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Title Page

Factors influencing the selection of a procurement route for UK offsite housebuilding

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Abstract

While there is a plethora of research into the perceived benefits of offsite construction systems and the barriers towards their adoption, there has been very little discussion of the procurement route selection factors for offsite residential projects in the UK Midlands region. This study sought to identify the factors which influence the selection of a procurement method for offsite housebuilding projects in the Midlands. The aim of the paper was to identify the critical factors influencing the procurement selection for offsite housebuilding developments through a survey of 157 construction professionals and housing developers using the Relative Importance Index as a basis for analysis. A comparison between the most highly ranked factors for offsite manufacturing and those presented in the literature indicate that practitioners' perceptions are largely aligned with those of traditional construction processes. The higher constructability of design and environmental sustainability have been shown to have a greater influence on the selection of the most appropriate procurement route for offsite housebuilding as compared to those applicable to traditional construction. The research findings can also help practitioners to develop a wider and deeper perspective of the criteria for selecting the appropriate procurement method for offsite residential projects at a regional level.

INTRODUCTION

The Construction 2025 Report (HM Government, 2013) advocates a wider offsite manufacturing strategy. The Farmer Review's (Farmer, 2016) recommendations included that the housing sector should be used a scalable pilot programme using industry, clients and government collaboration to change commissioning trends from traditional to pre-manufactured approaches and the Government should act to provide stimulus to innovation in the housing sector by promoting the use of pre-manufactured solutions through policy measures. There is therefore shared government and industry aspiration for implementation of an off-site manufacturing (OSM) strategy, in particular, in the housing sector. According to O'Neill and Organ (2016) and Nadim and Goulding (2010) MMC intends to improve predictability, business efficiency, environmental performance, quality, and sustainability. However, Nadim and Goulding (2010) also suggest adopting offsite manufacturing is challenging and an intricate understanding of the industry's perception of its characteristics is required. The first systematic attempt to raise MMC's profile was the Buildoffsite Property Assurance Scheme (BOPAS), launched in 2013 a database was set up providing details of housing units by scheme with the aim of addressing confidence issues with MMC (RICS, 2018).

Recently, the UK government has introduced the Home Build Fund, a £3bn fund set up to assist SME developers in increasing use of offsite manufacturing, and the Accelerated Construction Scheme, which encourages developers to use time-saving construction methods. In the latest UK Government budget, it was announced offsite manufacturing would be promoted through government purchasing powers and a presumption offsite manufacturing would be adopted where it represented best value (MacFarlane, 2020).

Small (2020) identifies the primary procurement methods as traditional, design and build, construction management and integrated project delivery. The NBS (2018) report records that traditional procurement remains the most common method with 46% of professionals rating it as their most used method followed by design and build with 41% usage. The results of 30 interviews with housing industry construction professionals, particularly members of Buildoffsite organisations, indicated that a regulatory key constraint was *"No legal framework available to support OSM"* (Elnaas et al., 2014, p.54).

Buildoffsite is an industry-wide campaigning organisation that promotes greater uptake of offsite techniques by UK construction. Agapiou (2019) advises that Joint Contracts Tribunal (JCT) contracts may not be appropriate for OSM projects. Instead, he suggests a pre-construction phase contract between contractor and OSM, such as JCT's pre-contract services agreement, which could ameliorate design interface issues which may occur between manufacture and installation of the modules on site.

The NBS report (2018) records the most frequently used contracts as JCT (62%); NEC (14%); bespoke (5%) and FIDIC (4%). Small (2020, p.392) argues that *"Implementation of alternative forms of project delivery will also require a 'sponsor' or 'change-agent' to drive/advise potential owners to employ alternative contract forms."* He identifies legal frameworks as an inhibitor of the implementation of OSM.

The Construction Leadership Council (2017) position paper aims to develop a compelling proposition for housing clients to increase demand for smart construction and provide volume surety to enable greater investment in industrialisation. This paper calls for (p.x) *"revised procurement guidance and model forms of contract, with appropriate measures to manage risk investment and reward collaboratively and transparently."*

Trowers and Hamlins (2018) argue that offsite construction technology requires forms of contract that underpin long-term strategic co-operative relationships, which should address the 'factory to finished building' model. They suggest this is not addressed by industry-standard forms such as JCT contracts, but alliancing contracts such as the Association of Consulting Architects (ACA) Project Partnering Contract PPC2000 and Framework Alliance Contract (FAC)-1 may offer solutions.

There is no dearth of academic research into the perceived benefits of offsite manufacture (OSM) in construction, and the barriers to its implementation in the housebuilding sector (Arif *et al*, 2017; Arif and Egbu 2010; Jaillon and Poon 2010; Taylor 2009; Pan *et al* 2004; Pasquire and Gibb 2002).

Despite the proven benefits associated with offsite manufacturing, it is clear that the advantages are challenged by a number of procurement issues and contractual issues that create legal uncertainty. These challenges are barriers for a widespread adoption of offsite manufacturing and for realizing the full potential of modern methods of construction within the house-building sector (Agapiou, 2019).

Most house building projects are procured using a standard form of procurement developed to accommodate traditional construction. It would be ill-advised to use an inappropriate form of procurement without a better understanding of how they could be which specific 'offsite' issues can be satisfactorily addressed. While there is a plethora of research into the perceived benefits of offsite house building technology and the barriers to its implementation in the house-building sector (Okunlola 2012; Arif and Egbu, 2010; Jaillon & Poon, 2010; Taylor, 2009; Pan et al., 2004; Pasquire & Gibb, 2002), there is a gap in the corpus of the relevant literature concerning the influence of procurement processes on the success or otherwise of offsite construction practices in the housebuilding sector in the UK and elsewhere.

