ISSN 1392-3730/eISSN 1822-3605

VILNIUS TECH
Vilnius Gediminas Technical University

JOURNAL of CIVIL ENGINEERING and MANAGEMENT

2024
Volume 30
Issue 7
Pages 632–645
https://doi.org/10.3846/jcem.2024.21873

GREEN PROCUREMENT IN THE CONSTRUCTION INDUSTRY: UNFOLDING NEW UNDERLYING BARRIERS FOR A DEVELOPING COUNTRY CONTEXT

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Article History:
- received 31 March 2023
- accepted 28 May 2024

Abstract. Despite the construction industry's detrimental effects on environmental sustainability, the concept of green procurement (GP) is still relatively new in the developing world. The barriers hindering GP adoption need detailed investigation as studies in the context of developing countries are still limited and the underlying dimensions remain a known-unknown. This study appraised the critical barriers to GP adoption in the Malaysian construction industry. Twenty (20) barriers were identified from the detailed literature review and a field survey was conducted with 150 professionals. The ranking analysis results indicated the top five barriers are: high initial cost; lack of expertise and regulations; lack of government regulations; lack of top management commitment and lack of awareness among construction stakeholders. A factor analysis further identified five major underlying dimensions. The study showed that both government and organisational commitments are crucial in promoting GP adoption. This study adds to incremental knowledge in GP literature by analysing the critical barriers and the associated underlying dimensions to GP adoption in a developing country, which could help practitioners and policymakers in evaluating the organisation's or industry's readiness to adopt GP practices along with devising apt measures to mitigate the barriers to shift to sustainable and environmentally friendly construction.

Keywords: green procurement, barriers, construction industry, developing country, underlying dimensions.

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1. Introduction

Construction can negatively impact the environment. Enshassi's et al. (2014) evaluation of the construction sector in the Gaza Strip observed that dust generation, noise pollution, operations with vegetation removal and air pollution are the most significant environmental impacts due to construction activities. In another study in Ghana, the top three environmental concerns are related to resource consumption (water, electricity and fuel), effects on biodiversity (vegetation removal, interference with the ecosystem and loss of edaphic soil) and local issues (noise and vibration generation) (Ametepey & Ansah, 2015). Using autoregression and error correction analysis methods for the variables of construction and energy consumption, Sepehrdoust et al. (2022) reported that a 1% increase in energy consumption will contribute to an increase of 0.285% in the short run and 0.473% in the long run. The authors further recommend replacing the conventional construction methods with new construction strategies in favour of lower energy consumption and fewer CO_2 emissions into the environment. Given the significant environmental degradation, sustainable practices are urgently needed (Bohari et al., 2015; Yap et al., 2023). Likewise, Wong et al. (2016) accentuate the urgent need for the construction industry to adopt comprehensive clean production methods to support environmental initiatives and green policies. It is worth noting that scholars suggest integrating environmental principles, green technologies and environmental management methods into construction project practices (Li et al., 2020; Yap et al., 2023). In response, a more sustainable approach such as green procurement (GP) in the development of the built environment is needed to shift to a greener mode of operation with low carbon emissions,

high energy conservation and the use of green technology to reduce pollution to a greater extent – attaining sustainability goals from the perspective of Triple Bottom Line (TBL) (economic, social and environmental aspects).

Following a systematic citation network analysis, Rejeb et al. (2023) summarise that the related keywords to GP include sustainability, sustainable procurement, environmental concerns and green manufacturing. In an earlier study, Yang et al. (2019) reported that the concept of GP is mainly used in the manufacturing industry and the terms "green procurement", "sustainable procurement" and "environmental purchasing" are used interchangeably in the literature. The principles and methods of GP are used to reduce environmental pollution in the process of building production. Against such a backdrop, Yang et al. (2019, p. 4) define GP as: "*During the construction of the whole life cycle of the project, the purchasing behaviour of reducing the risk of environmental pollution and improving the social, economic and environmental benefits from the organizational culture of the enterprise to the selection of specific construction materials and construction machinery is carried out.*" Li et al. (2020) opine GP requires taking environmental considerations in the purchasing strategies and policies. Banihashemi et al. (2023) on the other hand categorised green supply chain management into: green procurement, green design, green production, green management and green information. According to Marcelline et al. (2022), GP is a part of the sustainable development goals (SDGs) whereby individuals, organisations and countries in their capacities, especially the developing world are urged to incorporate sustainable green methods and materials in their projects. That being said, GP facilitates sustainable development where institutions are anticipated to improve environmental performance, reduce waste, and increase resource efficiency while delivering and receiving green products and/or services in the construction industry. That being said, the present study considers GP as the recognition, integration, and implementation of green practices along the procurement process.

Previous studies have highlighted that the concept of GP is still in its infancy and the update is slow in the construction industries of the developing world (Darko et al., 2018; Mojumder et al., 2022; Ogunsanya et al., 2022; Simion et al., 2019) and Malaysia is no exception (Alqadami et al., 2020; Ashikin & Vasudevan, 2021; Khaderi et al., 2022). It must be pointed out that many construction firms still do not include green as part of their visions and missions (Shurrab et al., 2019). Given that the implementation of green supply management is not well understood, more research is therefore needed to take cognizance of the barriers faced (Mojumder et al., 2022; Rejeb et al., 2023). Notably, little attempt has been made to explore the underlying dimensions of these barriers in the context of the developing world, particularly in the Southeast Asian region. As a corollary, this study aims to contribute towards bridging these gaps in knowledge by providing answers to the research questions:

1. What are the major barriers to the adoption of GP in the construction industry? and
2. What are the fundamental underlying dimensions involved?

2. Fundamental barriers hindering the adoption of green procurement

Table 1 presents a list of 20 barriers identified from the literature using a deductive content analysis. The most frequently cited barrier is "unfamiliar of green procurement concept" (6 studies), followed by those with 5 studies which are: high initial cost, lack of incentives, lack of top management commitment, and lack of government regulations. Appolloni et al. (2014) through a literature review of papers published between 1996 and 2013 have identified 20 papers that appraised the barriers to the adoption of GP which are divided into internal (costs, lack of legitimacy) and external (regulation, poor supplier commitment, industry-specific problems) barriers. The performance impacts of GP are investigated with respect to environment, financial and operational. It is worth noting that studies dealing with the barriers are fewer than those dealing with the drivers towards GP. The majority of papers published originated from developed countries while China is leading for the developing world. More recently, Rejeb et al. (2023) extracted 452 research papers from the Scopus database to observe the substantial potential of GP to reduce the impacts of climate change and the critical need to deal with GP challenges effectively. They also reported that the literature is currently focused on the public sector and has mostly ignored the private sector.

In researching the key barriers hindering GP in the photovoltaic industry in China, Fang et al. (2020) divided the barriers into two categories, namely internal factors caused by enterprises (including strategies and financial concerns) and external factors (including regulation, customer, competition and society). They reported internal issues such as the company's unawareness are having a higher impact on barrier strength as compared to external issues such as lack of legislation. Nevertheless, they also asserted that several internal issues are caused by external factors, especially weak incentive policies. In another Chinese study, Hasan and Zhang (2016) clustered the potential barriers into four groups: economics, technology, awareness and management. The results indicated that management-related barriers are the highest consideration by the construction stakeholders while the biggest predicaments are higher costs for green practices and unfamiliarity with green technologies. Likewise, Shen et al. (2017) observed only a few real estate developers in Chongqing, China adopted the GP strategy due to having little understanding of GP and green building materials. The causal factors are attributable to few marketing benefits and a lack of incentive policies.

