E-PROCUREMENT IN THE AUSTRALIAN CONSTRUCTION INDUSTRY: BENEFITS, BARRIERS AND ADOPTION

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ABSTRACT: *A clear benefit of e-procurement technology in the construction sector is its capacity for in reducing waste and costs. Despite its successful adoption in other major industries, the take-up of e-procurement in the construction industry has generally been slow. A variety of barriers to adoption have been identified in literature, predominantly at an international level. Whilst the benefits of e-procurement are well-known and the challenges and barriers to the adoption of these systems in the construction industry has been well-documented, research into actual outcomes following the adoption of e-procurement systems through a case study analysis is limited. Tracking and measurement of adoption rates in the Australian construction industry is particularly scarce. To build upon and add to the existing body of contemporary literature, this study seeks to examine the adoption of e-procurement technologies in the Australian construction industry. As the Australian construction sector enters a period of high inflation, technologies such as e-procurement have a critical role in mitigating these price escalations. Understanding the barriers and opportunities for wider adoption of e-procurement in the Australian construction industry is also a clear benefit with its capacity for digital transformation in the construction sector.*

KEYWORDS: *E-procurement, technologies, digital transformation, construction, Australia.*

1. INTRODUCTION

The construction industry is one of the largest sectors in the Australian economy, employing some 1.03 million workers across 395,000 individual businesses (IBISWorld, 2021). The industry accounts for 9% of Australian Gross Domestic Product (GDP) with the total value of construction work done over the 12-months to December 2021 in the order of $214 billion (ABS, 2022). Procurement management is a well-established technique utilised by firms to drive sustainable competitive advantages during periods of economic turbulence (Hong and Kwon, 2012). Since emerging more than two decades ago, e-procurement technologies have increased significantly across many sectors (e.g., manufacturing, wholesaling) as both government and private firms have realised the benefits of e-procurement platforms, including, inter alia, increased transparency and accountability, improved sustainability, and cost savings (Deraman et al., 2019). The evolution of e-procurement platforms has evolved greatly over this period, growing from simple electronic-based systems to fully integrated, web-based platforms. Despites its successful adoption in other major industries, the take-up of e-procurement in the construction industry has generally been slow and low (Afolabi et al., 2019).

A clear benefit of e-procurement technology in the construction sector is its capacity to reduce waste and costs. For instance, e-procurement enables building and construction firms to more accurately review and cost projects at the procurement stage and enables more efficient management processes on-site. Furthermore, e-procurement enables clients to achieve more competitive pricing through contacting more potential suppliers without increasing overheads. Technologies such as e- procurement systems have a critical role in mitigating price escalations and while the challenges to the adoption of these systems in the construction industry has been well-documented, research into actual outcomes following the adoption of e-procurement systems is limited. Tracking adoption rates in the Australian construction industry is particularly scarce. To build upon and add to the existing body of contemporary literature, this study applied the science mapping approach into the area of e-procurement in construction. It aims to provide insight into the existing challenges, benefits, and adoptions rates of e-procurement in the Australian construction industry and seeks to provide recommendations for future adoption.

2. LITERATURE REVIEW

E-procurement is the use of the Internet to support the delivery of procurement tasks. More specifically, it is an aspect of e-Commerce that incorporates web-based applications and communication technologies to carry out