To establish the most effective procurement strategies, it is be useful to evaluate the influence of the most critical actors on the selection of procurement methods for offsite housebuilding developments within the Midlands Region, drawing on the views of construction professionals & SME developers. Bolumole (2017) have highlighted the relevance of clients, architects, engineers, quantity surveyors and contractors in an effort to promote best value-for-money for clients through advising the adoption of procurement and contractual strategies that best address project objectives.

The main factors influencing clients to choose off-site manufacture (Blimas et al, 2006) include the potential to achieve significant reductions in programme time and improved quality of the end product (Blismas et al, 2006). Contractors are influenced by the opportunity for increased cash flow and turnover through self-production of the off-site "products" (Vernikos et al, 2013). Architects and design engineers are likely to be influenced by the opportunity to improve the quality and performance of their designs by the use of standardized and detailed off-site "products".

The research methodology adopted to achieve the aim and objectives is underlined in the next section.

RESEARCH METHODOLOGY

The aims and objectives of this study were accomplished using quantitative research methods. The objectives of the study were to: (i) to identify and categorise the most critical factors affecting the selection of procurement method for the construction context: and (ii) to quantify the relative importance of the key factors affecting the choice of procurement route and to demonstrate the ranking of factors and categories according to their importance levels on selection. In the first phase, a detailed review of the existing literature related factors influencing the selection of procurement system in construction was carried out using different keywords and databases. The time frame selected for this systematic review was the past 14 years (January 2006 - January 2020). Four main data basses including Web of Science, Scopus, Proquest, and Science direct were used to extract relevant data.

The keywords and phrases used in this search were “factors influencing the selection of procurement systems’’, ‘’decision support system for the selection of best procurement system in construction, ‘’selecting an appropriate procurement method for the construction process, and the ‘’perspectives of housebuilders on the use of offsite modern methods of construction’’. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were adhered to during this systematic review (Moher et al., 2009). Proper inclusion and exclusion criteria were adopted to screen the record identified from different databases.

The key inclusion criteria for considering a study in this research were i) the study should be in the English language, ii) the keywords/phrases selected for this study should appear in the keywords or in the abstract of the paper and iv) the paper or the study should focus with the application of procurement selection within the construction industry. During this systemic review, a total of 69 articles were downloaded from the selected data basses. After imposing the screening process and removing the duplicate items, a total of 40 items were selected for the final review. The majority of the final selected items (15 ~ 35%) were from the Web of Science, followed by Scopus (12~ 29%), Science Direct (9 ~18%), and Proquest (4 ~ 16%). A total of 13 items related to the factors influencing the most appropriate procurement for the construction context were identified from this systematic review from the existing literature. Table 1 illustrates the factors that influencing the selection of procurement method which was collected from the literature review.

Table 1: Factors that influencing the selection of procurement method

Factors	Maizon et al. (2006)	Shiyamini et. al. (2007);	Babatunde et. al. (2010);	Odhigu et. al. (2011);	Rosli et. al. (2006);	Husam & Sedki (2009);	Franco et. al. (2002);	Thomas (2001);	Shafik & Martin (2006);	Abu Hassan Abu Baker (2009)	Eyitope et al. (2012);	Naoum and Egbu (2016)	Sawalhi & Agha (2017);
Project completion within budget	X		X						X			X	X
Speed of construction		X	X						X			X	X
Good quality of construction project	X	X	X			X			X	X		X	X
Price certainty prior to commencement	X	X			X			X	X			X	X
Experienced clients	X	X		X		X	X		X		X	X	X
Client’s specific requirements and objectives can implement.													X
Flexibility to change design during both design and construction periods	X	X		X				X	X		X		X
Quick response to clients’ new requirements												X	
According to client financial capabilities minimum risk	X	X		X		X						X	X
Allocation of responsibility	X	X		X								X	X
Qualified professional involvement													
Client willingness to take risk				X		X						X	

Payment modality							X	X	X		X		
Technical Complexity of the project	X					X						X	X
Design reliability			X						X			X	
Prefabrication Process										X	X	X	
Material transportation process									X			X	
Project funding Method		X					X	X			X		
Constructability of design				X				X		X		X	X
Site risk factors	X			X									X
Available resources of project													X
Construction Method		X				X		X			X		X
Qualified knowledgeable and experienced contractor		X					X					X	
Minimizes Construction Disputes			X			X						X	
Material distribution									X				
Project size		X					X	X			X	X	
Project site location		X		X			X	X			X	X	
Skilled / unskilled labour availability										X			
Material availability									X			X	
Industrial Action													
Regulatory environment regulating feasibility										X		X	
Government Policies										X	X		
Market forces							X					X	X
Political Considerations										X	X		
Environmental Issues		X								X	X	X	X
Inclement Weather										X			
Price Competition	X	X			X		X	X		X	X	X	X

For this paper, the selection criteria are based on those identified in previous research conducted by other authors, as discussed in the above paragraphs. In order to establish general and comprehensive criteria, a combination of all of the previous studies can be summarized in the following Table 1. From this Table showing information from previous studies by researchers between 2006 and 2017, it can be suggested that the criteria of selection for an appropriate offsite procurement route could be based on several of the applicable factors. The literature indicates that, in spite of considerable research into the choice of appropriate procurement systems for traditional construction projects, no generally applicable solutions have been found. Nonetheless, researchers have suggested a number of important criteria to establish a profile of client requirements and preferences for the procurement method in both traditional and offsite construction.

