55. Ash, C.G.; Burn, J.M. Assessing the benefits from e-business transformation through effective enterprise management. *Eur. J. Inf. Syst.* **2003**, *12*, 297–308. [CrossRef]
56. Barthorpe, S.; Chien, H.J.; Shih, J.K. A survey of the potential for enterprise resource planning (ERP) in improving the effectiveness of construction management in the UK construction industry. *Int. J. Comput. Appl. Technol.* **2004**, *20*, 120–128. [CrossRef]
57. Wong, C.H.; Sloan, B. An empirical survey of the UK construction SMEs' E-procurement readiness from the E-legal aspects. *J. Constr. Res.* **2006**, *7*, 81–97. [CrossRef]
58. Grilo, A.; Jardim-Goncalves, R. Cloud-Marketplaces: Distributed e-procurement for the AEC sector. *Adv. Eng. Inform.* **2013**, *27*, 160–172. [CrossRef]
59. de Boer, L.; Harink, J.H.A.; Heijboer, G.J. A model for assessing the impact of electronic procurement forms. In Proceedings of the 10th International Annual IPSERA Conference, Jonkoping, Sweden, 8–11 April 2001; pp. 119–130.
60. Knudsen, D. Aligning corporate strategy, procurement strategy and e-procurement tools. *Int. J. Phys. Distrib. Logist. Manag.* **2003**, *33*, 720–734. [CrossRef]
61. Aguiar Costa, A.; Grilo, A. BIM-Based E-Procurement: An Innovative Approach to Construction E-Procurement. *Sci. World J.* **2015**, *2015*, 905390. [CrossRef]
62. Dissanayaka, W.M.D.M.; Sahapattana, P. Unifying the fragmented landscape of electronic public procurement research: A systematic review and future directions. *JeDEM—eJournal eDemocracy Open Gov.* **2025**, *17*, 78–105. [CrossRef]
63. Inusah, Y.; Kazaz, A.; Ulubeyli, S. Barriers to E-Tendering Implementation in the Construction Industry: A Comprehensive Review and Analysis of a Decade and Beyond. *Sustainability* **2025**, *17*, 2052. [CrossRef]
64. Mariconda, M.; Ruggiero, E. La digitalizzazione degli appalti pubblici: L'attesa continua. *Astrid Rass.* **2021**. Available online: https://www.astrid-online.it/rassegna/2021/01-12-2021-n-346.html (accessed on 5 March 2026).
65. Ohwofadjeke, P.O. Effect of e-procurement adoption in public sector construction projects in akwa ibom state, Nigeria. *Acad. J. Soc. Sci. AJSS* **2025**, *2*.
66. MacManus, S.A. Understanding the incremental nature of e-procurement implementation at the state and local levels. *J. Public Procure.* **2002**, *2*, 5–28. [CrossRef]
67. Eadie, R.; Perera, S.; Heaney, G. Identification of E-Procurement Drivers and Barriers for UK Construction Organisations and Ranking of These from the Perspective of Quantity Surveyors. *J. Inf. Technol. Constr.* **2010**, *15*, 23–43.
68. Legenvre, H.; Henke, M.; Ruile, H. Making sense of the impact of the internet of things on Purchasing and Supply Management: A tension perspective. *J. Purch. Supply Manag.* **2020**, *26*, 100596. [CrossRef]
69. Julià-Barceló, R. A new legal framework for electronic contracts: The EU electronic commerce proposal. *Comput. Law Secur. Rep.* **1999**, *15*, 147–158. [CrossRef]

70. Kheng, C.B.; Al-Hawamdeh, S. The Adoption of Electronic Procurement in Singapore. *Electron. Commer. Res.* **2002**, *2*, 61–73. [CrossRef]
71. Hawking, P.; Stein, A.; Wyld, D.C.; Foster, S. E-procurement: Is the ugly duckling actually a swan down under? *Asia Pac. J. Mark. Logist.* **2004**, *16*, 3–26. [CrossRef]
72. Davila, T.; Gupta, M.R.; Palmer, R.J. Moving Procurement Systems to the Internet: The Adoption and Use of E-Procurement Technology Models. *SSRN Electron. J.* **2002**, *21*, 11–23. [CrossRef]
73. Hayden, E.; Chan, M.; van Kan, D.; Arowoiya, V.; Mohamed, M.A. E-Procurement in the Australian Construction Industry: Benefits, Barriers, and Adoption. In *CONVR 2023—Proceedings of the 23rd International Conference on Construction Applications of Virtual Reality*; Firenze University Press: Firenze, Italy, 2023; pp. 489–498. [CrossRef]
74. Carayannis, E.G.; Popescu, D. Profiling a methodology for economic growth and convergence: Learning from the EU e-procurement experience for central and eastern European countries. *Technovation* **2005**, *25*, 1–14. [CrossRef]
75. Costa, A.; Tavares, L.V. Advanced multicriteria models to promote quality and reputation in public construction e-marketplaces. *Autom. Constr.* **2013**, *30*, 205–215. [CrossRef]
76. Croom, S.R.; Brandon-Jones, A. Key issues in e-procurement: Procurement implementation and operation in the public sector. *J. Public Procure.* **2005**, *5*, 367–387. [CrossRef]
77. Aduwo, E.B.; Ibem, E.O.; Uwakonye, O.; Tunji-Olayeni, P.; Ayo-Vuaghan, E.K. Barriers to the uptake of e-procurement in the Nigerian building industry. *J. Theor. Appl. Inf. Technol.* **2016**, *89*. Available online: https://repository.covenantuniversity.edu.ng/items/7c7867bc-2eb0-4829-a383-1dae5aedf08a/full (accessed on 5 March 2026).