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procurement activities such as sending and receiving tender information, submission of tenders, acquisition of materials, equipment and services, and payment of goods and services (Ibem and Laryea, 2015). A study conducted in the United Kingdom by Eadie et al., (2010) sort to identify the leading barriers and benefits in e-procurement. A survey of 775 construction organizations was conducted and revealed that the leading benefits were 'Process, transaction and administration cost savings', 'Convenience of archiving completed work', and 'Increased quality through increased accuracy'. These benefits support the findings of Brandon-Jones (2017) who suggests that the use of e-procurement can deliver significant operational benefits, including improved delivery accuracy, reduced transaction costs and greater control over organization procurement. Furthermore, Yevu and Yu (2019) found that drivers of e-procurement can be broken into seven categories: external drivers, project-level drivers, technological and process-level drivers, company-level drivers, individual-level drivers, service satisfaction drivers and sustainability concept drivers. Interestingly, they note that modern construction concepts such as sustainability and client satisfaction are influencing the adoption of e-procurement. Conversely, Eadie et al., (2010) identified the dominate barriers to e-procurement as 'Prevention of tampering with documents', 'Confidentiality of information', and 'Resistance to change'. Another study by Yevu et al., (2021b) categorized barriers into six groups: technological usability and evolution, security and unsupportive environment, culture, infrastructure, unethical practices, and financial and skills related.

A wide range of international studies has been undertaken, (Zunk et al., 2014; Ibem and Laryea, 2015; Afolabi et al., 2017, 2019; Tran et al., 2021) and found that whilst e-procurement is not a new concept in the varying industrial sectors, the construction industry has been slow in adoption compared to other industries such as manufacturing and retail business (Ibem and Laryea, 2015). These studies indicated the varying barriers and drivers e-procurement has on developing and developed economies. It has been discovered that the high cost and low access of Internet services in developing countries combined with lack of industry experience and training has had an adverse effect on initial uptake of e-procurement (Ibem et at., 2021; Tran et al., 2021). A common barrier found both in developing and developed countries was the lack of expertise and promotion of e-procurement (Yevu et al., 2021b; Zunk et al., 2014). Zunk et al., (2014) reports that some construction firms in Austria didn't know what e-procurement was let alone the benefits. Afolabi et al., (2017) states that the benefits of e-procurement platforms should not be overlooked. They note it is a viable tool for increasing productivity and empowering construction professionals to exercise greater control of the construction process. Aghimien et al., (2021) added that digitalisation offers solutions to consistent challenges of delivering projects over budget, beyond the expected timeframes and not to specification. It is evident that a large volume of international research exists relating to e-procurement within the construction sector.

Enterprise Resource Planning (ERP) systems have become commonplace applications in significant sectors. According to industry rankings and turnover, the top suppliers include SAP, ORACLE, Microsoft. ABAS, IFS and Step Ahead. Implementing BIM enables better project management, process efficiency, increased transparency, cost control, and real-time communication, just like with ERP systems. Additionally, the system may retain all technical information, drawings, and construction methods, and users can simultaneously work on different project phases throughout the course of the project's lifespan. BIM may be used to manage the technical elements of a building project as well as help with strategic procurement choices like choosing a contractor. There are many advantages of adopting ERP systems in the construction industry including automating procedures in client assistance, project management, cost predictions, employee management and procurement management through operational automation. Project management needs to be optimized since it is vital to the success of any construction company. Without good project management, the company would lose Clients and money. With all operational activities are automated by the ERP system, project management supervision is improved. ERP is a useful tool for cost estimation since it considers all important cost aspects, including materials, design, contracts, and transportation. Budgets for specific cost centres can be estimated and allocated to include overhead liabilities and even potential delays.

In the construction sector, successful project execution depends on efficient communication, in which ERP systems are enhancing communication. One issue that construction businesses frequently struggle with is maintaining strong departmental communication. Project schedules may be impacted by departmental disconnections that slow down operations and business processors. Employees may rapidly tell executives and management on projects on their mobile devices thanks to mobile features. It is possible to handle external communication and updates using stakeholder and customer relationship management software that is integrated with the ERP system. Another key benefit of ERP in construction is it enables remote access to all pertinent files and data. ERP systems assist in the efficient and speedy centralisation of huge amounts of data. Cloud applications can be used by the latest technology, which eliminates the need for big, expensive servers. ERP and BIM technologies provide more efficient project management and improved cost accuracy. All project data may be kept in a single repository, and numerous users

can access it at once. Computing aided design applications can be integrated with BIM as a solution to improve efficiency in procurement in the construction industry.