In the case of Ghana, the three most critical barriers to GP adoption are higher costs, lack of government incen-

Table 1. Barriers that undermine the adoption of green procurement

Ref	Barriers	Buniamin et al. (2016)	Alqadami et al. (2020)	Liu et al. (2019)	McMurray et al. (2014)	Zhu et al. (2013)	Wilkinson (2012)	Giunipero et al. (2012)	Saferi et al. (2018)	Woo et al. (2016)	Golpîra (2020)	Sourani and Sohail (2011)	Hoffman and Henn (2008)	Lu et al. (2019)	Khan et al. (2018)	Geng and Doberstein (2008)	Hwang and Ng (2013)	Zhao et al. (2020)	Akadiri (2015)	Bohari et al. (2017, 2020)	He and Yuan (2020)	Wilson and Tagaza (2006)	Wong et al. (2016)	Total
O1	Lack of guidance	√	√		√							√												4
O2	High initial cost	√	√			√			√						√									5
O3	Technical difficulty															√	√	√	√					4
O4	Lack of expertise and knowledge					√			√											√			√	4
O5	Lack of green supplier			√																				1
O6	Additional risks																√							1
O7	Low interest of clients								√			√				√							√	4
O8	Lack of incentives	√	√									√			√								√	5
O9	Low supply and limited information on green building materials	√										√							√				√	4
O10	Lack of environmental responsibilities						√																	1
O11	Financial constraint				√							√			√	√								4
O12	Lack of top management commitment	√	√		√			√				√											√	5
O13	Lack of government regulations		√												√	√				√			√	5
O14	Unfamiliarity with green procurement concept	√	√					√							√	√				√				6
O15	Lack of client's demand								√						√									2
O16	Inadequate capacity of small-scale suppliers and contractors									√	√													2
O17	Reluctance to change towards green practices											√	√		√									3
O18	Wrong perception of the quality of the end products													√							√			2
O19	Time-consuming	√											√				√					√		4
O20	Lack of awareness among construction stakeholders				√															√				2

tives and lack of financing schemes (Chan et al., 2017). In the Indian construction industry, the topmost barriers are related to the reduced commitment from higher management, lack of management support, and perception of higher costs for adhering to GP (Mojumder et al., 2022). Comparable findings are also reported for construction projects in Malaysia (Alqadami et al., 2020; Shurrab et al., 2019) and Singapore (Hwang & Tan, 2012). In Nigeria, the perception of the extra cost being incurred and the lack of sustainable material information are acknowledged as critical challenges to sustainable materials selection (Akadiri, 2015). In Romania, the most significant clusters of barriers are related to technical and technological difficulties as well as project execution costs (Simion et al., 2019). In another recent Nigerian study, Ogunsanya et al. (2022) identified 19 barriers to GP and conducted an exploratory factor analysis from the field survey data collected from 320 construction professionals to reveal four principal dimensions, namely sustainability knowledge, transparency and governance, mismatch of procurement strategy and national policy issues; and construction industry development related issues.

In Malaysia, Ashikin and Vasudevan (2021) used the relative importance index (RII) analysis based on the feedback from 50 respondents to observe that the highest-rated barrier of GP implementation is the perception of higher associated costs while the second and third barriers are higher costs of green products and lack of incentive respectively. The least chosen barrier is the lack of client demand. From the Malaysian developers' perspectives, the major barriers are related to the perception that green products would be more expensive, the lack of incen-

tive for companies to implement GP and the high cost of green products and services (Khaderi et al., 2022). From this background, demand in the market and economic variables take precedence over environmental concerns.

3. Research method

3.1. Questionnaire design

To recognise the prevailing barriers to GP in the construction industry, a comprehensive literature review was initially performed to observe a preliminary list (Table 1). The self-administered online questionnaire contained two sections. The first section of the questionnaire was drafted to contain the rating of the 20 barriers where the respondents were asked to "Please indicate one level of agreement on the following barriers to green procurement adoption in the construction industry" based on a five-item Likert scale (1 = strongly disagree to 5 = strongly agree). The second section was designed to gather general background information about the respondents, which comprised the primary parties in a construction project, namely clients, consultants (such as architects, engineers, quantity surveyors) and contractors. The structured questionnaire form was designed to be anonymous and self-administered to avoid any respondent biases and/or errors.

3.2. Data collection and respondents' profile

In this cross-sectional survey, the respondents were selected via a non-probability sampling approach involving convenience and judgemental techniques. Stratification was applied to ensure equal distribution among three groups of respondents (including clients, consultants and contractors) based in the Klang Valley region, which includes areas within Kuala Lumpur and Selangor – the epicentre of construction activities in Malaysia (Yap et al., 2019). Following a successful pilot test with 30 targeted respondents where the Cronbach coefficient alpha value for the 20 barriers is 0.882 (>0.70 for good scale reliability), a total of 350 online questionnaires were shared via email, WhatsApp and LinkedIn platforms for which 120 valid responses were collected, attaining a response rate of 34.3%. As the pilot questionnaires did not require further alterations, all were included in the sample (Love & Sing, 2013; Yap et al., 2018), which led to 150 valid responses.

Table 2 provides detailed information concerning the respondents' demographics, comprising professionals from client, consultant and contractor organisations. About half (46.7%) had more than five years of construction working experience, with more than a third holding managerial positions or above. Additionally, approximately 80% are involved in privately funded projects.

3.3. Statistical analysis approach

The responses are analysed using the IBM SPSS Statistics software which is commonly used for advanced statistical analysis. Mean scores are used to prioritise the barriers.

Table 2. Respondents' background

Category	Categories	Frequency (N = 120)	Percentage (%)
Nature of work	Client	32	21.3
	Consultant	44	29.3
	Contractor	44	29.3
	Supplier	30	20.0
Designation	Executive	96	64.0
	Manager	23	15.3
	Senior Manager	20	13.3
	Top Management / Director	11	7.3
Working experience (years)	Less than 1–5	80	53.3
	6–10	32	21.3
	11–15	19	12.7
	More than 15	19	12.7
Sector	Private	122	81.3
	Public	28	18.7

Based on the five-point Likert scale, a mean score exceeding 3.00 indicates that the variable is regarded as significant. Next, the Kruskal-Wallis H test is used to determine to investigate whether there is a significant difference among the opinions of different groups of respondents towards the studied barriers. Finally, an exploratory factor analysis (EFA) is applied to uncover the underlying factors involved.

3.4. Expert validation

Nesting qualitative data collection methods within quantitative studies improves results by assessing validity and providing depth and context (Creswell, 2014). After the quantitative data was generated, structured interviews were carried out accordingly with the industry experts to seek validation and acquire the industry feedback towards the results obtained. On that premise, the purpose of conducting validation for quantitative research is to evaluate the "accuracy" of the findings (Yap & Skitmore, 2020). In this study, the ranking of the barriers obtained and the naming of the five underlying groups from the factor analysis are subjected to validation by four highly experienced industry experts. This provided face validity by seeking the "approval" of industry practitioners (nonresearchers) (Lucko & Rojas, 2010).

4. Research findings and discussion

4.1. Ranking of barriers

Cronbach's coefficient alpha is 0.911, which is higher than the 0.7 value needed for acceptable reliability and internal consistency of the research instrument (Hair et al., 2019). Based on Table 3, the top five barriers that hinder the implementation of GP are:

1) High initial cost (Mean = 4.320; δ = 0.736);