78. Sakutemba, N.; Muvungani, R.; Moyo, T. Barriers to the Adoption of Electronic Procurement in Public Sector Construction Projects in Zimbabwe. *J. Constr. Dev. Ctries.* **2024**, *29*, 231–255. [CrossRef]
79. Stenning & Associates Pty Ltd. (S&A). *Final Report: Evaluation and Review of the e-Procurement Pilot Project*, Version 1.2; Stenning & Associates Pty Ltd. (S&A): Hobart, Australia, 2003.
80. Hochstetter, J.; Vásquez, F.; Diéguez, M.; Bustamante, A.; Arango-López, J. Transparency and E-Government in Electronic Public Procurement as Sustainable Development. *Sustainability* **2023**, *15*, 4672. [CrossRef]
81. Panduranga, V. Transparency in public procurement through e-procurement in India. *J. Internet Bank. Commer.* **2016**, *21*, 1.
82. European Union. Directive 2014/24/EU of the European Parliament and of the Council of 26 February 2014 on public procurement and repealing Directive 2004/18/EC. *Off. J. Eur. Union* **2014**, *L 94*, 65–242.
83. European Union. Directive 2014/25/EU of the European Parliament and of the Council of 26 February 2014 on procurement by entities operating in the water, energy, transport and postal services sectors and repealing Di-rective 2004/17/EC. *Off. J. Eur. Union* **2014**, *L 94*, 243–374.
84. European Union. Directive 2014/23/EU of the European Parliament and of the Council of 26 February 2014 on the award of concession contracts. *Off. J. Eur. Union* **2014**, *L 94*, 1–64.
85. European Commission. Overview of Digital Public Procurement [Panoramica Degli Appalti Digitali]. Available online: https://commission.europa.eu (accessed on 5 March 2026).
86. Dumortier, J. Regulation (EU) No 910/2014 on Electronic Identification and Trust Services for Electronic Transactions in the Internal Market (eIDAS Regulation) (1 July 2016). Available online: https://ssrn.com/abstract=2855484 (accessed on 5 March 2026).
87. Anelli, D.; Morano, P.; Acquafredda, T.; Tajani, F. Structuring Multi-Criteria Decision Approaches for Public Procurement: Methods, Standards and Applications. *Systems* **2025**, *13*, 777. [CrossRef]
88. Lehtonen, J.M.; Virtanen, K. Choosing the most economically advantageous tender using a multi-criteria decision analysis approach. *J. Public Procure.* **2022**, *22*, 164–179. [CrossRef]
89. Marović, I.; Perić, M.; Hanak, T. A Multi-Criteria Decision Support Concept for Selecting the Optimal Contractor. *Appl. Sci.* **2021**, *11*, 1660. [CrossRef]
90. European Union. Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 on the energy performance of buildings (recast). *Off. J. Eur. Union* **2024**. Available online: http://data.europa.eu/eli/dir/2024/1275/oj (accessed on 5 March 2026).
91. European Union. Regulation (EU) 2024/1781 of the European Parliament and of the Council of 13 June 2024 es-tablishing a framework for the setting of ecodesign requirements for sustainable products (ESPR). *Off. J. Eur. Union* **2024**, *L 2024/1781*.