3. METHODOLOGY

This review-based study applied the science mapping approach into the area of e-procurement in construction. It aims to provide insight into the existing challenges, benefits, and adoptions rates of e-procurement in the Australian construction industry and seeks to provide recommendations for future adoption. To achieve these objectives, a three-stage review process will be adopted.

3.1 Bibliometric search

The initial step of the review was the preliminary literature search using academic research database, Scopus. Scopus database has been used as the main source of information as it is considered a reliable source of scientific publications by academics (Baas et al., 2020). A comprehensive search was undertaken using a search string of keywords consisting of "e- procurement" or "procurement" or "sustainable procurement" or "digital procurement" and "construction" or "building". Initially, 654 publications were found. These publications were further screened by only including publications dated between 2012 – 2022, journal articles exclusively and in English. This screening reduced the available literature samples to 492. Further screening of the remaining articles was conducted through the review of publication titles, abstracts, and keywords. Publications that were not closely related to this study were removed. This exercise highlighted that Automation in Construction, Construction Innovation and International Journal of Procurement Management had at least three papers each. A total of 82 papers from 45 journals were selected as the literature sample for the scientometric analysis.

3.2 Scientometric analysis

The second step of the review involved a scientometric analysis method by adopting the bibliometric mapping software VOSviewer (Van Eck and Waltman, 2010). Scientometrics can be described as the quantitative approach applied in text mining of scientific publications (Hawkins, cited in Aghimien et al., 2021). Scientometrics are useful in facilitating a visual perspective of structural and dynamic aspects of scientific research and analysis outlined within existing literature (Olawumi and Chan, cited in Aghimien et al., 2021). Thus, it has allowed researchers to discover existing systematic literature-related findings by connecting literature theories that may have been missed in manual review studies. VOSviewer generates, visualises, and analyses bibliometric networks (Van Eck and Waltman, 2010). Specifically, its text mining capabilities can construct network maps of journal sources, co-citations, co-authorship, country of origin and co-occurring keywords sourced from abstracts and bodies of research articles (Van Eck and Waltman, 2011). The literature sample sourced from Step 1 was imported into VOSviewer to create a network of co-occurrence keywords, along with lead journal authors and sources, and country of origin. The co-occurrence network assisted in identifying the primary area of interest of e-procurement.

4. RESULTS

A total of 30 countries was identified from the literature sample. Australia has the highest number of publications (15), with 82 citations. This is followed by United Kingdom with 9 publications and 86 citations, and China with 8 publications and 42 citations. Countries which closely followed included Malaysia, Hong Kong, and Nigeria. Interestingly, 14 out of the 30 countries only published one article between 2012 and 2022. The potential for further research within these countries to gain a greater understanding of e-procurement in construction could be beneficial for future researchers.

4.1 Publications per author

An authorship network map is used to identify the influential researchers in the e-procurement sector of construction research (Marzouk et al., 2022). A minimum of two published articles and five citations was set as the criteria of the authors. Tunji-Olayeni P., Yevu S.K., and Yu A.T.W. are the most productive scholars in this research domain based on the number of published articles. Additionally, Eadie, R., Perera, S., and Heaney, G., are in the same cluster, indicating their mutual relationship by citing one another's work. The distance and connection lines between clusters can also be used to determine the authors linkage strength (Van Eck and Waltman, 2014). The quantitative measurements of the most prominent authors are explored in Table 1. The affiliation column shows the author's institution at the time of publication and reveals that Ibem E.O. has the highest number of citations 79 for their three extracted documents. However, Yevu S.K., Yu A.T.W., and Tunji-Olayeni P. have the

highest number of publications of four extracted documents with 14, 14 and 53 citations, respectively.