Table 3. Ranking of the barriers

Barriers	Overall (N = 150)			Developer (N = 32)			Consultant (N = 44)			Contractor (N = 44)			Supplier (N = 30)			Chi-square	Asymp. sig
	Mean	SD	R	Mean	SD	R	Mean	SD	R	Mean	SD	R	Mean	SD	R		
High initial cost	4.320	0.736	1	4.312	0.859	1	4.250	0.651	4	4.341	0.745	1	4.400	0.724	3	1.687	0.640
Lack of expertise and knowledge	4.140	0.836	2	4.000	0.916	2	4.273	0.817	3	3.909	0.910	8	4.433	0.504	2	8.549	0.036*
Lack of government regulations	4.120	0.904	3	3.906	1.058	7	4.273	0.758	2	4.000	0.964	3	4.300	0.794	4	3.619	0.306
Lack of top management commitment	4.080	0.871	4	3.719	1.023	15	4.386	0.618	1	3.932	1.021	6	4.233	0.568	5	10.282	0.016*
Lack of awareness among construction stakeholders	4.067	0.748	5	3.906	0.734	6	4.182	0.657	7	3.977	0.902	4	4.200	0.610	6	4.114	0.249
Financial constraint	4.033	0.806	6	3.719	0.958	14	4.227	0.642	5	3.955	0.888	5	4.200	0.610	6	6.657	0.084
Lack of environmental responsibilities	4.000	0.890	7	3.969	0.897	3	4.159	0.745	9	3.909	1.053	9	3.933	0.828	13	1.864	0.601
Unfamiliarity with green procurement concept	3.993	0.847	8	3.813	0.965	9	4.182	0.786	8	3.909	0.802	7	4.033	0.850	11	4.380	0.223
Lack of guidance	3.973	0.802	9	3.781	0.870	12	4.205	0.668	6	3.795	0.930	13	4.100	0.607	10	7.320	0.062
Reluctance to change towards green practices	3.947	0.865	10	3.937	0.914	5	3.864	0.795	13	3.886	0.945	10	4.167	0.791	8	2.760	0.430
Lack of client's demand	3.940	0.845	11	3.781	0.706	11	4.159	0.745	9	3.864	1.091	12	3.900	0.662	14	5.099	0.165
Technical difficulty	3.940	0.861	12	3.844	0.920	8	3.841	0.834	14	3.750	0.866	16	4.467	0.629	1	15.306	0.002**
Lack of incentives	3.933	0.932	13	3.656	1.004	16	4.023	0.762	12	4.068	0.950	2	3.900	1.029	15	3.832	0.280
Inadequate capacity of small-scale suppliers and contractors	3.927	0.812	14	3.719	0.851	13	4.114	0.722	11	3.864	0.955	11	3.967	0.615	12	4.625	0.201
Low supply and limited information on green building materials	3.860	0.983	15	3.812	1.230	10	3.841	0.914	15	3.727	0.997	17	4.133	0.730	9	2.877	0.411
Lack of green suppliers	3.820	0.949	16	3.938	0.982	4	3.773	1.054	17	3.773	1.008	15	3.833	0.648	16	0.870	0.833
Wrong perception of the quality of the end products	3.693	0.882	17	3.531	0.879	17	3.773	0.774	16	3.682	1.073	19	3.767	0.728	17	1.800	0.615
Time-consuming	3.673	0.986	18	3.500	0.916	18	3.705	1.091	18	3.795	0.978	14	3.633	0.928	18	2.413	0.491
Low interest of clients	3.587	0.957	19	3.500	0.916	18	3.568	0.974	19	3.682	1.052	18	3.567	0.858	19	1.347	0.718
Additional risks	3.387	0.933	20	3.313	0.931	20	3.364	0.942	20	3.432	0.950	20	3.433	0.935	20	0.400	0.940

Notes: * – the mean difference is significant at the 0.05 level of significant; ** – the mean difference is significant at the 0.01 level of significant.

2) Lack of expertise and knowledge (Mean = 4.140; δ = 0.836);
3) Lack of government regulations (Mean = 4.120; δ = 0.904);
4) Lack of top management commitment (Mean = 4.080; δ = 0.871);
5) Lack of awareness among construction stakeholders (Mean = 4.067; δ = 0.748).

Overall, the high initial cost has been ranked as the most critical barrier which hindered the implementation of GP in the construction industry. Sustainable procurement may well be realised with the aid of green-based construction technologies and thus, additional investment costs may be needed (Mojumder et al., 2022; Simion et al., 2019). The integration of green techniques into the construction process such as the use of water- and energy-saving equipment would also incur a high capital cost (Hasan & Zhang, 2016; Saferi et al., 2018). Despite the benefits offered by GP being countless, its development is still retarded in many developing countries as the extra upfront cost generated by GP adoption deterred the firms from practising it (Bag, 2017; Mojumder et al., 2022). Ezani et al. (2020) affirmed that both clients and contractors are less concerned about the environmental impacts and tend to procure low-cost materials. For that reason, they may well be reluctant to spend too much to purchase green materials with higher costs regardless of the long-term benefits which could be brought by GP adoption.

The second position is the lack of expertise and knowledge, which indicates the absence of relevant information regarding green issues would hinder the implementation of GP. A recent study in Pakistan by Khahro et al. (2021) also identified this as a key factor for GP adoption. On the contrary, Chan et al. (2017) observed that those stakeholders who are equipped with better information and knowledge on green building technologies are more likely to

apply them. Accordingly, the practitioners may refuse to practice GP if they have poor comprehension of the matter. Honing such skills and expertise presents a new problem for firms in green training (Liu et al., 2020). Meanwhile, as GP is still in the infancy stage in Malaysia's construction industry, the execution of GP may be more difficult due to the lack of expertise (Razali et al., 2021). Zhu et al. (2013) affirmed that most of the procurement staff had limited skills in evaluating the greenness of the products and services. Thus, the client is unwilling to take the risks to integrate green products and services into their project as the outcome is uncertain.

Next, the lack of government regulations is ranked third among the 20 barriers identified. Insufficient enforcement of regulations and policies contributed to the impediment in addressing sustainability issues in procurement (Buniamin et al., 2016; Khaderi et al., 2022). Arif et al. (2009) further noted that the move towards green is stagnant as the enforcement and audit of the legislative framework are weak. For example, "lack of related laws and regulations and government support" is a major environmental challenge for green management in the construction industry (Banihashemi et al., 2023). As such, the construction stakeholders are negligent in integrating the environmental aspects into the procurement process due to the absence of valid grounds to urge them to practice GP. Such a condition is affirmed by Wong et al. (2016) explaining that some clients rejected to practice green in the construction process due to the absence of legal enforcement by the government.

The fourth barrier is the lack of top management commitment. According to Hasan and Zhang (2016) and Ahmed et al. (2020), the level of support from senior management would significantly affect the adoption rate of GP. The employees at lower hierarchies had limited power to implement changes to shift towards GP if the senior management in their organisations were putting fewer concerns on environmental issues (Liu et al., 2020). In addition, the realization of GP might become more arduous when the top management of a construction organisation refuses to expose their employees to the information regarding GP (Ali et al., 2016).

The lack of awareness among construction stakeholders is ranked fifth. The project stakeholders are essential determinants which would affect the "make or break" of a construction project (Bohari et al., 2020). Hence, the enhancement of awareness among the project stakeholders is regarded as a great opportunity to expedite GP adoption. Nevertheless, the awareness of GP adoption is still not propagated across the whole construction sector despite rising awareness of GP in other industries (Chan et al., 2018; Khahro et al., 2021). As a consequence, the construction players might refuse to execute this initiative in their projects as they are unaware of the potential benefits of applying GP towards the environment, economy and society (Bidin et al., 2019).

4.2. Comparison of perception between groups

Table 3 shows that there is no significant difference for all of the barriers except lack of expertise and knowledge, lack of top management commitment and technical difficulty.

The clients, consultants and suppliers had ranked "lack of expertise and knowledge" as the top 3 critical barriers to GP adoption while the contractors ranked it at only 8th. This scenario could be explained following the findings of Bohari et al. (2020), Khahro et al. (2021) and Mojumder et al. (2022) whereby most of the project stakeholders had still not grasped the meaning of sustainable principles. Although they acknowledged the sustainable concepts, they lack the knowledge on how to translate sustainability into actions. Meanwhile, the contractor had perceived this as the less significant barrier as they may already have started to equip themselves with the technical skills and knowledge to practice green in construction procurement in the past few years. As sustainable projects are mushrooming in the current construction industry, the possession of adequate knowledge and skill would aid the contractor to gain superiority in bidding the projects with specific green requirements.

Top management is responsible for establishing policies, guidelines and strategic objectives within an organisation. Wong et al. (2016) highlighted that the commitment of top management would influence the company's involvement in green practices and activities. Likewise, Liu et al. (2020) affirmed the positive attitude of top management would accelerate the adoption of GP within the firms. In this light, the respondents might have a different insight on the importance of top management commitment as their options might be indirectly affected by the top management attitude in their belonging organisations.

Technical difficulty is ranked first place by the suppliers. This is consistent with Bohari et al. (2017) accentuating that most of the suppliers are still in a grey area regarding green projects, especially concerning technical-related issues. According to Mathiyazhagan et al. (2013), it is difficult for the supplier to design pollution-free products which could fulfil sustainable requirements due to the lack of technical expertise. The researchers further claimed the process of manufacturing a new material using waste or recycled products is arduous without the aid of proper technologies. Thus, it is unsurprising that the suppliers perceived technical difficulty as the most significant barrier that hindered GP application.