92. European Commission. *The European Green Deal (COM(2019) 640 Final)*; European Commission: Brussels, Belgium, 2019.
93. Dumortier, J. *Electronic Identification and Trust Services for Electronic Transactions in the Internal Market (eIDAS Regulation n. 910/2014)*; Edward Elgar Publishing: Cheltenham, UK, 2017.
94. European Commission. Operational Manual on the European Single Procurement Document (ESPD) [Manuale Operativo sul Documento di Gara Unico Europeo (DGUE)]. 2016. Available online: https://ec.europa.eu (accessed on 5 March 2026).
95. *Legislative Decree n. 209/2024*; Integrative and corrective provisions to the Public Procurement Code [Disposizioni integrative e correttive al Codice dei contratti pubblici]. Gazzetta Ufficiale della Repubblica Italiana: Rome, Italy, 2024.

96. OpenPEPPOL. PEPPOL Specifications and Governance Framework. 2022. Available online: https://peppol.org (accessed on 5 March 2026).
97. Agenzia per l'Italia Digitale (AgID). e-Procurement e Piattaforme Digitali. 2023. Available online: https://www.agid.gov.it (accessed on 5 March 2026).
98. *Legislative Decree 31 March 2023, n. 36*; Italian Public Procurement Code [Codice dei Contratti Pubblici]. Gazzetta Ufficiale della Repubblica Italiana: Rome, Italy, 2023.
99. *AgID Determination No. 148*; Technical Rules for Digital Procurement Platforms [Regole Tecniche per le Piattaforme di Approvvigionamento Digitale]. Gazzetta Ufficiale della Repubblica Italiana: Rome, Italy, 2021.
100. Agenzia per l'Italia Digitale (AgID). Linee Guida Sulla Formazione, Gestione e Conservazione dei Documenti Informatici. 2022. Available online: https://www.agid.gov.it (accessed on 5 March 2026).
101. Lo, J.T.Y.; Kam, C. Innovation of Organizations in the Construction Industry: Progress and Performance Attributes. *J. Manag. Eng.* **2022**, *38*, 04022064. [CrossRef]
102. Du, S.; Hou, L.; Zhang, G.; Tan, Y.; Mao, P. BIM and IFC Data Readiness for AI Integration in the Construction Industry: A Review Approach. *Buildings* **2024**, *14*, 3305. [CrossRef]
103. Alaloul, W.S.; Liew, M.S.; Zawawi, N.A.W.A.; Kennedy, I.B. Industrial Revolution 4.0 in the construction industry: Challenges and opportunities for stakeholders. *Ain Shams Eng. J.* **2020**, *11*, 225–230. [CrossRef]
104. Georgiadou, M.C. An overview of benefits and challenges of building information modelling (BIM) adoption in UK residential projects. *Constr. Innov.* **2019**, *19*, 298–320. [CrossRef]
105. Takyi-Annan, G.E.; Zhang, H. A bibliometric analysis of building information modelling implementation barriers in the developing world using an interpretive structural modelling approach. *Heliyon* **2023**, *9*, e18601. [CrossRef] [PubMed]
106. Wu, S.; Lu, W.-Z.; Qin, C.; Wen, B.; Wu, D.; Xiang, Y. A goal-oriented planning approach for two-dimensional cutting components in architectural design: Coupling BIM and Parametric design (PD). *J. Build. Eng.* **2023**, *76*, 107156. [CrossRef]
107. Salzano, A.; Intignano, M.; Mottola, C.; Biancardo, S.A.; Nicolella, M.; Dell'Acqua, G. Systematic Literature Review of Open Infrastructure BIM. *Buildings* **2023**, *13*, 1593. [CrossRef]
108. Rodríguez, J.F.F. Implementation of BIM Virtual Models in Industry for the Graphical Coordination of Engineering and Architecture Projects. *Buildings* **2023**, *13*, 743. [CrossRef]
109. Salleh, H.; Ahmad, A.A.; Abdul-Samad, Z.; Alaloul, W.S.; Ismail, A.S. BIM Application in Construction Projects: Quantifying Intangible Benefits. *Buildings* **2023**, *13*, 1469. [CrossRef]
110. de Souza, M.P.; Fialho, B.C.; Ferreira, R.C.; Fabricio, M.M.; Codinhoto, R. Modelling and coordination of building design: An experience of BIM learning/upskilling. *Archit. Eng. Des. Manag.* **2021**, *19*, 74–91. [CrossRef]
