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Barriers to Offsite Construction Adoption in Jordan: An Exploratory Factor Analysis

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Abstract: This research investigated the barriers to Offsite Construction (OSC) adoption in Jordan. Four hypothesised groups, with their associated items, were used to develop a questionnaire survey to gather data. Twenty-three survey items were finalised through an extensive literature review and a pilot study. The questionnaire was used to collect data from 208 construction professionals in Jordan. An exploratory factor analysis revealed that the OSC adoption is affected by three groups of barriers: economic, social, and environmental. The analysis assists in developing evaluation frameworks for continuous and process improvements. Understanding the barriers to OSC adoption is essential so that decision-makers and practitioners can effectively plan and implement effective strategies and development plans, thriving the adoption of OSC in Jordan.

Keywords: Offsite Construction (OSC); Barriers; Modern Methods of Construction (MMC); Prefabrication

1 INTRODUCTION

The construction industry greatly contributes to Jordan's Gross Domestic Product (GDP) (Trading Economics, 2022). Despite this important role in Jordan's development, several problems appear within the traditional construction sector, including delays and a lack of workforce (AlBalkhy et al., 2021; Yasin & Rjoub, 2017). Previous research has established that Offsite Construction (OSC) is advantageous to mitigate the issues of traditional construction. For example, Razkenari et al. (2020) asserted that OSC is superior in terms of concurrency and sustainability.

However, research has also consistently shown that OSC adoption rates are still limited, demonstrating the presence of several barriers to such adoption. For instance, AlBalkhy et al. (2021) stated that OSC adoption in Jordan is still minimal. These low adoption rates are most likely due to numerous barriers and challenges, including inflexible design (Pan et al., 2007), insufficient knowledge and experience (Arif et al., 2012), and limited awareness of environmental impact (Hu et al., 2019). Therefore, this paper aims to examine the barriers to OSC adoption in Jordan utilising an Exploratory Factor Analysis (EFA) method. The study results will help Jordanian construction companies better understand the crucial barriers to OSC adoption, enabling them to effectively strategise for performance enhancement.

2 BARRIERS TO OSC ADOPTION

Enhancing OSC adoption requires the cooperation of clients, organisations, and governments (Guribie et al., 2022). In addition, industry readiness (Pan et al., 2007), guidance on OSC promotion (Azhar et al., 2013), and government policies (Mao et al., 2018) are key to fostering OSC concepts and implementation. Nonetheless, an assured way to promote the adoption rates of OSC is to realise its challenges (Wai et al., 2021). Several research studies have been conducted to identify the barriers to OSC adoption (Arif et al., 2017; Hong et al., 2018; Rahman, 2014).

Economic, social, and environmental pillars tie together common themes that group the factors affecting OSC. In real practice, several barriers directly and indirectly affect the economic aspect of OSC adoption. For instance, transportation accounts for 6-18% of overall costs when adopting OSC methods (Hong et al., 2018; Lu & Yuan, 2013), highlighting that the lack of transportation and storage solutions impedes OSC's costs. Also, the inability to provide bespoke designs and freezing designs early lead to extensive planning issues and long lead times (Rahman, 2014), significantly increasing the total cost of OSC projects.

Moving from the economic perspective to a social one, which involves broader societal barriers, sheds light on the impact of knowledge and perspectives to expound and understand the added value of OSC. While Nadim and Goulding (2011) emphasised that sharing the same optimistic viewpoint among stakeholders is essential to promote OSC adoption, Bendi et al. (2020) considered it a major challenge in developing countries. Moreover, in many countries, the lack of laws and guidelines poses a significant barrier (Arif & Egbu, 2010; Zhai et al., 2014). Thus, continuous development, knowledge sharing, and effective strategies and incentives are essential to address the resistance to change that is related with OSC adoption.

Similarly, addressing the environmental barriers is advocated for further OSC adoption and better performance (Tam et al., 2007). This view is supported by recognising that the lack of sustainability awareness hinders OSC adoption and green building development (G. Wu et al., 2019a; Z. Wu et al., 2019). Based on the literature, this research documented 23 variables that determine four key factors: economic barriers, social barriers, environmental barriers, and OSC adoption, as shown in Table 1. These variables were used to develop an online questionnaire survey to gather data from Jordanian construction professionals for further analysis.