There are several factors that inform the appropriate procurement route, including project objectives, constraints (budget, timeframe, exit strategy) and allocation of/attitude to risk (environmental, economic, social and sustainability concerns). Several studies also identify external factors, flexibility, quality, and performance, noting that decisions should be driven by the need to satisfy client and stakeholder needs, e.g. price certainty (cost and affordability), time schedule (delivering housing according to scheduled time to meet clients' housing demands), complexity of design, and numerous other factors. To simplify this research, the groups of factors or criteria were categorized and clustered into three elements, client selection factors, project selection factors and external selection factors respectively (see Table 2).

Table 2: The selected factors that influence the selection of procurement method

Internal		External
Client	**Project**	
Project completion within budget	Technical Complexity of the project	Material availability
	Price certainty on commencement	
Speed of construction	Design reliability	
Good quality of construction project	Prefabrication Process	Industrial Action
Experienced clients	Material transportation process	Regulatory environment regulating feasibility
Client's specific requirements and objectives can implement		Government Policies
Flexibility to change design during both design and construction periods	Project funding Method	Market forces
Quick response to clients' new requirements	Higher constructability of design	Political Considerations
According to client financial capabilities minimum risk	Site risk factors	Environmental Sustainability
Allocation of responsibility	Available resources of project	Inclement Weather
Qualified professional involvement	Construction Method	Price Competition.
Client willingness to take risk	Qualified knowledgeable and experienced contractor	
Payment modality	Minimizes Construction Disputes	
	Material distribution	
	Project size	
	Project site location	
	Skilled / unskilled labour availability	

It is generally agreed that there is no perfect procurement strategy; rather a strategy should be based on a sensible policy (Murdoch & Hughes, 2008) and aligned with the client's requirements and nature of the project (Kirkham, 2007). Several previous studies have identified number of factors influencing the selection of procurement system in construction (Sawalhi & Agha, 2017). The selection criteria for project procurement will influence which procurement system should be used in a particular project. Rosli et al., (2006) mentioned that it is critical at the outset of the project to carefully consider all factors when selecting the most appropriate procurement approach for a construction project. This is because each system has its own feature and peculiarity that will have effect on the cost, time, and quality of the project i.e. the project performance. When project client, or consultant and decision-makers are selecting a procurement system for a project, their previous experience plays an influential role. This question sought to determine the main criteria clients use in selecting procurement systems (Shiyamini, 2006). Thomas (2001) identified nine procurement selection criteria commonly used by Australian clients: speed, time certainty, price certainty, complexity, flexibility, responsibility, quality level, risk allocation and price competition. Franco et al., (2002) concluded that twelve factors affecting the selection of procurement method under four main headings including: firms' background; past performance capacity to accomplish the work and project approach. Maizon et al., (2006) identified time, controllable variation, complexity, quality level, price certainty, competition, responsibility division, risk avoidance, price completion, government policy and client's familiarity with a procurement method for the Malaysian context. Shiyamini et al., (2007) focused on the selection criteria in terms of client requirements, project characteristics, and external environment, thus ensuring that the selection criteria have been focused on the macro level.

The results of factor analysis revealed nine significant factors from client requirements which are risk management, time availability and predictability, price certainty, price competition, accountability, flexibility for changes, quality of works, responsibility and parties‟ involvement, and familiarity. Six factors from the project characteristics which are project cost and funding method, project complexity, project type, time constrains, degree of flexibility, and payment modality. Five factors from the external environment which are market completion, economic conditions and the fiscal policy, technology, socio cultural suitability, and regulatory environment. Abu Bakar et al., (2009) mentioned that among the most important factors in Aceh rehabilitation and reconstruction in procurement stage are timing, responsibility, and quality. Husam and Sedki (2009) identified fifteen criteria that are influential in determining the most appropriate procurement route, and include: quality level, speed, flexibility for changes, technology, complexity, time predictability, certainty of cost, familiarity, responsibility, risk avoidance, accountability, client involvement, price competition, availability of procurement system in the local market, and legal issues. Mahon (2011) confirmed that the procurement selection parameter of client requirement for budget/cost requirements was universally rated as the single most influential parameter on procurement route selection. This was closely followed by client requirement for on time completion. Eyitope et al., (2012) identified a list of thirteen critical criteria classified under four major areas encompassing project technicality; project business case and financing; project risk management and public policy requirement.

Naoum and Egbu's (2016) ranked 20 factors that should be considered when determining the most appropriate procurement method within the UK construction industry which included amongst other things such as including: the importance of speed of construction; certainty on cost; importance of certainty on time; required quality level; complexity level of the project; need for buildability; need for creativity and innovation in the design; importance of utilizing the supply chain concept; facilitating lean construction; importance of sustainability in design and material; application of value engineering; need for the application of BIM; and need for e-procurement. Similarly, Sawalhi & Agha (2017) analysis ranked 10 factors that can affect the selection of procurement method within the Gaza construction industry which included amongst other things price competition; degree of project complexity; speed of construction; project type and nature; client's nature and culture; and client's experience of construction procurement systems.

The comprehensive literature review conducted into the relative importance of the factors influencing the selection of the most appropriate procurement route for housebuilding projects identified themes and trends from previous research and informed the present study. The list of 37 factors was selected as a result of a review of the academic research.

Survey development

A survey was conducted to establish the relative importance of the factors influencing the selection of the most appropriate procurement route for offsite house-building projects in the UK Midlands region. For this purpose, a rating scale of 1 to 5 was adopted with 1 representing the lowest level of effect and 5 representing the highest level of effect. A pilot test was carried out prior to the distribution of the questionnaire and following completion of validity testing.