111. Rehman, S.U.; Kim, I.; Hwang, K.-E. Advancing BIM and game engine integration in the AEC industry: Innovations, challenges, and future directions. *J. Comput. Des. Eng.* **2025**, *12*, 26–54. [CrossRef]
112. Luan, H.; Li, L.; Zhang, S. Exploring the Impact Mechanism of Interface Management Performance of Sustainable Prefabricated Construction: The Perspective of Stakeholder Engagement. *Sustainability* **2022**, *14*, 10704. [CrossRef]
113. Zhang, R.; Wang, Z.; Tang, Y.; Zhang, Y. Collaborative Innovation for Sustainable Construction: The Case of an Industrial Construction Project Network. *IEEE Access* **2020**, *8*, 41403–41417. [CrossRef]
114. Salzano, A.; Cascone, S.; Zitiello, E.P.; Nicolella, M. Construction Safety and Efficiency: Integrating Building Information Modeling into Risk Management and Project Execution. *Sustainability* **2024**, *16*, 4094. [CrossRef]
115. Salzano, A.; Miano, A.; Zitiello, E.P.; Prota, A.; Nicolella, M. Construction Safety and Efficiency: Digital Twin Integration for Risk Management from Design to Execution. In *Proceedings of the Protection of Historical Constructions*; Springer Nature: Cham, Switzerland, 2025; pp. 513–520. [CrossRef]
116. Tajuddin, M.A.; Mohamed, M.R.; Rashid, M.N.A.; Nasir, N.; Mahdzir, M. Barriers and solutions of building information modelling (BIM) in construction site safety in malaysia. *Plan. Malays.* **2025**, *23*, 480–494. [CrossRef]
117. Shalaka, H.; Sayali, S.; Kirti, R. Technology Landscape for BIM in Construction Site Safety Management. In *Proceedings of SECON'23*; Springer: Cham, Switzerland, 2023; pp. 931–943. [CrossRef]
118. Peng, Y.; Qin, H.; Peng, L.; Luo, T.; Dai, B.; Yu, S.; Xu, Y. Real-time Monitoring and Alarm Strategy for Construction Site Safety Based on the Integration of BIM and AI. *J. World Archit.* **2025**, *9*, 134–140. [CrossRef]
119. Azhar, S. Building Information Modeling (BIM): Trends, Benefits, Risks, and Challenges for the AEC Industry. *Leadersh. Manag. Eng.* **2011**, *11*, 241–252. [CrossRef]
120. Tu, T. BIM Application in Life-Cycle Cost Management of Construction Projects. *Trans. Eng. Technol. Res.* **2025**, *5*, 99–107. [CrossRef]
121. Ang, P.S.E.; Mohd Noh, N.I.; Sheng, L.J.; Vun Mei Shan, V.; Ali, R.; Sin, T.J.; Lin, P.Y.; Len, T.K.; Kasim, N.; Adnan, S.H.; et al. A comparison study on cost management between BIM and non-BIM projects in the construction industry. *ASEAN Eng. J.* **2025**, *15*, 19–25. [CrossRef]

122. Ade-Ojo, C.; Okesooto, A.; Akintan, O. BIM Implementation for Cost Management by Quantity Surveyors in Nigeria. *Am. J. Oper. Manag. Inf. Syst.* **2025**, *10*, 73–80. [CrossRef]
123. Diaz, P.M. Analysis of Benefits, Advantages and Challenges of Building Information Modelling in Construction Industry. *J. Adv. Civ. Eng.* **2016**, *2*, 1–11. [CrossRef]
124. Bryde, D.; Broquetas, M.; Volm, J.M. The project benefits of Building Information Modelling (BIM). *Int. J. Proj. Manag.* **2013**, *31*, 971–980. [CrossRef]
125. Sinenko, S.; Hanitsch, P.; Aliev, S.; Volovik, M. The implementation of BIM in construction projects. *E3S Web Conf.* **2020**, *164*, 08002. [CrossRef]
126. Alam, F.; Ali, J.; Madni, S.; Husnain, H.A. Identifying Barriers to Effective BIM Adoption in the Re-Engineering of Construction Business Practices in Developing Countries. *Preprint* **2023**. [CrossRef]
127. Nasila, M.; Cloete, C. Adoption of Building Information Modelling in the construction industry in Kenya. *Acta Struct.* **2018**, *25*, 1–38. [CrossRef]
128. Takyi-Annan, G.E.; Zhang, H. A Multivariate Analysis of the Variables Impacting the Level of BIM Expertise of Professionals in the Architecture, Engineering and Construction (AEC) Industries of the Developing World Using Nonparametric Tests. *Buildings* **2023**, *13*, 1606. [CrossRef]