Table 1: The hypothesised items

Measurement	Key References
Initial/ capital cost and cash flow issues	(Arif et al., 2012) (Razkenari et al., 2020)
Long lead times and time certainty issues	(Zhai et al., 2014) (Bendi et al., 2020)
Lack of appropriate technologies and equipment	(Rahman, 2014) (Marinelli et al., 2022)
Transportation and storage issues	(Choi et al., 2017) (Sun et al., 2020)
Design complexity and standardisation issues	(Zhang et al., 2014) (Navaratnam et al., 2022)
Lack of manufacturing capabilities	(Blismas et al., 2005)
Intensive planning and engineering requirements	(Shahtaheri et al., 2017) (Wuni & Shen, 2020)
Lack of knowledge and experience	(Arif et al., 2012) (Feldmann et al., 2022)

Lack of adequate labour	(Almutairi et al., 2017) (Wuni & Shen, 2020)
Resistance to change and innovation	(Gan et al., 2018) (Bendi et al., 2020)
Low-quality or product value perception	(Han & Wang, 2018) (Marinelli et al., 2022)
Lack of collaboration and early engagement	(Hwang et al., 2018) (Attouri et al., 2022)
Lack of regulations, standards, and incentives	(Arif & Egbu, 2010) (Zhai et al., 2014)
Lack of environmental awareness	(Tam et al., 2007) (G. Wu et al., 2019b)
Lack of waste management strategies	(Kamali & Hewage, 2016) (Brissi et al., 2021)
Lack of local environment-friendly materials	(Wuni & Shen, 2020) (Brissi et al., 2021)
Uncertain energy performance	(Blismas & Wakefield, 2009) (Wuni & Shen, 2020)
Site environmental disruptions	(Jaillon & Poon, 2008) (Rahman, 2014)
The client's willingness to adopt OSC	(Azhar et al., 2013) (Guribie et al., 2022)
Organisations' willingness to adopt OSC	(Azhar et al., 2013) (Guribie et al., 2022)
The availability of OSC policies	(Mao et al., 2018) (Guribie et al., 2022)
The availability of OSC implementation guides	(Blismas & Wakefield, 2009) (Guribie et al., 2022)
Industry's preparedness to implement OSC	(Pan et al., 2007) (Guribie et al., 2022)

3 METHODOLOGY

An online questionnaire was developed based on the 23 variables with four proposed factors to gather data on barriers to OSC adoption in Jordan. The targeted sample consisted of professionals with experience or knowledge of the construction sector in Jordan due to limited OSC adoption rates and, hence, knowledge of OSC. The survey included five sections: general information, economic barriers, social barriers, environmental barriers, and variables of OSC adoption. The participants were asked to rate the variables from extremely unimportant (1) to extremely important (5).

A pilot study was conducted to refine the questionnaire according to five respondents from academia and industry. The data collection process was conducted from May 2023 to July 2023. A total of 208 completed responses were submitted. The respondents comprised 78 Contractors (37.5%), 68 Consultants (32.7%), 36 Academics (17.3%), and 26 other nature of business (12.5%). As performing exploratory factor analysis requires a reliable and clean data set, the collected data was tested for respondent misconduct, missing

data, and normality. The normality of the data was confirmed through Skewness and Kurtosis tests, with data being normal if both are between -3 and +3 (Brown, 2015; Hair et al., 2018). Hence, it is inferred that the collected data exhibits no non-normality and is suitable for performing the EFA.

4 FINDINGS AND INTERPRETATION

EFA is used to identify the relationships between a group of variables and to group these variables into smaller clusters (Hair et al., 2018). In this research, the EFA is performed to group 23 variables into four factors (i.e., OSC adoption and the three groups of barriers to it). The Principal Component Analysis (PCA) and Varimax rotation techniques were used to perform the analysis. As shown in Figure 1, the variables were regrouped into the four predefined components, with a total variance of approximately 65%.