4.3. Exploratory factor analysis of barriers

Exploratory factor analysis (EFA) is employed to provide a summary of the interrelationships among the variables concisely and accurately. In this study, EFA sorts the correlated data into a smaller set of underlying constructs. The Kaiser–Meyer–Olkin (KMO) index (KMO > 0.50) and

Bartlett's test (p-value < 0.05) are used to ascertain the factor reliability, whereas the latent root criterion (eigenvalues > 1.0) is applied to determine the optimal number of groupings (Hair et al., 2019; Yap et al., 2022). The KMO value is 0.851 and Bartlett's test of sphericity is 1356.4 (p-value = 0.000) – affirming the fitness of the data for factor analysis (see Table 4).

Table 4. Results of KMO and Bartlett's Tests

Parameter	Value
Kaiser-Meyer-Olkin measure of sampling adequacy	0.851
Bartlett's test of sphericity	
Approximate chi-square	1356.364
Degree of freedom	190
Significance	0.000

4.4. Discussion of the uncovered underlying dimensions for the barriers

Dimension 1: Government and organisation-related barriers

Dimension 1 accounts for 15.437% of the total variance explained among all the barriers demonstrated in Table 5. This underlying dimension generally highlighted the issues that fall within the purview of government and organisation. It represented five critical barriers which are lack of incentives, low interest of clients, lack of client's demand, lack of top management commitment and lack of government regulations.

In the effort to realise GP adoption in the local construction industry, the government plays a decisive role in establishing related requirements, regulations and legal frameworks for the firms to comply with during the construction process (Wong et al., 2016). However, policies and regulations are not strictly enforced by the government to regulate firms to implement GP practices (Bai & Satir, 2020). As a result, most companies are reluctant to execute GP without the mandatory requirements from the government (Fang et al., 2020). Moreover, the cost to procure green materials and technologies is comparatively higher than the conventional one. Nonetheless, the incentives and support from the government are found to be unsatisfactory (Khan et al., 2018). Without a sufficient amount of incentives and financial support, companies are reluctant to disburse a large amount of money to procure green services or adopt green technologies as they are uncertain about the possible benefits that could be delivered through GP applications (Rane & Thakker, 2020).

Furthermore, the negative attitude of organisations towards GP tends to hamper its implementation as well. Clients and top management are always regarded as critical decision-makers within an organisation (Liu et al., 2020). Meanwhile, the unwillingness of clients and top management to practice environmentally friendly activities during the procurement process may lead to poor implementation of GP. For instance, if the organisations are profit-oriented, they might have little demand or interest to implement sustainability-oriented procurement strategies which are unlikely to generate financial benefits for them (Sourani & Sohail, 2011). The execution of GP is undermined when the top management of an organisation refuses to impart their employees with relevant information (Ali et al., 2016).

Dimension 2: Knowledge and technical-related barriers

This underlying group had the second-highest variance, which was 14.844%. It comprised four critical barriers which embraced "lack of expertise and knowledge", "technical difficulty", "unfamiliarity with green procurement concept" and "lack of guidance".

In the effort to actualise a sustainable procurement approach, construction practitioners need to equip themselves with adequate knowledge and technical skills. Abidin (2010) asserted that knowledge is an essential factor to jumpstart the sustainable movement. Nevertheless, it is found that the knowledge and level of comprehension of the construction players towards GP are insufficient (Khahro et al., 2021; Razali et al., 2021). For instance, the lack of knowledge of a firm in identifying appropriate green products and services to be procured inhibited the execution of GP (Wong et al., 2016). It is reported that some construction companies rejected procuring sustainable materials as they are unfamiliar with their performance and uncertain of their cost implications (Shi et al., 2013).

Moreover, the advocacy of GP would actively involve the adoption of green technologies as previously mentioned. Notably, the application of green technologies is technically difficult and needs to be carried out by green-skilled professionals and workers (Ali et al., 2020). Because of this, the lack of technical skills or expertise to apply green technologies will thwart the actions to bring GP practice into reality (Chan et al., 2018). It is arduous for the suppliers to design an eco-friendly product to fulfil environmental requirements in the absence of proper technical support and guidance within the industry (Mathiyazhagan et al., 2013). Such a situation might indirectly affect the availability of green construction materials in the market and hamper the GP exercise accordingly.

Dimension 3: Attitude-related barriers

Dimension 3 comprised four critical barriers, namely: reluctance to change towards green practices, wrong perception of the quality of the end products, lack of environmental responsibilities and inadequate capacity of small-scale suppliers and contractors. This underlying group accounted for 14.105% of the total variance explained among all the critical factors.

The application of sustainable procurement in construction projects would be affected by the attitude displayed by the construction practitioners. Sourani and Sohail (2011) pointed the transformation towards sustainability required new ways of thinking, practices and attitudes. Nevertheless, it is observed that the initial reaction of the

public towards the implementation of new initiatives is disbelief and resistance. This condition could be applied to the evolution of GP in the construction sector. As the GP approach is relatively new in the Malaysian construction industry, most of the construction players might have a negative attitude and are reluctant to change towards such an approach. One of the reasons is hard for them to identify the possible risks and unforeseen costs of applying new technologies in the projects (Hwang & Tan, 2012). Besides, some professionals might have a negative perception towards the quality and durability of green products manufactured from recycled wastes (Jin et al., 2017). Thus, they are prone to practice traditional construction procurement as such an approach is time-tested and the outcomes are more reliable. Further, the poor attitude of construction firms towards the mitigation of environmental issues would also thwart the exertion of GP practices. If construction practitioners do not take the issues of environmental degradation seriously, they are less likely to make environmentally responsible decisions in procurement action (Liu et al., 2020).

Dimension 4: Project and market constraints

Dimension 4 consisted of five critical barriers which included time-consuming, additional risks, low supply and limited information on green building materials, lack of green suppliers and lack of awareness among construction stakeholders. This underlying factor explained 10.724% of the total variance and generally emphasized the barriers attributed to project and market constraints.

Project constraint refers to the factors that could affect the quality, delivery and overall performance of a project. In the construction project, time and risk are regarded as two key elements of the project constraints. Time is treated as one of the benchmarks of project performance (Wong et al., 2016). According to Zhang et al. (2015), early completion is always preferable by the clients as the postponement of project completion times would cause them to lose business opportunities and potential returns. As such, they might refuse to apply the GP approach since the actions of incorporating environmental considerations into the construction process will consume time and resources. Since the market for recycled products is still immature, the actions to source green products may be time-consuming (Ahsan & Rahman, 2017). Furthermore, since the reliability and effectiveness of sustainable building materials are hard to assure, some professionals are unwilling to bear the risk of procuring such materials (Hwang & Ng, 2013). On that account, the construction practitioners might opt for traditional materials which they are more familiar with to lessen the time consumed and potential risk of acquiring green materials (Akadiri, 2015).

Further, the implementation of GP is also hampered by market constraints. Banihashemi et al. (2023) relate this to the lack of access to green materials, lack of market for recyclable materials and improper maintenance of materials. A past study by Wong et al. (2016) accentuated that the current market supply of green products and services is unsatisfactory and often limits the selection of project teams. This is akin to Hasan and Zhang (2016) and Shi et al. (2013) reasoning that it is hard to obtain green materials from the standard distribution networks. Thus, sustainable materials are less preferable as a flexible and reliable supply cannot be guaranteed. Moreover, the exertion of GP will be obstructed in the absence of green suppliers in the market who are obliged to manufacture green products for construction firms.

Dimension 5: Financial-related barriers

Dimension 5 accounted for 8.554% of the total variance explained and comprised two critical barriers, which were financial constraints and high initial cost respectively.