129. Acheng, P.O.; Kibwami, N.; Mukasa, T.J.; Odongkara, B.B.; Birungi, R.; Semanda, J.; Manga, M. Building information modelling adoption in Uganda's construction industry. *Int. J. Constr. Manag.* **2022**, *23*, 2185–2208. [CrossRef]
130. Ismail, N.A.A.; Zulkifli, M.Z.A.; Baharuddin, H.E.A.; Ismail, W.N.W.; Mustapha, A.A. Challenges of Adopting Building Information Modelling (BIM) Technology amongst SME's Contractors in Malaysia. *IOP Conf. Ser. Earth Environ. Sci.* **2022**, *1067*, 012047. [CrossRef]
131. Olanrewaju, O.I.; Kineber, A.F.; Chileshe, N.; Edwards, D.J. Modelling the relationship between Building Information Modelling (BIM) implementation barriers, usage and awareness on building project lifecycle. *Build. Environ.* **2022**, *207*, 108556. [CrossRef]
132. Takyi-Annan, G.E.; Zhang, H. Assessing the impact of overcoming BIM implementation barriers on BIM usage frequency and circular economy in the project lifecycle using Partial least Squares structural Equation modelling (PLS-SEM) analysis. *Energy Build.* **2023**, *295*, 113329. [CrossRef]
133. Waqar, A.; Othman, I.; González-Lezcano, R.A. Challenges to the Implementation of BIM for the Risk Management of Oil and Gas Construction Projects: Structural Equation Modeling Approach. *Sustainability* **2023**, *15*, 8019. [CrossRef]
134. Murguia, D.; Vasquez, C.; Demian, P.; Soetanto, R. BIM Adoption among Contractors: A Longitudinal Study in Peru. *J. Constr. Eng. Manag.* **2023**, *149*, 04022140. [CrossRef]
135. Mohemad, R.; Hamdan, A.R.; Othman, Z.A.; Noor, N.M.M. Modelling ontology for supporting construction tender evaluation process. In Proceedings of the 2011 International Conference on Semantic Technology and Information Retrieval, Putrajaya, Malaysia, 28–29 June 2011; pp. 282–288. [CrossRef]
136. Ciribini, A.L.C.; Bolpagni, M.; Oliveri, E. An Innovative Approach to e-public Tendering Based on Model Checking. *Procedia Econ. Financ.* **2015**, *21*, 32–39. [CrossRef]
137. Porwal, A.; Hewage, K.N. Building Information Modeling (BIM) partnering framework for public construction projects. *Autom. Constr.* **2013**, *31*, 204–214. [CrossRef]
138. Eastman, C.; Teicholz, P.; Sacks, R.; Liston, K. *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors*, 2nd ed.; John Wiley & Sons, Inc.: Hoboken, NJ, USA, 2011.
139. Liu, T.; Hsieh, T. BIM-based Government Procurement System—The Likely Development in Taiwan. In Proceedings of the 28th ISARC, Seoul, Korea, 29 June–2 July 2011; pp. 758–763.
140. Mcauley, B.; Hore, A.; West, R.; Kehily, D. Addressing the Need to Reform Construction Public Procurement in Ireland Through the Implementation of Building Information Modelling. In Proceedings of the 1st ASEA-SEC International Conference on Research, Development and Practice in Structural Engineering and Construction, Perth, Australia, 28 November–2 December 2012; pp. 895–900. [CrossRef]
141. Zitiello, E.P.; Porcellini, F.; Basile, E.; Salzano, A.; Nicolella, M. Synergy Between BIM and e-Procurement: A New Paradigm for Digital Procurement Management. In *Proceedings of the Computational Science and Its Applications—ICCSA 2025 Workshops*; Springer Nature: Cham, Switzerland, 2025; pp. 63–77. [CrossRef]
142. Cheng, J.C.P.; Lu, Q.; Deng, Y. Analytical review and evaluation of civil information modeling. *Autom. Constr.* **2016**, *67*, 31–47. [CrossRef]
143. Popov, V.; Medineckienė, M.; Grigorjeva, T.; Zabulėnas, A.R. Building information modelling: Procurement procedure. *Bus. Manag. Econ. Eng.* **2021**, *19*, 180–197. [CrossRef]
144. Gurevich, U.; Sacks, R. Longitudinal Study of BIM Adoption by Public Construction Clients. *J. Manag. Eng.* **2020**, *36*, 05020008. [CrossRef]
145. 7° Report OICE Sulla Digitalizzazione E Sulle Gare BIM 2023, OICE. Available online: https://www.oice.it/849794/2024-oice-7-rapporto-sulla-digitalizzazione-e-gare-bim (accessed on 5 March 2026).