Sample design

Purposive Sampling is commonly chosen when conducting quantitative research as respondents need to have knowledge and experience on the subject area. Offsite manufacturing is a relatively new construction method and a selected sample of respondents was thought to be more appropriate than random sampling (Naoum, 2013).

Population and sample frame

The population of this study consists of construction professionals and SME developers working on a local or regional scale. This population was chosen due to the role of construction professionals and SME developers play in UK housebuilding and the effect they can have on the selection of an appropriate procurement route for offsite manufactured residential developments. The population of this study was limited to SME developers and larger developers identified as providing significant infrastructure for the increased uptake of offsite manufacturing such as Laing O'Rourke, Legal and General, Berkeley Group and Capital and Centric, were not considered. It was decided to target SME developers, who are most likely to have experience in OSC, mirroring the approaches of HBF (2004), Pan et al. (2005; 2007) and NHBC Foundation (2016).

To target experienced developing SMEs, organisations featured in the 'Inside Housing Top 50 Biggest Builders 2019' were used as a non-random purposive sample (Hollander 2019; Naoum 2013). The SMEs identified through the literature review as experienced or having shown interest in OSC formed the second sample, a number of which are not present in the Top 50. It is understood that results from these samples cannot be inferred to all developers, as these samples contain developers most established in development or offsite construction usage. Consequently, the perceptions of these organisations may differ from developers with limited experience in these remits, an area requiring future research.

The survey was also distributed to a sample of construction industry professionals (architects, structural engineers, quantity surveyors and construction project managers) who had been involved in offsite housing developments in the Midlands. To establish target participants, employees of the organisations in the sample sets were identified through online searches. Organisational websites, news articles and LinkedIn were used to identify job role and valid email addresses for 350 construction industry professional employees. Those with senior or managerial positions in development, construction, technology, design, innovation, commercial, property services, sustainability and project management were targeted. Additionally, network contacts were used to identify the employees of consultancy firms in the sample populations.

It is acknowledged that there was an inherent bias in the process of identifying recipients for the questionnaire. Assumptions had to be made regarding job titles and listed experience for LinkedIn profiles to determine whether the employee should be a targeted recipient, such as whether a project manager was involved in construction project management.

The online search was heavily dependent on the detail of information each organisation publicly shares. Where information was available on employees and job roles, this was often provided for a whole team. Therefore, some construction firms in the sample sets had multiple targeted participants, where such information was available, the highest being 12, whereas some only had two. A larger number of targeted employees were also identified for some consultancy practices through network connections. Consequently, some organisations had greater opportunity to be represented than others and this bias may be reflected in the results.
To alleviate the risk of this bias impacting results, demographic information was collected to understand the types of participants who completed the questionnaire, such as the operating regions of the organisation.

A comment box was also included in the survey questionnaire to garner respondents' views and opinions of their specific experiences of using offsite manufactured components within residential developments in the Midlands region. It was made clear, nevertheless, that the respondents were under no obligation to enter anything in the survey comment box itself.

Table 3 presents an overview of the sample of 227 construction professionals including their years of experience in the offsite context, professional background fields and the organisations they represent.

Table 3: Construction Professional Respondents' profiles

Respondent Characteristics	Categories	Count
Years of experience in the offsite housebuilding context	0-2 years	120
	3-5 years	80
	6-10 years	27
Professional background	Architect	67
	Structural Engineer	65
	Quantity Surveyor	60
	Construction Manager	35
Organisation	Client	45
	Contractor	89
	Consultant	66
	Construction Management	27

Scope

The research is confined to public and private sector residential construction in the Midlands. Goodier and Gibb (2007) corroborate that the Midlands region faces housing shortages. The House Building Federation (2018) and Homes England (2019) have described the housing shortages in the West Midlands, highlighting the unsustainable housing targets in both urban and rural areas of the region. Coe (2017) underlined the housing crisis by detailing how Wolverhampton has increased its housing provision to address the housing crisis. The paper is also part of a collaborative research project with the University of Wolverhampton which is focusing on the 'procurement and contractual strategies for the offsite residential sector in the Midlands'.

Table 4 presents a breakdown of the sample of SME housebuilding developers, comprising their turnover, volume of homes built in 2019 by category, the scale of the company's developments and the types of offsite manufacturing techniques used for their developments.

Table 4: company information on use of Off-site manufacturing

Respondent Characteristics	Categories	Count
Company Turnover in 2019	Under £40m	11
	£41m - £60m	20
	£61m - £80m	7
	Over £81m	4
Company Volume of Homes Built in 2019	Residential	30
	Commercial	6
	Industrial	2
	Other	0
Scale of the Company's development	Local	30
	Regional	13
	National	2
	International	0
Types of Offsite Manufacturing Techniques used in developments	Panelised Systems	12
	Volumetric Systems	10
	Site Based	24
	Other	0

Smart Survey was used for the questionnaire, due to the time advantage of automated data collection and cost and environmental benefits compared with a postal survey (Wright, 2005). There was no inherent risk of sampling bias from using this method, as warned by Bhattacherjee (2012), as the sampled population require internet access and proficiency to fulfil their job roles. In total, 46 SME developers and 227 construction professionals participated in the survey.
The final combined response rate was 66%. Out of the 180 responses received, in total 23 were incomplete. A response rate around this figure compares favourably with similar surveys conducted by Pan et al. (2005; 2007) and Alonso-Zandari and Hashemi (2017), which set a benchmark response rate between 31% and 36% (Denscombe, 2010).