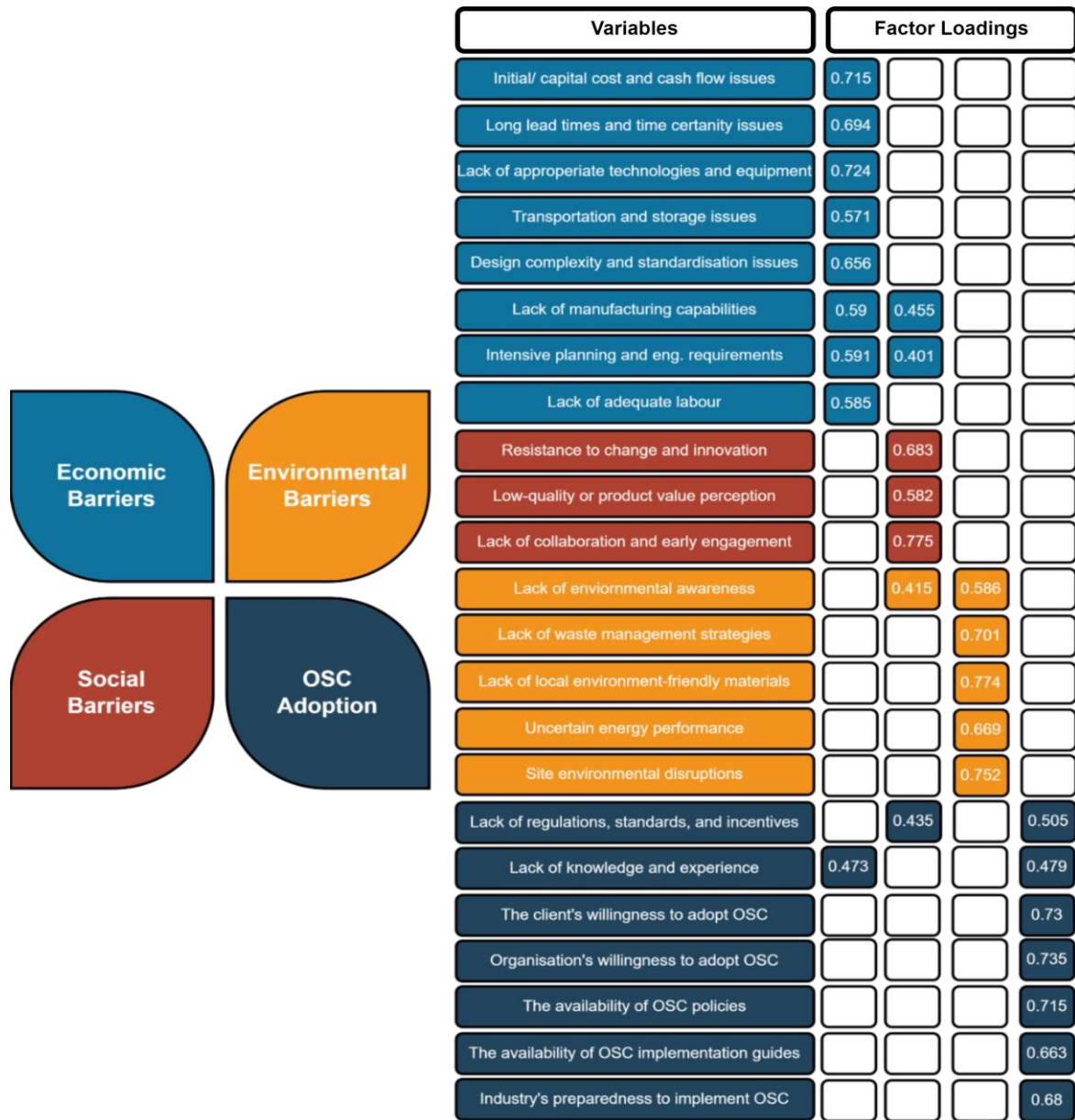


Figure 1: Results of EFA

The economic barriers group consisted of eight items. Managing costs in OSC is a pressing global issue exacerbated by the industry's fragmentation and cost-driven nature of competition. Except for the lack of adequate labour, all other items are consistent with Brissi et al. (2021), who stated that this factor comprised subfactors related to cost, productivity, and risks involved in the OSC process. However, it can be argued that the lack of adequate labour is included in this factor because of its direct effect on projects' costs and cashflows. This barrier is directly linked to the financial consequences of implementing OSC, especially in countries with enormous numbers of foreign workers (Azman et al., 2010). There was a clear consensus in the literature that OSC is more expensive than the traditional construction methods due to, to name a few, expensive rectification (Shahtaheri et al., 2017), expensive logistics (Pan & Hon, 2020), and additional management and design work (Wuni & Shen, 2020). For a relatively new concept in Jordan, OSC capital costs are high and need to be addressed by mutual efforts. Another reason for cost-related issues is the long lead times attached to OSC. This can be attributed to the lack of manufacturing capabilities and transportation challenges, which naturally contribute to increased costs and project delays. Hence, enhancing value management practices to mitigate these barriers is imperative, given their interrelation and mutual influence on one another.

The social barriers factor included three items. In this context, Blismas et al. (2006) stated that objectively determining the value-added advantages is the biggest obstacle preventing stakeholders from adopting OSC. This might be a result of past negative perceptions and instances of failure associated with OSC. For OSC approaches to gain widespread adoption, stakeholders must have a shared understanding and perspective (Nadim & Goulding, 2011). This underscores the crucial need for collaborative efforts and knowledge sharing among all parties involved in OSC processes. Also, Gan et al. (2018) argued that early stakeholder collaboration would tackle several barriers to OSC adoption. Thus, enhancing stakeholder collaboration and disseminating awareness of OSC's quality advantages are pivotal for fostering its effective adoption.

Five items were included in the environmental barriers factor. The lack of environmental awareness directly induces the neglect of sustainable practices. Addressing environmental barriers is significant to mature OSC markets (Yuan et al., 2022). For example, Brissi et al. (2021) indicated that waste management strategies impact OSC adoption. Implementing effective waste management strategies can assist in mitigating these concerns and promoting the adoption of OSC. Also, the absence of eco-friendly materials has a detrimental impact on the successful implementation of OSC (Tam et al., 2007). This is probably due to higher transportation expenses, reduced sustainability advantages, or restricted design choices. Hence, addressing such barriers also provides several advantages for the economic and social sides.