146. BPIE. *The European Renovation Wave: From Words to Action*; Building Performance Institute Europe (BPIE): Brussels, Belgium, 2020.
147. Esmaeili, I.; Barreira, E.; Martins, J.P.; Castro, J.M. Towards Data Mining and Knowledge Discovery for AECO Applications Using BIM Embedded Data: A Systematic Review. *Arch. Comput. Methods Eng.* **2025**, *33*, 1865–1886. [CrossRef]
148. Daniotti, B.; Bolognesi, C.M.; Lupica Spagnolo, S.; Pavan, A.; Signorini, M.; Ciuffreda, S.; Mirarchi, C.; Lucky, M.N.; Andersson, B.; Andersson, P.; et al. An Interoperable BIM-Based Toolkit for Efficient Renovation in Buildings. *Buildings* **2021**, *11*, 271. [CrossRef]
149. Edwards, R.E.; Lou, E.; Bataw, A.; Kamaruzzaman, S.N.; Johnson, C. Sustainability-led design: Feasibility of incorporating whole-life cycle energy assessment into BIM for refurbishment projects. *J. Build. Eng.* **2019**, *24*, 100697. [CrossRef]
150. Lasarte, N.; Elguezabal, P.; Sagarna, M.; Leon, I.; Otaduy, J.P. Challenges for Digitalisation in Building Renovation to Enhance the Efficiency of the Process: A Spanish Case Study. *Sustainability* **2021**, *13*, 12139. [CrossRef]
151. Carbonari, G.; Ricci, M.; Dourlens-Quaranta, S.; Calderoni, M.; Loureiro, T.; Sterling, R.; Glicker, J.; Toth, Z.; Volt, J.; De Groote, M.; et al. *Building Logbook-Report 2 of the Study on the Development of a European Union Framework for Buildings' Digital Logbook*; Publications Office of the European Union: Luxembourg, 2020.
152. Moretti, N.; Xie, X.; Garcia, J.M.; Chang, J.; Parlikad, A.K. Federated Data Modeling for Built Environment Digital Twins. *J. Comput. Civ. Eng.* **2023**, *37*, 04023013. [CrossRef]
153. Zio, E.D.; Paparella, R. L'attestazione della qualità dei fabbricati tra la necessità e optional: Le proposte normative in Italia. In *Tecnologia, Progetto, Manutenzione*; Missori, A., Ed.; Franco Angeli: Milano, Italy, 2003.
154. European Commission. *Proposal for a Directive of the European Parliament and of the Council on the Energy Performance of Buildings (Recast)*; European Commission: Luxembourg, 2021.
155. Dejaco, M.C.; Maltese, S.; Cecconi, F.R. *Il Fascicolo del Fabbricato*; Maggioli Editore: Rimini, Italy, 2017.
156. Gonçalves, J.D.S.; Lam, W.C.; Ritzen, M. The Role of Digital Building Logbooks for a Circular Built Environment. In *A Circular Built Environment in the Digital Age*; Springer International Publishing: Cham, Switzerland, 2024; pp. 229–243. [CrossRef]
157. Mêda, P.; Calvetti, D.; Hjelseth, E.; Sousa, H. Incremental Digital Twin Conceptualisations Targeting Data-Driven Circular Construction. *Buildings* **2021**, *11*, 554. [CrossRef]
158. Dejaco, M.C.; Moretti, N.; Cecconi, F.R. Streamlined Management of the Built Environment: The District and the Building Logbook as Risk Prevention Tools. In *Re-Shaping the Construction Industry*; Maggioli Editore SpA: Santarcangelo di Romagna, Italy, 2017; pp. 185–194. ISBN 978-88-916-2486-4.