Several studies have shown that the impediment to GP adoption is due to financial-related matters. Firstly, the application of GP would incur a higher cost as the firms need to invest in eco-friendly construction methods and technologies (Banihashemi et al., 2023; Zhang et al., 2015). As such construction techniques and procedures are fairly complex, and skilful workers are thus required to carry out the work. In this circumstance, the firms need to spend an extra amount of money to send their staff for training (Kipkorir & Wanyoike, 2015). A huge amount of financial input is also necessitated for the firm to purchase eco-friendly construction equipment (Zeng et al., 2003). Thus, some clients are hesitant to implement GP as they are unwilling to pay for the high upfront cost. Moreover, the decision to adopt GP is also restricted by the financial capability of the companies. A common finding of many studies also identified financial constraints and lack of budget as the significant barriers which impede the development of GP in the construction sector (Mojumder et al., 2022; Ruparathna & Hewage, 2015). As the cost to procure green products is relatively higher than conventional materials, it is burdensome for small size companies who have limited budgets to practice GP although they are conscious of the benefits and importance of going green in the procurement process (Mathiyazhagan et al., 2013; Mojumder et al., 2022). Consequently, they might go for traditional construction procurement which is less pricey even though such practice tends to be less environmentally friendly.

4.5. Expert validation results and construction industry context

The details of the participants are shown in Table 6. The industry experts chosen held different designations in their company, which included contract manager, M&E engineer and quantity surveyor.

The responses collected through the questionnaire survey showed that high initial cost is the most significant barrier that hinders the adoption of GP in construction. In this regard, the perceptions of the industry experts are unanimous. The cost of procuring green materials and technologies tends to be higher as compared to traditional building materials and technologies. As experienced by one of the interviewees: "…I have been involved in a project

Table 5. Factor loading and variance explained

Factor profile	Factor Loading	Variance Explained (%)
Dimension 1: Government and organisation-related barriers		
Lack of incentives	0.765	15.437
Low interest of clients	0.714	
Lack of client's demand	0.674	
Lack of top management commitment	0.535	
Lack of government regulations	0.532	
Dimension 2: Knowledge and technical-related barriers		
Lack of expertise and knowledge	0.811	14.844
Technical difficulty	0.689	
Unfamiliarity with green procurement concept	0.678	
Lack of guidance	0.566	
Dimension 3: Attitude-related barriers		
Reluctance to change towards green practices	0.789	14.105
Wrong perception on the quality of the end products	0.658	
Lack of environmental responsibilities	0.575	
Inadequate capacity of small-scale suppliers and contractors	0.564	
Dimension 4: Project and market constraints		
Time-consuming	0.759	10.724
Additional risks	0.623	
Low supply and limited information on green building materials	0.523	
Lack of green suppliers	0.495	
Lack of awareness among construction stakeholders	0.491	
Dimension 5: Financial-related barriers		
Financial constraint	0.738	8.554
High initial cost	0.490	
Cumulative variance explained		63.665

which adopts a range of sustainable features, which is the International School of Kuala Lumpur (ISKL). One of the green technologies adopted by ISKL is chill slabs… Despite this sustainable feature being effective in cutting down the operation cost, the building cost of ISKL is 20% higher than the ordinary international school". (P3)

A contract manager (P1) further commented that: "As green materials are uncommon to be seen in the market, the price for such materials tends to be higher".

Given that the cost of practising GP is relatively high, most clients who are responsible to initiate and finance the project may resist going for GP due to the cost barrier. As one of the interviewees (P2) pointed out: "From the client's point of view, profit is always the most important thing. I can say that most developer firms are money-oriented. Thus, they will not be interested in constructing a project which will generate little financial benefits to them".

Such a statement had also been mentioned by one Quantity Surveyor (P4), claiming that: "…the main objective of most of the developer firms is to generate profit in every project constructed by them. As such, they may refuse to go for green procurement which will cause them to spend much".

The barrier ranked 2nd place by the respondents is "lack of expertise and knowledge". In respect of this, most of the industry experts opined that this barrier is not so significant as compared to other barriers identified and should be ranked the 4th or 5th place. As mentioned by Interviewees P2 and P4, the development of green building projects has started to become a norm in Malaysia. Therefore, it is a must for construction companies to equip themselves with adequate skills and knowledge related to green so that they can compete with their peers. One Quantity Surveyor (P3) highlighted: "…most of the construction practitioners have already grasped the knowledge and skill related to green procurement, especially the younger generation. Most of them have been educated with the knowledge associated with green and sustainability in the education institution".

One of the interviewees (P1) further asserted: "…even if they have adequate skills to do it, the cost is always their major concern. In other words, they will still reject to procure green materials or technologies which are much more expensive even though they have adequate technical skills to manage it".

Proceeding to the third barrier ranked which is "lack of government regulations and policies", most of the interviewees ranked this variable at the middle position among the 5 barriers identified. As proclaimed by interviewee P4: "…there is no nationwide kind of regulations being imposed by the government to force the construction firms to implement green procurement in the construction".

Such assertion is coincident with the words of one interview participant (P3), claiming that: "…the regulations imposed by the Malaysian government on the matters related to green procurement is not as strict as other developed country such as Singapore".

Another participant (P1) expressed concern that: "In the absence of strict regulations, green procurement is less likely to be practised by the developers as they will not choose the approach which will cost them more".

Nevertheless, one of the interviewees (P2) argued that most of the local authorities in Malaysia have started putting in the effort by incorporating the green requirements into the building plan approvals to promote the adoption of GP, especially in urban areas. The participant further stated: "Perhaps such regulations are less likely to be imposed by the local council in rural areas such as Majlis Perbandaran Selayang or Sepang. If they impose too many regulations, the developers may resist developing their projects in the rural area".

The fourth barrier is "lack of top management commitment". The interview participants ranked it as moderately significant. Top management always possesses the power to decide on matters related to cost within an organisation. As such, one of the interviewees (P4) pointed out: "The authority to make a decision is always held by the top-level manager. If they do not commit to green procurement, it is hard for their staff to commit to such initiative as well".

Three interviewees (P1, P2 and P3) concurred that most top management is reluctant to go for GP initiatives when they consider the high upfront cost. As aforesaid, the purchasing of green materials and technologies is relatively costly. One interview participant (P1) further revealed that: "…generating profits is the most critical objective of every business organisation…. they will choose the construction approach which enables them to spend less and gain more profit".

Lack of awareness among construction stakeholders is ranked 5th place. The interviewees have a heterogeneous view regarding the ranking of this barrier. One M&E engineer (P2) has ranked it as the third significant barrier. This is because the interviewee opined that: "The awareness level of the Malaysian construction players is still insufficient as compared to other countries like Singapore or other developed countries".

Nevertheless, the rest of the interviewees agreed with the current position of this barrier. They perceived this variable as the least significant deterrent to the adoption of GP as they thought the awareness level of the construction players towards the environmental issues was quite sufficient. As disclosed by one of the interviewees (P3): "… most of the people had noticed the issues of environmental degradation. Hence, the action of going green is just depending on the attitude of the construction companies on the environmental issues".

Besides, another interviewee (P1) uttered that cost was still the biggest hindrance to GP exercise even if the construction players had an adequate level of awareness on green-related matters.

It is worth noting that the naming of the underlying dimensions has been validated by all the interviewees, except for the fourth factor. It is suggested by Interviewee P3 to replace the "project and market constraint" with "procurement constraint". This is because the interviewee perceived that "time-consuming", "additional risk", "low supply and limited information on green building materials", "lack of green suppliers" and "lack of awareness among construction stakeholders" are considered as the constraints that would be faced by the construction practitioners during the process of procuring green materials, products and services.