Table 1: Number of publications per author

Author	Affiliation	Nos	Citations
Tunji-Olayeni P.	Department of Building Technology, Covenant University, Nigeria	4	53
Yevu S.K.	Department of Building and Real Estate, The Hong Kong Polytechnic University, Kowloon, Hong Kong	4	14
Yu A.T.W.	Department of Building and Real Estate, The Hong Kong Polytechnic University, Kowloon, Hong Kong	4	14
Ibem E.O.	Department of Architecture, Covenant University, Nigeria	3	79
Layryea S.	School of Construction Economics and Management, University of Witwatersrand, South Africa	2	60
Grilo A.	UNIDEMI, Faculdade de Ciências e Tecnologia da, Universidade Nova de Lisboa, Monte de Caparica, Portugal	2	58
Costa A.A.	CIST/Instituto Superior Técnico, University of Lisbon, Portugal	2	37
Tavares L.V.	CESUR/Instituto Superior Técnico, University of Lisbon, Portugal	2	37

4.2 Publications per source

Publications within the literature sample originated from 49 sources. Table 2 depicts five sources with at least three publications focusing on e-procurement in construction. Engineering, Construction and Architectural Management and Construction Innovation have the highest number of extractions with four articles each and interestingly, 14 citations each. The most cited source is Automation in Construction, with three articles and 42 citations.

Table 2: Number of publications per source

Source	Nos	Citations
Engineering, Construction and Architectural Management	4	14
Construction Innovation	4	14
Automation in Construction	3	42
International Journal of Procurement Management	3	34
International Journal of Construction Management	3	22

4.3 Pattern of keywords

Through analysing keyword co-occurrences, knowledge advancements can be mapped to assist in understanding the knowledge structure of study (Su and Lee, 2010). To formulate such map, VOSviewer's co-occurrence analysis of keywords was used. The assessed articles produced a total of 459 keywords. VOSviewer groups the keywords into clusters using a set criterion for co-occurrences (Aghimien et al., 2021). The clusters identify common areas of research in past studies. The threshold of minimum number of occurrences of keywords in automatically set to five. According to Aghimien et at. (2021) there is no joint agreement regarding the ideal number of minimum co-occurrences to be applied in the body of knowledge. To ensure an optimal representation of keywords was identified in this study, the minimum number of occurrences was set to three. A total of 37 keywords met this threshold with a total link strength (TLS) of 460. General keywords such as "construction", "construction industry', "construction project", etc, were removed. Additionally, keywords with the same meaning, such as block-chain and blockchain were blended. Finally, 32 keywords were generated as illustrated in Fig. 1.