159. Santoboni, P. Il fascicolo del fabbricato e le sue interazioni con la digitalizzazione delle pratiche edilizie. *DigItalia* **2023**, *18*, 94–109. [CrossRef]
160. Alonso, R.; Olivadese, R.; Ibba, A.; Recupero, D.R. Towards the Definition of a European Digital Building Logbook: A Survey. *Heliyon* **2023**, *9*, e19285. [CrossRef]
161. European Commission. A RenovationWave for Europe-Greening our Buildings, Creating Jobs, Improving Lives. In *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions*; European Commission: Brussels, Belgium, 2020; Available online: https://eur-lex.europa.eu/resource.html?uri=cellar:0638aa1d-0f02-11eb-bc07-01aa75ed71a1.0003.02/DOC_1&format=PDF (accessed on 21 October 2024).
162. European Commission. *European Commission European Green Deal*; European Commission: Luxembourg, 2019.
163. Gómez-Gil, M.; Espinosa-Fernández, A.; López-Mesa, B. Review and Analysis of Models for a European Digital Building Logbook. *Energies* **2022**, *15*, 1994. [CrossRef]
164. Blum, A. Building passport-A tool for Quality, Environmental Awareness and Performance in the Building Sector. In Proceedings of the OECD/IEA Joint Workshop on the Design of Sustainable Building Policies, Paris, France, 28–29 June 2001.
165. Talamo, C.; Bonanomi, M. *Knowledge Management and Information Tools for Building Maintenance and Facility Management*; Springer International Publishing: Cham, Switzerland, 2015. [CrossRef]
166. Karami, S.; de Almeida, J.P.; Ellul, C.; Cardoso, A. Semantic Mapping Analysis of Digital Building LogBook/Passport Models. In Proceedings of the 2024 European Conference on Computing in Construction, Crete, Greece, 14–17 July 2024; Volume 5. [CrossRef]
167. Puček, M.M.; Khoja, A.; Bazzan, E.; Gyuris, P. A Data Structure for Digital Building Logbooks: Achieving Energy Efficiency, Sustainability, and Smartness in Buildings across the EU. *Buildings* **2023**, *13*, 1082. [CrossRef]
168. Commission, E.; Small, E.A.F.; Enterprises, M.S.; Quaranta, S.D.; Carbonar, G.; De Groote, M.; Borragán, G.; De Regel, S.; Toth, Z.; Volt, J.; et al. Study on the Development of a European Union Framework for Digital Building Logbooks: Final Report, Publications Office. 2021. Available online: https://op.europa.eu/it/publication-detail/-/publication/40f40235-509e-11eb-b59f-01aa75ed71a1 (accessed on 5 March 2026).
169. Fabbri, M.; de Groote, M.; Rapf, O. *Building Renovation Passports-Customised Roadmaps towards Deep Renovation and Better Homes*; Building Performance Institute Europe (BPIE): Brussels, Belgium, 2016.
170. European Parliament and Council of the European Union. Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L0844&from=ES (accessed on 30 October 2024).

171. Gómez-Gil, M.; Sesana, M.M.; Salvalai, G.; Espinosa-Fernández, A.; López-Mesa, B. The Digital Building Logbook as a gateway linked to existing national data sources: The cases of Spain and Italy. *J. Build. Eng.* **2023**, *63*, 105461. [CrossRef]
172. Hartenberger, U.; Frics, D.L. Global Trends in Data Capture and Management in Real Estate and Construction. *RICS Insight Pap.* **2017**. Available online: https://www.rics.org/content/dam/ricsglobal/documents/to-be-sorted/global-trends-in-data-capture-and-management-in-real-estate-and-construction-rics.pdf (accessed on 5 March 2026).