Results and Analysis

The Relative Importance Index method (RII) was then used to determine the construction professionals' and SME developers' assessment of the relative importance of the main and sub-factors that influence procurement route selection and to demonstrate the ranking of factors and categories according to their importance levels on selection. The RII was used to rank the main factor and sub-factor variables.

The RII is calculated as (Sambasivan & Soon, 2007):

$$RII = \frac{\sum W}{A \times N}$$

where:
W = the weighting given to each factor by the respondents and ranges from 1 to 5
A = the highest weight (i.e. 5 in this case)
N = the total number of respondents.

The author determined the weighted for the two groups based on the ranking (R) of relative indices (RI). There are five levels that can implied from RI values: high (H) (0.8 ≤ RI ≤ 1), high-medium (H-M) (0.6 ≤ RI ≤ 0.8), medium (M) (0.4 ≤ RI ≤ 0.6), medium-low (M-L) (0.2 ≤ RI ≤ 0.4) and low (L) (0 ≤ RI ≤ 0.2).

The factors affecting procurement route selection

Group one: client-related factors

The RII value and ranking sub-factors related to the client group are summarised in Table 5

Table 5: Relative Importance Index and ranking for client factors

No.	Client Factors	Mean	RII (%)	P-value	Rank
1.	Project completion within budget	4.48	86.87	0.000*	2
2.	Speed of Construction	4.86	87.01	0.000*	1
3.	Good quality of construction project	4.26	84.80	0.000*	3
4.	Experienced clients	3.05	75.41	0.000*	12
5.	Client's specific requirements and objectives can implement.	3.99	85.14	0.000*	4
6	Flexibility to change design during both design and construction periods	3.15	80.06	0.000*	10
7	Quick response to clients' new requirements	3.80	83.38	0.000*	5
8	According to client financial capabilities minimum risk	3.75	82.01.73	0.019*	6
9.	Allocation of responsibility	3.10	78.41	0.000	11
10	Qualified professional involvement	3.68	83.01	0.000*	7

11	Client willingness to take risk	3.43	81.99	0.000	9
12	Payment modality	3.88	82.70	0.000	8
	Average	3.760			

The results of the ranking analysis indicate that the speed of construction (RII 87.01%, mean = 4.86, P-value = 0.000). and to lesser extent the project completion within budget (RII 86.87%, Mean = 4.48, P-value = 0.000) and the client's specific requirements and objectives can implement. (RII = 85.14, Mean = 4.18, P-value = 0.000) as the most significant factors under the client group. This result aligns with the findings in Shiyamini et al., (2007) as time constrains factor affects strongly on the selection of procurement method. Mortledge et al., (2006) posits that early completion because of time constrains is a critical sub-factor and a procurement method that supports speedy completion may be favoured. The results indicate that client willingness to take risk; flexibility to change design during both design and construction periods; allocation of responsibility; and the experience of the client are least significant factors for the selection of the most appropriate procurement route for offsite housebuilding developments. Nadim and Goulding (2010), Elnass, Gidado and Philip (2014) and Rahman's (2014) research identified inflexibility for design changes as a significant barrier for implementing offsite manufacturing. However, the results suggest early design freeze is not a problem when developing smaller housing developments but becomes more of an issue at a slightly larger scale.

Group two: project-related factors

Table 6: Relative Importance Index and ranking for project factors

No.	Project factors	Mean	RII (%)	P-value	Rank
1.	Technical Complexity of the project	4.175	85.90	0.000*	3
2.	Price certainty on commencement	4.63	86.52	0.000*	2
3.	Design reliability	4.01	84.02	0.000*	5
4.	Prefabrication Process	4.10	84.21	0.000*	4
5.	Material transportation process	4.09	83.41	0.142	8
6	Project funding Method	3.82	82.90	0.000*	11
7	Higher Constructability of design	4.82	87.01	0.000*	1
8	Site risk factors	3.95	83.22	0.000*	9
9	Available resources of project	3.86	83.03	0.000*	10
10	Construction Method	4.00	84.01	0.000*	6
11	Qualified knowledgeable and	3.92	83.92	0.000*	7

	experienced contractor				
12	Minimizes Construction Disputes	3.34	82.00	0.000*	15
13	Material distribution	3.71	82.61	0.000*	12
14	Project size	3.22	79.44	0.000*	16
15	Project site location	3.60	81.40	0.000*	13
16	Skilled / unskilled labour availability	3.55	81.22	0.000*	14

The results of the rating exercise indicate that higher constructability of design (RII 87.01%, Mean = 4.82, P-value = 0.000). price certainty on commencement RII = 86.52%; Mean = 4.63, P-value = 0.000) and to lesser extent the technical complexity of the project (RII = 85.90%, Mean = 4.175) as the most significant factors under the project factor grouping. This result is compatible with Shiyamini et al., (2007) and Eyitope et al., (2012) who agree to a certain extent with this result as they ranked the degree of project complexity factor in the first position from the project characteristics group. The result of Maizon et al., (2006) and Husam & Sedki (2009) are also close to this result as they ranked the project complexity factor in the third position and fifth position respectively in the Malaysian construction industry. Those ranking design reliability as an important factor echo previous research suggesting offsite manufacturing is significantly hampered by differing design standards and a lack of harmonisation, and hence achieving efficiency is more difficult (Offsite Hub, 2018). Similarly, the prefabrication process, construction method qualified knowledgeable and experienced contractor were the very important procurement method selection factors.