Finally, the OSC adoption factor consisted of seven items that affect the industry's mindset toward adopting OSC methods. A new mindset focused on OSC processes can help overcome the barriers to adopting it and optimise the potential of realising its benefits. Five items agree with those obtained by Guribie et al. (2022). The willingness to adopt OSC depends on factors such as perceived value and project requirements. These requirements may vary across different stakeholders and projects. In addition, it can be argued that the industry's readiness to implement OSC is influenced by investments in research and development. Remarkably, the lack of knowledge, experience, regulations, standards, and incentives are two variables affecting the OSC adoption mindset rather than barriers to OSC. This highlights the role of knowledge and experience in shaping OSC's mindset and underscores the importance of early decision-making in OSC adoption.

5 CONCLUSION AND LIMITATION

This study set out to examine the barriers to OSC adoption in Jordan through an exploratory factor analysis approach. The findings clearly revealed three major groups of barriers: economic, social, and environmental, which impact OSC adoption in the Jordanian construction industry. Economic barriers encompassed barriers associated with cost, productivity, and risks in the OSC process, highlighting the financial implications of OSC implementation. Social barriers included resistance to change, perception of low quality or product value, and the lack of collaboration and early engagement. As these emerged as critical barriers influencing OSC adoption, enhancing stakeholder cooperation and spreading OSC's benefits could improve its adoption in the Jordanian industry. Environmental barriers, such as the lack of

waste management strategies and eco-friendly materials, were also found as barriers to OSC adoption. Addressing these barriers promotes sustainability and provides economic and social benefits.

This study contributes to the body of knowledge by identifying and analysing the barriers to OSC adoption in Jordan, providing valuable insights for decision-makers to develop effective strategies for promoting OSC adoption. Being limited to the Jordanian context, this study's findings may not be directly generalisable to other countries with different socio-economic and cultural contexts. Notwithstanding this limitation, the identified barriers can be used in future research to conduct more comprehensive assessments of OSC adoption. Moreover, further work needs to be done to establish how these barriers would be addressed, contributing to a more comprehensive understanding of OSC adoption and facilitating decision-making in the OSC industry.

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