5. Conclusions

To decrease the environmental impact of construction, GP has been considered a gateway approach for enhancing environmental performance in the construction industry along with achieving sustainability goals and promoting economic and social developments in Malaysia. Despite the growing academic attention and potential benefits of GP to attain sustainable development goals (SDGs), the adoption rate in the developing world is still in its infancy which further signifies that the construction industry is encountering numerous barriers. Intrinsically, these barriers need to be identified and addressed to enhance GP practices in the construction process and facilitate widespread adoption – making it a more sustainable and responsible industry. For that very reason, this study aimed to appraise the critical barriers to GP adoption using Malaysia as the base of the study for the context of a developing country in the Southeast Asian region. To achieve this aim, 20 barriers were first identified from a detailed literature review and listed in Table 1. Through a field survey involving 150 professionals, the ranking analysis results indicated the top five barriers are: *high initial cost*; *lack of expertise and regulations*; *lack of government regulations*; *lack of top manage-*

Table 6. Interviewee profile

Participants (anonymous name)	P1	P2	P3	P4
Designation	Contract manager	M&E engineer	Quantity surveyor	Quantity surveyor
Position in company	Senior	Senior	Associate assistant	Director
Organisation type	Consultant	Consultant	Consultant	Consultant
Working experience (years)	21	12	30	33
Education background	Bachelor	Bachelor	Bachelor	Bachelor

ment commitment and *lack of awareness among construction stakeholders*. These barriers are seen to impede the implementation of GP in Malaysia and the same can be observed for other developing countries in various parts of the world. Furthermore, the exploratory factor analysis for the 20 barriers revealed five major dimensions underlying the barriers, relating to *government and organisation-related barriers*, *knowledge and technical-related barriers*, *attitude-related barriers*, *project and market constraints* and f*inancial-related barriers*. The results also showed that the most dominant of the five underlying dimensions is government and organisation-related barriers. This implies that both government and organisational commitments are crucial in promoting GP adoption. Expert validation was also performed on the ranking of the barriers obtained and the naming of the five underlying groups from the factor analysis, which helped to establish face validity and provide the context for the Malaysian construction industry.

The findings of this study not only contribute to incremental knowledge concerning the barriers to GP adoption but also fill the existing gap in knowledge by revealing the underlying dimensionality of the barriers in the context of a developing country. This study helps to highlight the critical barriers faced by a developing country such as Malaysia and the underlying dimensions involved which are a valuable reference for helping policymakers and practitioners to better understand the predicaments undermining GP adoption. These barriers identified herewith need to be systematically addressed across the diverse stakeholders (such as policymakers, regulatory bodies, local authorities, designers, construction practitioners, suppliers, and facilities managers) to ensure successful GP implementation. The underlying dimensions largely explain the barriers involved and serve as an indicator to guide practitioners and policymakers in evaluating the organisation's or industry's readiness to adopt GP practices. Moreover, the underlying dimensions and the corresponding barriers are useful indicators to assess the construction industry's readiness to adopt GP practices. The results are also helpful for devising apt measures to mitigate adoption barriers which are crucial to shift to sustainable and environmentally friendly construction in Malaysia and beyond as well as to reduce the theory-practice gap.

Although the objective was achieved, this study still has some limitations that are worth mentioning. This study was conducted using a field survey with a structured questionnaire to collect quantitative data for statistical support can inhibit further probing into the rich experiences of the respondents which is only possible in qualitative interviews and focus groups. To compensate for this shortfall, expert validation interviews were employed to generate meaningful explanations. While the sample size is adequate, it does not include government officials and suppliers, who can have a critical and direct effect on the adoption of GP practices in construction. Although a five-point Likert scale is commonly used to assess opinions quantitatively, it may be subjected to some social desirability. This study gathered data solely from the Malaysian construction industry. Nevertheless, this study is expected to encourage future studies in this field. Future comparative studies can be extended to other developing countries in Asia, particularly within the Southeast and South Asian regions to allow a further generalisation of the results. Future research opportunities exist to formulate cogent short- and long-term strategies to address the barriers that have been assessed by this study to have the greatest potential effect on attaining sustainability through construction procurement processes.

Acknowledgements

The authors gratefully acknowledge the funding by UTAR Research Fund (UTARRF) (Project Number: IPSR/RMC/UTARRF/2022-C1/L07). Special gratitude is also extended to those industry practitioners who have kindly participated in the surveys and interviews reported in this paper.

Funding

The research presented in this paper was funded by UTAR Research Fund (UTARRF) (Project Number: IPSR/RMC/UTARRF/2022-C1/L07).

Author contributions

All authors have contributed to this article. Conceptualization and supervision, JBH, Yap; data collection and statistical analysis, YH Teh; writing of the manuscript, JBH Yap; interpretation of the results, SC Loo; review and editing of the manuscript, K Sharavebi.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

Abidin, N. Z. (2010). Investigating the awareness and application of sustainable construction concept by Malaysian developers. *Habitat International*, *34*(4), 421–426. https://doi.org/10.1016/j.habitatint.2009.11.011

Ahmed, M., Thaheem, M. J., & Maqsoom, A. (2020). Barriers and opportunities to greening the construction supply chain management: Cause-driven implementation strategies for developing countries. *Benchmarking: An International Journal*, *27*(3), 1211–1237. https://doi.org/10.1108/BIJ-04-2019-0192

Ahsan, K., & Rahman, S. (2017). Green public procurement implementation challenges in Australian public healthcare sector. *Journal of Cleaner Production*, *152*, 181–197. https://doi.org/10.1016/j.jclepro.2017.03.055

Akadiri, P. O. (2015). Understanding barriers affecting the selection of sustainable materials in building projects. *Journal of Building Engineering*, *4*, 86–93. https://doi.org/10.1016/j.jobe.2015.08.006

Ali, A. N. A., Jainudin, N. A., Tawie, R., & Jugah, I. (2016). Green initiatives in Kota Kinabalu construction industry. *Procedia - Social and Behavioral Sciences*, *224*, 626–631. https://doi.org/10.1016/j.sbspro.2016.05.453

Ali, Y., Saad, T. Bin, Sabir, M., Muhammad, N., Salman, A., & Zeb, K. (2020). Integration of green supply chain management practices in construction supply chain of CPEC. *Management of Environmental Quality: An International Journal*, *31*(1), 185–200. https://doi.org/10.1108/MEQ-12-2018-0211

Alqadami, A., Zawawi, N. A., Rahmawati, Y., & Alaloul, W. (2020). Challenges of implementing green procurement in public construction projects in Malaysia. *IOP Conference Series: Materials Science and Engineering*, *849*(1), Article 012047. https://doi.org/10.1088/1757-899X/849/1/012047

Ametepey, S. O., & Ansah, S. K. (2015). Impacts of construction activities on the environment: The case of Ghana. *Journal of Environment and Earth Science*, *5*(3), 18–27.

Appolloni, A., Sun, H., Jia, F., & Li, X. (2014). Green Procurement in the private sector: a state of the art review between 1996 and 2013. *Journal of Cleaner Production*, *85*, 122–133. https://doi.org/10.1016/j.jclepro.2014.08.106

Arif, M., Egbu, C., Haleem, A., Kulonda, D., & Khalfan, M. (2009). State of green construction in India: drivers and challenges. *Journal of Engineering, Design and Technology*, *7*(2), 223–234. https://doi.org/10.1108/17260530910975005

Ashikin, N. N. B. N. M., & Vasudevan, G. (2021). Barriers and strategies of green procurement in Malaysian construction industry. In A. M. M. F. Bin Meor Razali, M. Awang, & S. S. Emamian (Eds.), *Lecture notes in civil engineering: Vol 139. Advances in civil engineering materials* (pp. 11–20). Springer, Singapore. https://doi.org/10.1007/978-981-33-6560-5_2

Bag, S. (2017). Identification of green procurement drivers and their interrelationship using total interpretive structural modelling. *Vision*, *21*(2), 129–142. https://doi.org/10.1177/0972262917700990

Bai, C., & Satir, A. (2020). Barriers for green supplier development programs in manufacturing industry. *Resources, Conservation and Recycling*, *158*, Article 104756. https://doi.org/10.1016/j.resconrec.2020.104756

Banihashemi, S. A., Khalilzadeh, M., Antucheviciene, J., & Edalatpanah, S. A. (2023). Identifying and prioritizing the challenges and obstacles of the green supply chain management in the construction industry using the fuzzy BWM method. *Buildings*, *13*(1), Article 38. https://doi.org/10.3390/buildings13010038

Bidin, Z. A., Bohari, A. A. M., Rais, S. L. A., & Saferi, M. M. (2019). A S.W.O.T. analysis of green procurement implementation in construction projects. *IOP Conference Series: Earth and Environmental Science*, *385*(1), Article 012017. https://doi.org/10.1088/1755-1315/385/1/012017