Group three: external-related factors

The RII value and the rank of sub-factors for time are summarised in Table 7 below

Table 7: Relative Importance Index and ranking for external factor

No.	External Factors	Mean	RII (%)	P-value	Rank
1	Material availability	4.28	84.33	0.000*	4
2	Industrial action	3.56	79.56	0.002*	8
3	Regulatory environment regulating feasibility	4.19	82.01	0.008*	5
4	Government policies	3.77	79.99	0.097	7
5	Market forces	4.44	87.01	0.015*	3
6	Political considerations	3.99	79.99	0.000*	6

7	Environmental sustainability	4.67	89.65	0.000*	2
8	Inclement weather	3.57	77.06	0.000*	9
9	Price competition	4.90	92.03	0.000*	1

According to the survey respondents, price competition was ranked the most important factor as it directly affects the selection of a procurement method. This factor was considered as a critical factor by Thomas (2001), who illustrated that this factor should be taken into consideration for Australian clients when they are selecting a procurement method. This result concurs with the findings of Sawalhi and Agha (2017), Gbadebo and Ojo (2012), and Shiyamini et al. (2007), who ranked price competition in first place. On the other hand, Maizon et al., (2006) are relatively far from this result as they ranked the price competition factor in sixth place in the Malaysian construction industry while Husam and Sedki (2009) ranked this factor in the thirteenth position. The respondents ranked the environmental sustainability factor in second position, and this is consistent with the findings of Abu Hassan Abu Bakar (2009), Eyitope et al. (2012) Naoum and Egbu (2016) and Sawalhi and Agha (2017). For residential properties, the main benefits of offsite construction are likely to come through higher build quality, which leads to better airtightness and better standards of insulation.

The relative ranking of procurement selection factors for offsite residential construction

Table 8 presents the 10 most highly ranked factors in terms of their influence on the selection of a procurement method for the offsite housebuilding sector as agreed by the respondents on the basis of calculated RII values. RII value was used to calculate a unique value for each factor and known as, “utility factor”. Utility factor represents how much each procurement selection factor successfully achieve the respective procurement method.

Table 8: Top ranked procurement selection factors for offsite housebuilding

Selection factor	RII value (Utility factor)	Ranking
Price competition	4.90	1
Speed of construction	4.86	2
Higher constructability of design	4.82	3
Environmental sustainability	4.67	4
Price certainty on commencement	4.63	5
Market forces	4.44	6
Good quality of construction project	4.26	7
Regulatory environment regulating feasibility	4.19	8

Technical complexity of the project	4.175	9
Prefabrication process	4.100	10

The section below discusses the findings of the ranking analysis and the degree of influence the identified critical factors exert on the practitioner's choice of procurement route as the basis for comparing the differences and similarities between the factors influencing the selection of the most appropriate procurement routes for offsite manufacturing and traditional construction processes.

DISCUSSION

Thirteen items from the literature review were identified as including some method of ranking of procurement selection factors for traditional construction processes. In Thomas (2001), Franco et. al. (2002), Maizon et al (2006), Shafik and Martin (2006), Rosli et. al. (2006), Shiyamini et. al. (2007) participants selected the five critical procurement selection factors. Husam & Sedki (2009), Abu Hassan Abu Bakar (2009); Eyitope et al. (2012); and Sawalhi and Agba (2017) ranked factors based on the frequency at which participants consider the factor to be significant, while participants in Naoum and Egbu. (2016) ranked drivers on a Likert scale.

Table 9: Ranking of the frequency with which drivers were included within the top five mostly highly ranked factors in the literature (most frequently = 1).

Selection Factor	Ranking	Total times driver is featured as a top five selection factor in the literature
Price competition	1	10
Experience of the client	2	9
Quality of construction	3	8
Price certainty prior to commencement	4	7
Flexibility to change design during both design and construction periods	4	7
According to client financial capabilities minimum risk	5	6

The top five ranked selection in each piece of literature were recorded. These were then ranked based on the number of pieces of literature the driver was a perceived as a top five factor, as shown in Table 9. This does not show the perceived significance of the selection factor, solely its frequency as being considered within the top five factors. Noticeably, the top five ranked selection factors from the literature correspond with those most selected as a top five factors in the primary data collection, showing a degree of consensus between participants and previous research.

Figure 1 presents a graphical illustration of the critical factors affecting the selection of a procurement method for offsite housebuilding developments