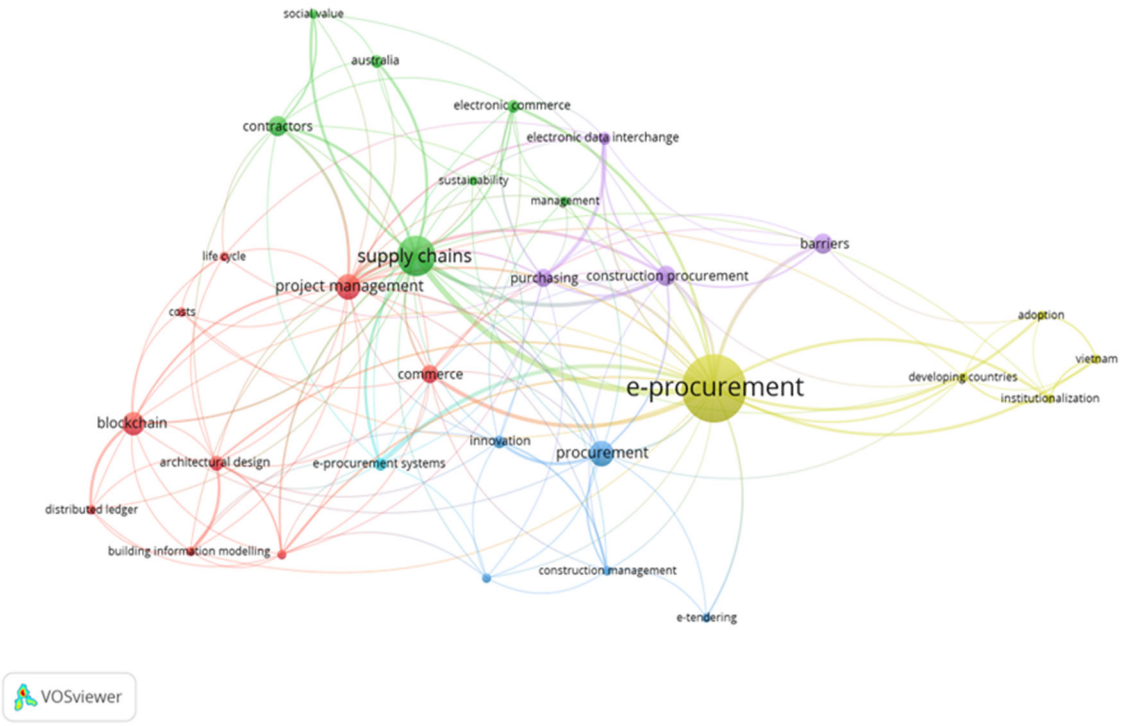

Fig. 1: Keyword co-occurrence network

The size of the nodes shows the frequency of occurrence and the lines between the nodes represent their co-occurrence in the same publication (Van Eck and Waltman, 2018). The closer the two nodes are, the greater the number of co-occurrences of the two keywords. For example, architectural design is found with close relationship with blockchain, information management and building information modelling design. It has been identified that, e-procurement, supply chains and project management were the most frequently entered keywords in the context of e- procurement in construction. It is unsurprising that e-procurement is at the centre of this network given it was the main search keyword to which other keywords are linked. Table 3 shows the occurrence and TLS of each keyword. Furthermore, the analysis categorised keywords that appeared multiple times into six clusters.

Table 3: List of clusters and co-occurring keywords

Cluster 1 (Red)	Occ.	TLS	***Cluster 3 (Blue)***	Occ.	TLS
Architectural design	5	16	Construction management	3	11
Blockchain	8	14	E-tendering	3	4
Building Information Modelling	3	11	Innovation	4	14
Commerce	6	18	Procurement	9	19
Costs	3	5	Public procurement	3	8
Life cycle	3	7	***Cluster 4 (Yellow)***		
Project management	9	34	Adoption	3	8
Cluster 2 (Green)			Developing countries	3	10
Australia	4	7	E-procurement	27	58
Contractors	7	15	Institutionalisation	3	9
Electronic commerce	4	13	Vietnam	3	8
Management	3	9	***Cluster 5 (Purple)***		
Social value	3	8	Barriers	7	10
Supply chains	15	47	Construction procurement	7	24
Sustainability	3	5	Electronic data interchange	4	15
			Purchasing	6	21
Occ. = Occurrence			***Cluster 6 (Teal)***		
TLS = Total Link Strength			E-procurement systems	4	16

4.4 Pattern of keywords

In addition to the network map, an overlay visualisation map is produced in VOSviewer. This map shows the keywords based on their year of publication during the period of 2016 to 2021. A coloured bar, identifying the years with a correlating colour is displayed in the bottom right- hand corner of the map (Van Eck and Waltman, 2018). For example, keywords coloured blue were published between 2016–2017 and focused on e-procurement areas relating to developing countries, adoption, institutionalisation, e-commerce, and information management. Publications between 2017–2019 seemed to shift focus slightly to areas such as supply chains, costs, barriers, purchasing, e-tendering, and e-procurement systems. These keywords are displayed in dark green/blue on the visualisation map. The latest years on the map which include 2020 – 2021 see a wide range of topics be introduced, including, electronic data exchange, social value, blockchain, building information modelling (BIM), innovation, sustainability, construction management and life cycle. These keywords are represented in bright green/yellow. Fig. 2 illustrates the overlay visualisation map. Examining the overlay visualisation map in conjunction with the

TLS results in Table 3 (cluster table) suggests that future research of e-procurement in construction could explore areas relating to e- tendering, costs, life cycle, sustainability, adoption, and social value. These areas have been identified to have low TLS results from past research studies. Despite their importance, these research areas have received little attention.