173. López, F.; Lerones, P.; Llamas, J.; Gómez-García-Bermejo, J.; Zalama, E. Una revisione del Heritage Building Information Modeling (H-BIM). *Multimodal Technol. Interact.* **2018**, *2*, 21. [CrossRef]
174. Yao, M.; Yao, B.; Cenci, J.; Liao, C.; Zhang, J. Visualisation of High-Density City Research Evolution, Trends, and Outlook in the 21st Century. *Land* **2023**, *12*, 485. [CrossRef]
175. Jang, K.; Kim, J.-W.; Ju, K.-B.; An, Y.-K. Infrastructure BIM Platform for Lifecycle Management. *Appl. Sci.* **2021**, *11*, 10310. [CrossRef]
176. Rethlefsen, M.L.; Kirtley, S.; Waffenschmidt, S.; Ayala, A.P.; Moher, D.; Page, M.J.; Koffel, J.B.; PRISMA-S Goup. PRISMA-S: An extension to the PRISMA statement for reporting literature searches in systematic reviews. *Syst. Rev.* **2021**, *10*, 39. [CrossRef]
177. Regona, M.; Yigitcanlar, T.; Xia, B.; Li, R.Y. Opportunities and Adoption Challenges of AI in the Construction Industry: A PRISMA Review. *J. Open Innov. Technol. Mark. Complex.* **2022**, *8*, 45. [CrossRef]
178. Gorraiz, J.; Schloegl, C. A bibliometric analysis of pharmacology and pharmacy journals: Scopus versus Web of Science. *J. Inf. Sci.* **2008**, *34*, 715–725. [CrossRef]
179. Francalanci, C.; Giacomazzi, P. *Motori di Ricerca e Indicatori Bibliometrici di Impatto*; Mondo Digitale: Roma, Italy, 2017.
180. Bosman, J.; van Mourik, I.; Rasch, M.; Sieverts, E.; Verhoeff, H. *Scopus Reviewed and Compared: The coverage and Functionality of the Citation Database Scopus, Including Comparisons with Web of Science and Google Scholar*; Universiteitsbibliotheek Utrecht: Utrecht, The Netherlands, 2006.
181. 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.; et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *Int. J. Surg.* **2021**, *88*, 105906. [CrossRef]
182. Tetzlaff, J.; Page, M.; Moher, D. PNS154 the PRISMA 2020 statement: Development of and key changes in an updated guideline for reporting systematic reviews and meta-analyses. *Value Health* **2020**, *23*, S312–S313. [CrossRef]
183. Jüni, P.; Holenstein, F.; Sterne, J.; Bartlett, C.; Egger, M. Direction and impact of language bias in meta-analyses of controlled trials: Empirical study. *Int. J. Epidemiol.* **2002**, *31*, 115–123. [CrossRef] [PubMed]
184. Owusu, E.K.; Chan, A.P.C.; Nani, G.; Agymang, D.Y. A Turn to Smart Contracts and Future Applications towards Construction Innovation: A Hybrid-Metric Review. *Constr. Res. Congr.* **2020**, *2020*, 246–257. [CrossRef]
185. Malhotra, R. Systematic Literature Reviews. In *Empirical Research in Software Engineering*; Chapman and Hall/CRC: Boca Raton, FL, USA, 2016; pp. 59–90. [CrossRef]
186. Schryen, G.; Wagner, G.; Benlian, A. Theory of Knowledge for Literature Reviews: An Epistemological Model, Taxonomy and Empirical Analysis of IS Literature. In Proceedings of the International Conference on Information Systems (ICIS), Fort Worth, TX, USA, 13–16 December 2015.
187. Datta, S.D.; Tayeh, B.A.; Hakeem, I.Y.; Aisheh, Y.I.A. Benefits and Barriers of Implementing Building Information Modeling Techniques for Sustainable Practices in the Construction Industry—A Comprehensive Review. *Sustainability* **2023**, *15*, 12466. [CrossRef]
188. Al Aamri, A.M.S.; Evdorides, H.; Baniotopoulos, C. Barriers and Opportunities for the Adoption of Building Information Modelling in the Design of Buildings: Case Study of Oman. *Sustainability* **2025**, *17*, 3510. [CrossRef]
189. Matos, B.C.; Cruz, C.O.; Branc, F.B. Digitalization and procurement in construction projects: An integrated BIM-based approach. *J. Inf. Technol. Constr.* **2024**, *29*, 400–423. [CrossRef]
190. Pérez-García, A.; Martín-Dorta, N.; Aranda, J.Á. BIM Requirements in the Spanish Public Tender—Analysis of Adoption in Construction Contracts. *Buildings* **2021**, *11*, 594. [CrossRef]
191. Grilo, A.; Jardim-Goncalves, R. Value proposition on interoperability of BIM and collaborative working environments. *Autom. Constr.* **2010**, *19*, 522–530. [CrossRef]
192. Analisi dei Tempi di Aggiudicazione Degli Appalti in Italia e in Europa Sulla Base dei Dati TED, ANAC. Available online: https://www.anticorruzione.it/-/analisi-dei-tempi-di-aggiudicazione-degli-appalti-in-italia-e-in-europa-sulla-base-dei-dati-ted-1-ottobre-2024 (accessed on 5 March 2026).