Bohari, A. A. M., Skitmore, M., Xia, B., Teo, M., Zhang, X., & Adham, K. N. (2015). The path towards greening the Malaysian construction industry. *Renewable and Sustainable Energy Reviews*, *52*, 1742–1748. https://doi.org/10.1016/j.rser.2015.07.148

Bohari, A. A. M., Skitmore, M., Xia, B., & Teo, M. (2017). Green oriented procurement for building projects: Preliminary findings from Malaysia. *Journal of Cleaner Production*, *148*, 690–700. https://doi.org/10.1016/j.jclepro.2017.01.141

Bohari, A. A. M., Skitmore, M., Xia, B., Teo, M., & Khalil, N. (2020). Key stakeholder values in encouraging green orientation of construction procurement. *Journal of Cleaner Production*, *270*, Article 122246. https://doi.org/10.1016/j.jclepro.2020.122246

Buniamin, S., Ahmad, N., Rauf, F. H. A., Johari, N. H., & Rashid, A. A. (2016). Green government procurement practices (GGP) in Malaysian public enterprises. *Procedia Economics and Finance*, *35*(16), 27–34. https://doi.org/10.1016/S2212-5671(16)00006-X

Chan, A. P. C., Darko, A., & Ameyaw, E. E. (2017). Strategies for promoting green building technologies adoption in the construction industry – An international study. *Sustainability*, *9*(6), Article 969. https://doi.org/10.3390/su9060969

Chan, S. W., Tiwari, S. T. S., Ahmad, M. F., Zaman, I., & Sia, W. L. (2018). Green procurement practices and barriers in furniture manufacturing companies. *International Journal of Supply Chain Management*, *7*(6), 431–438.

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed method approaches*. Sage Publications, Inc.

Darko, A., Chan, A. P. C., Yang, Y., Shan, M., He, B. J., & Gou, Z. (2018). Influences of barriers, drivers, and promotion strategies on green building technologies adoption in developing countries: The Ghanaian case. *Journal of Cleaner Production*, *200*, 687–703. https://doi.org/10.1016/j.jclepro.2018.07.318

Enshassi, A., Kochendoerfer, B., & Rizq, E. (2014). An evaluation of environmental impacts of construction projects. *Revista Ingenieria de Construccion*, *29*(3), 234–254. https://doi.org/10.4067/S0718-50732014000300002

Ezani, N. S. N., Alias, A. H., Azami, I. C., Hassim, S., & Haron, N. A. (2020). Sustainability: Assessment of green procurement implementation in the construction industry of Malaysia. In *AIP Conference Proceedings*, Article 020062. https://doi.org/10.1063/1.5062688

Fang, H., Wang, B., & Song, W. (2020). Analyzing the interrelationships among barriers to green procurement in photovoltaic industry: An integrated method. *Journal of Cleaner Production*, *249*, Article 119408. https://doi.org/10.1016/j.jclepro.2019.119408

Geng, Y., & Doberstein, B. (2008). Greening government procurement in developing countries: Building capacity in China. *Journal of Environmental Management*, *88*(4), 932–938. https://doi.org/10.1016/j.jenvman.2007.04.016

Giunipero, L. C., Hooker, R. E., & Denslow, D. (2012). Purchasing and supply management sustainability: Drivers and barriers. *Journal of Purchasing and Supply Management*, *18*(4), 258–269. https://doi.org/10.1016/j.pursup.2012.06.003

Golpîra, H. (2020). Optimal integration of the facility location problem into the multi-project multi-supplier multi-resource Construction Supply Chain network design under the vendor managed inventory strategy. *Expert Systems with Applications*, *139*, Article 112841. https://doi.org/10.1016/j.eswa.2019.112841

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). *Multivariate data analysis*. Cengage Learning.

Hasan, M. S. M. S., & Zhang, R.-J. (2016). Critical barriers and challenges in implementation of green construction in China. *International Journal of Current Engineering and Technology*, *6*(2), 435–445.

He, L., & Yuan, H. (2020). Investigation of construction waste recycling decisions by considering consumers' quality perceptions. *Journal of Cleaner Production*, *259*, Article 120928. https://doi.org/10.1016/j.jclepro.2020.120928

Hoffman, A. J., & Henn, R. (2008). Overcoming the social and psychological barriers to green building. *Organization and Environment*, *21*(4), 390–419. https://doi.org/10.1177/1086026608326129

Hwang, B. G., & Ng, W. J. (2013). Project management knowledge and skills for green construction: Overcoming challenges. *International Journal of Project Management*, *31*(2), 272–284. https://doi.org/10.1016/j.ijproman.2012.05.004

Hwang, B. G., & Tan, J. S. (2012). Green building project management: Obstacles and solutions for sustainable development. *Sustainable Development*, *20*(5), 335–349. https://doi.org/10.1016/j.ijproman.2012.05.004

Jin, R., Li, B., Zhou, T., Wanatowski, D., & Piroozfar, P. (2017). An empirical study of perceptions towards construction and demolition waste recycling and reuse in China. *Resources, Conservation and Recycling*, *126*, 86–98. https://doi.org/10.1016/j.resconrec.2017.07.034

Khaderi, S. S., Yub, Y., Bakri, A. S., & Abd Shukor, A. S. (2022). Green procurement implementation in construction industry: Analysis of developer's challenges. *IOP Conference Series: Earth and Environmental Science*, *1067*(1), Article 012052. https://doi.org/10.1088/1755-1315/1067/1/012052

Khahro, S. H., Memon, A. H., Memon, N. A., Arsal, A., & Ali, T. H. (2021). Modeling the factors enhancing the implementation of green procurement in the Pakistani construction industry. *Sustainability*, *13*(13), Article 7248. https://doi.org/10.3390/su13137248

Khan, M. W. A., Ting, N. H., Kuang, L. C., Darun, M. R., Mehfooz, U., & Khamidi, M. F. (2018). Green procurement in construction industry: A theoretical perspective of enablers and barriers. *MATEC Web of Conferences*, *203*, Article 02012. https://doi.org/10.1051/matecconf/201820302012

Kipkorir, L. E., & Wanyoike, D. M. (2015). Factors influencing implementation of green procurement in multinational tea companies in Kericho County. *International Journal of Economics, Commerce and Management*, *3*(6), 431–446.

Li, Y., Xu, L., Sun, T., & Ding, R. (2020). The impact of project environmental practices on environmental and organizational performance in the construction industry. *International Journal of Managing Projects in Business*, *13*(2), 367–387. https://doi.org/10.1108/IJMPB-07-2018-0137

Liu, J., Shi, B., Xue, J., & Wang, Q. (2019). Improving the green public procurement performance of Chinese local governments: From the perspective of officials' knowledge. *Journal of Purchasing and Supply Management*, *25*(3), Article 100501. https://doi.org/10.1016/j.pursup.2018.05.002

Liu, J., Liu, Y., & Yang, L. (2020). Uncovering the influence mechanism between top management support and green procurement: The effect of green training. *Journal of Cleaner Production*, *251*, Article 119674. https://doi.org/10.1016/j.jclepro.2019.119674

Love, P. E. D., & Sing, C.-P. (2013). Determining the probability distribution of rework costs in construction and engineering projects. *Structure and Infrastructure Engineering*, *9*(11), 1136–1148. https://doi.org/10.1080/15732479.2012.667420

Lu, W., Chi, B., Bao, Z., & Zetkulic, A. (2019). Evaluating the effects of green building on construction waste management: A comparative study of three green building rating systems. *Building and Environment*, *155*, 247–256. https://doi.org/10.1016/j.buildenv.2019.03.050

Lucko, G., & Rojas, E. M. (2010). Research validation: Challenges and opportunities in the construction domain. *Journal of Construction Engineering and Management*, *136*(1), 127–135. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000025

Marcelline, T. R. S., Chengang, Y., Avotra, A. A. R. N., Hussain, Z., Zonia, J. E., & Nawaz, A. (2022). Impact of green construction procurement on achieving sustainable economic growth influencing green logistic services management and innovation practices. *Frontiers in Environmental Science*, *9*. https://doi.org/10.3389/fenvs.2021.815928