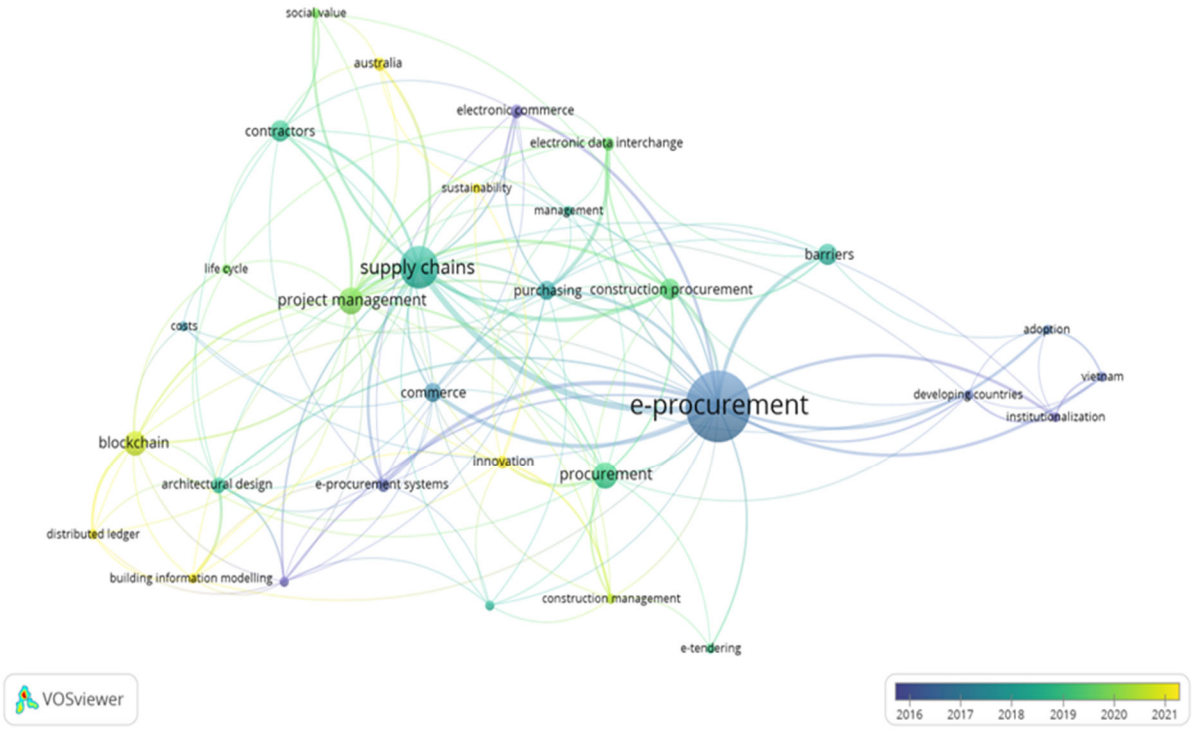

Fig. 2: Overlay visualization map.

5. DISCUSSION

From the foregoing review and bibliometric analysis, the following four key areas have been identified as the main categories of this research.

5.1 Adoption rates in other countries

Whilst several global studies into the barriers of e-procurement have been carried out (Yevu et al., 2022), analysis into the actual adoption levels of e-procurement practices globally is not heavily featured in the literature reviewed. Instead, analysis on adoption rates is often country specific. Several in-depth studies into a broad mix of developed and developing countries has been identified, such as Austria (Zunk et al., 2014), South Africa (Ibem and Laryea, 2015), Nigeria (Afolabi et al., 2019) and Vietnam (Tran et al., 2021). Whilst there has been some investigation into e-procurement practices in the Australian construction industry (Lin et al., 2022; Loosemore and Reid, 2019), there is very little contemporary literature into the adoption rates in the Australian context and how this compares globally. This Study will seek to partially address this gap in existing literature.