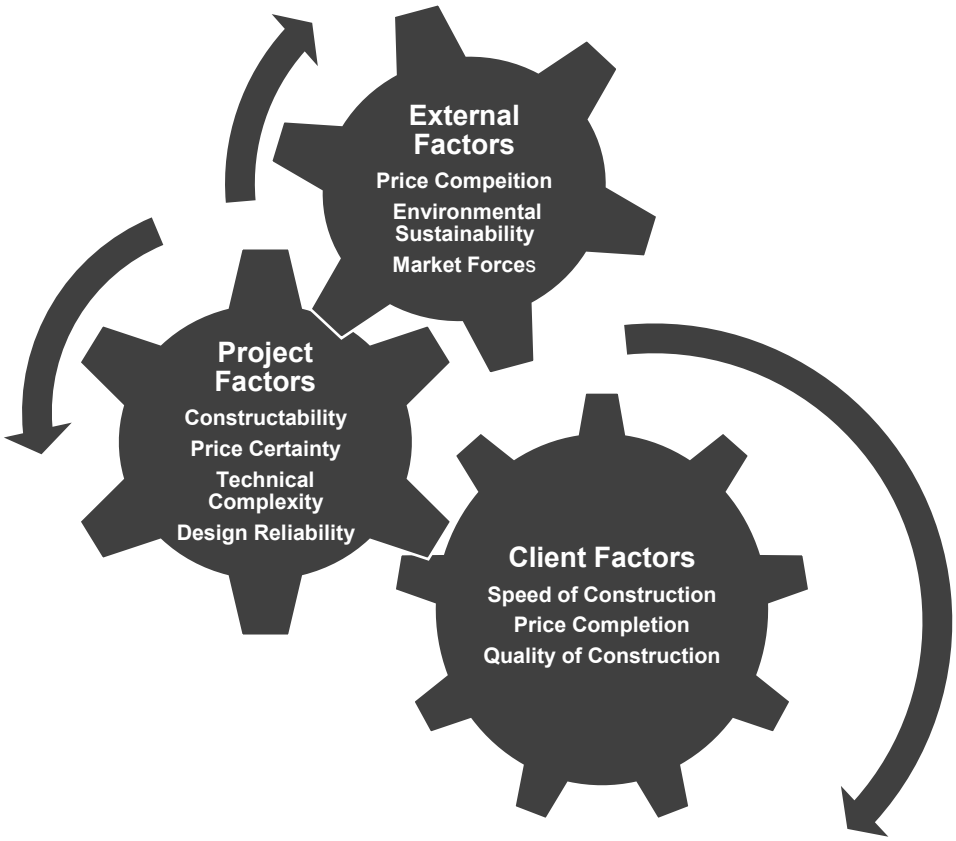

Figure 1: graphical illustration of the critical factors affecting the selection of a procurement method for offsite housebuilding

Notwithstanding the differences in research aims and targeted participants, studies have focused on practitioners' perceptions of the degree of influence of procurement selection factors for traditional construction processes. This should be considered when comparing results. However, there are no major differences in the literature which can be attributed to the difference in the specific method being researched – the critical procurement selection factors for these construction methods remain consistent. All identified research was conducted at this higher level of classification of the construction method. Research into perceptions of lower-level classifications, such as volumetric, panelised systems and pre-assembled sub-components should be conducted to determine the significant factors influencing the selection of the most appropriate procurement strategy for offsite house-building projects in the Midlands for each of these methods.

Pan, Gibb and Dainty (2008) and Nadim and Goulding (2010) identified how factors contributing to problems with uptake were associated with a resistance to change, inadequate processes, technical difficulties in methods used, lack of overall strategy, procurement methods and on-site management. Pan, Gibb and Dainty (2008) highlighted the risk-averse attitude to offsite manufacturing, with 42% of housebuilders surveyed planning to maintain current levels of usage.

Although Goodier and Gibb (2007) suggested the demand for offsite manufacturing was growing, the stigma surrounding the methods needs to be overcome through transparent information, especially relating to costs and comparisons with traditional construction techniques. Furthermore, Rahman (2014) found inflexibility of design changes and high initial costs were significant barriers and that overcoming cost-related problems was as crucial for implementing offsite manufacturing, an opinion shared by Nadim and Goulding (2010) and Elnass, Gidado and Philip (2014), suggesting the industry does not appear to fully appreciate the long-term appeal of OSM.

As one of the respondents to the survey noted:

'*We've found a lot of housing associations and councils are quite enthusiastic about off-site manufacture and utilising it, but the developers and a lot of the construction companies that are so used to traditional build, or what they've been doing for years, they've been a bit more resistant to the change.'*

The respondents ranked the speed of construction, the price competition prior to commencement, project completion within budget and good quality of construction as important factors for the selection of the most appropriate procurement route for offsite housebuilding developments, reflecting previous results found regarding time cost and quality as the most important factors for developers (Elnass, Gidado and Philip, 2014). Gbadebo and Ojo (2012) emphasised a similar notion in their study, where the time duration consumed by the pre-contract stage for the procurement process was a disadvantage to projects of a shorter duration.

The results may also reflect the widely held belief that faster construction equates to increased output, more houses per available plots and faster build programmes. Offsite manufacturing can provide developers with more options by introducing a new dynamic into traditional construction methods around resourcing, planning and environmental sustainability performance (RICS, 2018). Yet, Rahman (2014) and Pan, Gibb and Dainty (2008) argued that decisions made when choosing offsite manufacturing over traditional methods are often based on cost rather than value Indeed, as one survey respondent noted:

'We were getting very good traditional tender rates. Now, if you're building in London, or the southeast, the benefit, cost-wise, it might be fine. Where we were located, we were getting really good cost-per-square-metre for trad, so it was never going to work as modular'.

Efficiency and sustainability do not increase sales values and as most SME developers look to maximise profits, time, cost and quality are more precious. If traditional methods allow developers to generate profit and meet building regulations, there is no need to change, suggesting the role of regulations and government agendas have a bigger influence on the use of offsite manufactured components than a perceived increase in efficiency. The harmonisation of design standards has been identified as making scale and efficiency easier to achieve, in turn, enabling an increased usage of offsite manufactured components by SME developers (Offsite Hub, 2018).

Faludi, Lepech and Loisos (2012) suggest the most crucial environmental design priority of offsite manufacturing is reducing operational energy effects and the results of this study are in line with this. The respondents ranked environmental and sustainability issues highly under the external factor grouping. This finding echo those of Pan, Gibb, and Dainty (2007; 2008) and BSA (2016), who found reductions in environmental impact risks and improved life performance from the increased use of offsite manufactured components in the housebuilding sector. The result also resonates with research conducted by Tam, Zeng and Ng (2007) and Jaillon, Poon and Chiang (2009), which concluded that prefabrication was a remedy for waste reduction.