Mathiyazhagan, K., Govindan, K., NoorulHaq, A., & Geng, Y. (2013). An ISM approach for the barrier analysis in implementing green supply chain management. *Journal of Cleaner Production*, *47*, 283–297. https://doi.org/10.1016/j.jclepro.2012.10.042

McMurray, A. J., Islam, M. M., Siwar, C., & Fien, J. (2014). Sustainable procurement in Malaysian organizations: Practices, barriers and opportunities. *Journal of Purchasing and Supply Management*, *20*(3), 195–207. https://doi.org/10.1016/j.pursup.2014.02.005

Mojumder, A., Singh, A., Kumar, A., & Liu, Y. (2022). Mitigating the barriers to green procurement adoption: An exploratory study of the Indian construction industry. *Journal of Cleaner Production*, *372*, Article 133505. https://doi.org/10.1016/j.jclepro.2022.133505

Ogunsanya, O. A., Aigbavboa, C. O., Thwala, D. W., & Edwards, D. J. (2022). Barriers to sustainable procurement in the Nigerian construction industry: an exploratory factor analysis. *International Journal of Construction Management*, *22*(5), 861–872. https://doi.org/10.1080/15623599.2019.1658697

Rane, S. B., & Thakker, S. V. (2020). Green procurement process model based on blockchain–IoT integrated architecture for a sustainable business. *Management of Environmental Quality: An International Journal*, *31*(3), 741–763. https://doi.org/10.1108/MEQ-06-2019-0136

Razali, N., Khalil, N., Mohamad Bohari, A. A., & Husin, H. N. (2021). Green procurement in construction: Analysis of the readiness level and key catalyst among construction enablers. *International Journal of Sustainable Construction Engineering and Technology*, *12*(1), 1–11. https://doi.org/10.30880/ijscet.2021.12.01.001

Rejeb, A., Rejeb, K., Appolloni, A., Keogh, J. G., & Iranmanesh, M. (2023). Uncovering the green procurement knowledge structure: A systematic citation network analysis. *Circular Economy and Sustainability*, *4*, 287–316. https://doi.org/10.1007/s43615-023-00287-w

Ruparathna, R., & Hewage, K. (2015). Sustainable procurement in the Canadian construction industry: Current practices, drivers and opportunities. *Journal of Cleaner Production*, *109*, 305–314. https://doi.org/10.1016/j.jclepro.2015.07.007

Saferi, M. M., Bohari, A. A. M., Bidin, Z. A., & Rais, S. L. A. (2018). Green procurement for construction project: The roles of stakeholder values. *IOP Conference Series: Materials Science and Engineering*, *429*(1), Article 012024. https://doi.org/10.1088/1757-899X/429/1/012024

Sepehrdoust, H., Javanmard, D., Rasuli, M., & Sepehrdoust, H. (2022). Environmental impact of building construction and energy consumption; case study of Iran study of Iran. *Sustainable Environment*, *8*, Article 2076400. https://doi.org/10.1080/27658511.2022.2076400

Shen, L., Zhang, Z., & Long, Z. (2017). Significant barriers to green procurement in real estate development. *Resources, Conservation and Recycling*, *116*, 160–168. https://doi.org/10.1016/j.resconrec.2016.10.004

Shi, Q., Zuo, J., Huang, R., Huang, J., & Pullen, S. (2013). Identifying the critical factors for green construction – An empirical study in China. *Habitat International*, *40*, 1–8. https://doi.org/10.1016/j.habitatint.2013.01.003

Shurrab, J., Hussain, M., & Khan, M. (2019). Green and sustainable practices in the construction industry: A confirmatory factor analysis approach. *Engineering, Construction and Architectural Management*, *26*(6), 1063–1086. https://doi.org/10.1108/ECAM-02-2018-0056

Simion, C. P., Nicolescu, C., & Vrîncut, M. (2019). Green procurement in Romanian construction projects. A cluster analysis of the barriers and enablers to green procurement in construction projects from the Bucharest-Ilfov region of Romania. *Sustainability*, *11*(22), Article 6231. https://doi.org/10.3390/su11226231

Sourani, A., & Sohail, M. (2011). Barriers to addressing sustainable construction in public procurement strategies. *Proceedings of*

the Institution of Civil Engineers: Engineering Sustainability, *164*(4), 229–237. https://doi.org/10.1680/ensu.2011.164.4.229

Wilkinson, S. (2012). An analysis of the problems faced by project management companies managing construction projects. *Engineering, Construction and Architectural Management*, *8*(3), 160–170. https://doi.org/10.1108/eb021178

Wilson, J. L., & Tagaza, E. (2006). Green buildings in Australia: drivers and barriers. *Australian Journal of Structural Engineering*, *7*(1), 57–63. https://doi.org/10.1080/13287982.2006.11464964

Wong, J. K. W., Chan, J. K. S., & Wadu, M. J. (2016). Facilitating effective green procurement in construction projects: An empirical study of the enablers. *Journal of Cleaner Production*, *135*, 859–871. https://doi.org/10.1016/j.jclepro.2016.07.001

Woo, C., Kim, M. G., Chung, Y., & Rho, J. J. (2016). Suppliers' communication capability and external green integration for green and financial performance in Korean construction industry. *Journal of Cleaner Production*, *112*, 483–493. https://doi.org/10.1016/j.jclepro.2015.05.119

Yang, S., Su, Y., Wang, W., & Hua, K. (2019). Research on developers' green procurement behavior based on the theory of planned behavior. *Sustainability*, *11*(10), Article 2949. https://doi.org/10.3390/su11102949

Yap, J. B. H., & Skitmore, M. (2020). Ameliorating time and cost control with project learning and communication management Leveraging on reusable knowledge assets. *International Journal of Managing Projects in Business*, *13*(4), 767–792. https://doi.org/10.1108/IJMPB-02-2019-0034

Yap, J. B. H., Abdul-Rahman, H., Wang, C., & Skitmore, M. (2018). Exploring the underlying factors inducing design changes during building production. *Production Planning & Control*, *29*(7), 586–601. https://doi.org/10.1080/09537287.2018.1448127

Yap, J. B. H., Chow, I. N., & Shavarebi, K. (2019). Criticality of construction industry problems in developing countries: Analyzing Malaysian projects. *Journal of Management in Engineering*, *35*(5), Article 04019020. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000709

Yap, J. B. H., Lam, C. G. Y., Skitmore, M., & Talebian, N. (2022). Barriers to the adoption of new safety technologies in construction: A developing country context. *Journal of Civil Engineering and Management*, *28*(2), 120–133. https://doi.org/10.3846/jcem.2022.16014

Yap, J. B. H., Teh, Y. H., Loo, S. C., & Sulaiman, Z. B. (2023). Benefits of green procurement: perspectives from the Malaysian construction industry. *International Journal of Construction Management*. https://doi.org/10.1080/15623599.2023.2266628

Zeng, S. X., Tam, C. M., Deng, Z. M., & Tam, V. W. Y. (2003). ISO 14000 and the Construction Industry: Survey in China. *Journal of Management in Engineering*, *19*(3), 107–115. https://doi.org/10.1061/(ASCE)0742-597X(2003)19:3(107)

Zhang, X., Wu, Y., & Shen, L. (2015). Embedding 'green' in project-based organizations: The way ahead in the construction industry?. *Journal of Cleaner Production*, *107*, 420–427. https://doi.org/10.1016/j.jclepro.2014.10.024

Zhao, X., Hwang, B. G., & Lim, J. (2020). Job satisfaction of project managers in green construction projects: Constituents, barriers, and improvement strategies. *Journal of Cleaner Production*, *246*, Article 118968. https://doi.org/10.1016/j.jclepro.2019.118968

Zhu, Q., Geng, Y., & Sarkis, J. (2013). Motivating green public procurement in China: An individual level perspective. *Journal of Environmental Management*, *126*, 85–95. https://doi.org/10.1016/j.jenvman.2013.04.009