5.2 Benefits and enablers of e-procurement

There is a significant volume of research and analysis into the benefits and enablers of e- procurement practices. The drivers and barriers of e-procurement in the construction sector was comprehensively examined in Eadie et al. (2010), with the key drivers identified including (1) Process, transaction and administration cost savings; (2) Convenience of archiving completed work; (3) Increased quality, efficiency and accuracy; and (4) Shortened internal and external communication cycle times. The literature into drivers and benefits has continually strengthened over the past decade, with key contributions from Yevu et al., (2021), Khahro et al., (2021),

Pattanayak and Punyatoya (2021) and Wimalasena and Gunatilake (2018), amongst others.

Despite the significant volume of literature, there are few examples of 'firm-level' studies which validate the perceived benefits of e-procurement from a construction organisation perspective. The need for more firm-level studies to measure the link between productivity and digitization in the context of the Australian construction industry was identified by Leviakangas et al., (2017). There is also a clear lack of Australian-focused literature which examines the potential benefits of e-procurement based on the local industry environment.

5.3 Barriers to e-procurement adoption and challenges upon implementation

As observed with benefits and enablers, there is an extensive volume of existing literature and research into the barriers to e-procurement adoption in the construction industry. Eadie et al. (2010, 2012) was one of the first to examine these barriers in significant detail, though extensive primary research has been carried out across multiple countries since that time, with prominent examples being Yevu et al., (2021), Yevu and Yu (2019), Nawi et al., (2017) and Afolabi et al., (2017). Yevu et. al (2021) categorised some 21 individual barriers to e-procurement adoption into six barrier groups based on an extensive review of existing literature and primary research. These barrier groups include:

i. Technological Usability and Evolution-Related Barriers

ii. Security and Unsupportive Environment-Related Barriers

iii. Culture-Related Barriers

iv. Infrastructure-Related Barriers

v. Unethical Practices–Related Barriers.

vi. Financial and Skill-Related Barriers

There is more limited research into the challenges of e-procurement usage in the construction industry upon implementation. Primary research through direct interviews with construction industry professionals in Ibem et al. (2021), Isikdag (2019) Nawi et al. (2017) and Brandon- Jones (2017) provide useful insights into the first-hand challenges of industry participants upon implementation of e-procurement systems. Whilst there is an excellent base of research from which the Study can leverage, it is evident from the literature review that there is a lack of Australian-focused studies which have identified (if any) Australian-specific barriers and challenges of e-procurement practices in the construction sector. The Study will seek to examine this in detail and further build upon the strong evidence base of research into the barriers of e-procurement adoption and the challenges identified by industry participants upon implementation of e-procurement systems.

5.4 Conclusions

Existing literature has carried out extensive engagement with industry stakeholders to identify the barriers to adopting e-procurement practices and the challenges upon their implementation as observed in Ibem et al., (2021), Isikdag (2019) Nawi et al. (2017) and Brandon-Jones (2017). It is noted that none of these studies have focused specifically on the Australian construction industry. Whilst there is an excellent base of research from which this study can leverage, it is evident from the literature review that there is a lack of Australian-focused studies on specific barriers and challenges of e-procurement practices in the construction sector. The scope of this review focusses on the implementation of e-procurement in facilitating towards digital transformation in the construction sector. The study examines this in detail in the next phase of study and further build upon the strong evidence base of research into the barriers of e-procurement adoption and the challenges identified by industry participants upon implementation of e-procurement systems. Study findings may be used to guide construction companies' investment choices in digitally modernising the procurement function. Through their procurement processes, organisations may boost their digital transformation objectives.

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