The higher constructability of the design has been ranked highly by the respondents as a critical factor in the selection of a procurement method in the offsite housebuilding context, echoing previous results found with regard to limited or no changes to the design and the completion of project within the established budget (Luu and Chen, 2003). However, offsite construction techniques require finalised decision made before manufacturing, while the in traditional design details may still be in development while construction has started on site. Indeed, as one survey respondent noted:

The design process for off-site construction is also very somewhat different to a traditional construction process. If clients were to tender on RIBA Plan of Work Stage 4 information with little input from an off-site consultant or contractor, they would almost certainly have locked in design decisions which make off-site construction methods costlier and less efficient. Consequently, off-site suppliers often get involved early in the design process, with the RIBA Plan of Work 2020: Designing for Manufacture and Assembly being a helpful guide.

Studies have shown that the development of design at an early stage and stress-testing constructability within an existing supply chain before full-scale manufacture begins are keys to ensuring the viability of the offsite solution (Naoum & Egbu, 2016). Indeed, as one survey respondent stated:

'*Our biggest problem is getting the client to understand our system and buying into it and agreeing details and everything up front'…...'Well, I think the main benefit, and what needs to be done to make sure that the projects run smoothly, is the engagement upfront'.*

Greater collaboration in design projects is paramount for increasing delivery and usage, including the need for standardisation of terminology and ensuring accurate understanding of its advantages (Nawi, Hanifa, Kamar, Lee and Azman, 2014). Pan, Gibb and Dainty (2012) suggest it is crucial to establish overall offsite strategies into the development process from the start and sharing of information is required for developers to embrace offsite manufacturing methods and improve efficiency.

Early contractor involvement is key to ensuring the "constructability" of a proposed development. The contractor's input into the design of an off-site manufacturing development should also be sought, and wider involvement of and collaboration with each member of the project team should be encouraged.

Off-site construction projects usually involve different emphasis and time in the programme for the design development. This means that most of the design work and coordination between different parties involved is required to be completed before manufacturing takes place. While Finnie et al (2018) posits that design and build procurement would be suitable for projects with offsite manufacturing where the design is straightforward and changes during construction are unlikely, the view is not universally held by those who were engaged within the housebuilding sector in the Midlands Region. Indeed, as one of the respondents noted:

'The problem with design and build, you've got to do a whole host of design work until you can get to site. You're letting a contract, you might not be granting possession until however many months down the line, and the manufacturer wants to get paid for all this work that he's doing here. You'll have paid for probably 80 per cent of your contract value before anything's even arrived onsite'.

Another respondent raised the need for changes in procurement strategies for modern methods of construction to work. The respondent said:

'MMC can only work if organisations change their procurement strategy. Design and build and traditional methods will not work. There is a need for more collaborative and partnering agreements'

Most housebuilding projects are procured using a standard form of contract that includes standardised, non-negotiated provisions, and drafted to accommodate traditional construction. It is ill-advised to use an inappropriate standard form of contract without a better understanding of how it can be adapted as a base document from which specific offsite construction issues can be satisfactorily addressed. The type of contract should recognise that the scope of commitment and the relationship with the client and the client's advisers are commensurate with time, cost and quality factors specific to offsite procurement.

Contracting structures do exist to facilitate collaboration, however the culture and mindset of the housebuilding sector has limited expertise and experience in collaboration. The role of the end user / client as pivotal to ensuring that the appropriate procurement strategies are adopted to ensure that the structure has been set up to best manage risk, reward, and maximise collaboration.

There are also notable cultural factors which the parties should be sensitive to in proposing a procurement method and contractual terms. Inherent in contracting is the parties' experience of offsite procurement and their understanding of their basic needs forms, such as (i) how much they can afford to complete the project (ii) the level of design required and (iii) the timeframes available to complete the works. Superimposed on those basic questions, the client's desire to maintain control itself or delegate that function to a third party (such as a construction manager) or even wholly to the contractor undertaking the work directly itself or managing trade packages, depending on the nature of the works limit the procurement options and contractual structures which can be used.

CONCLUSION

A recent UK House of Lords report argued that offsite manufacture could help increase productivity, as well as the quality and efficiency of buildings, while reducing labour demands and the environmental impacts associated with traditional construction. The Construction Leadership Council has also proposed the development of procurement frameworks to provide enhanced surety to enable greater investment in smart construction and industrialisation within the UK house-building sector. Although the extant literature offers a wide range of procurement methods for managing risks and specifically risks in construction supply chains, those are not adapted sufficiently for offsite house building environment. The scope of this paper had been limited to identifying and ranking the selection factors of procurement methods for the offsite housebuilding sector in the UK Midlands region. The ranking process was conducted through the RII method, which concluded that a procurement method conforming to price competition, speed of construction and project completion within the established budget should be given priority in the selection process of an appropriate method for offsite housebuilding construction. The result of the ranking confirms the literature findings, which have only discovered qualitatively the significance of higher constructability of the design and environmental sustainability when selecting a suitable procurement method for the offsite residential sector. The results are based on a specific region of the UK, indicating that further research should be conducted to explore the relationship between geographical location and the degree of influence various practitioners exert on the choice of procurement routes. It must be remembered that these differences in perceptions could be due to the different personal experiences of those within that population. Therefore, further studies with significantly larger samples would confirm whether geographical location has an impact on practitioners' perceptions of the key factors affecting the choice of procurement route for the offsite housebuilding sector. Location should be explored more on a more granular level, such as city regions.

DATA AVAILABILITY STATEMENT

No data, models, or code were generated or used during this study.

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