

Article

# Risks in Prefabricated Buildings in China: Importance-Performance Analysis Approach

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**Abstract:** Prefabrication has drawn wide attention in China during the last decade. However, the market share of prefabricated buildings in China remains comparatively low. The Importance-Performance Analysis approach is employed in this study to investigate the crucial risk factors associated with prefabricated buildings in China. A preliminary list of risks associated with prefabricated buildings in China was developed based on a critical literature review, which was consequently refined by the interview with related experts. A questionnaire survey was then conducted with selected industry professionals to solicit their expert opinions of critical risks associated with prefabricated buildings in China. Findings show that attention should be paid to the following risks: improper decomposition system, low level of factory management, incompetent quality assurance system, deviation in specification of prefabricated components, defects of component system, missing catalogue of building parts and components, poor adaptability of prefabricated building during the operational stage, and lack of actual cases to prove the environmental benefits of prefabricated buildings. This study also revealed the discrepancy between perceived critical risks and those risks with comparatively lower management performance. These findings offer useful inputs for the future development of prefabricated buildings in China and beyond.

**Keywords:** prefabrication; Importance-Performance Analysis; risks; strategies

## 1. Introduction

The construction industry has significant impacts on the environment, society, and the economy. For instance, the building sector is one of the largest emitters of greenhouse gases [1]. Similarly, a large amount of solid waste has been generated from construction activities [2,3]. These have motivated the promotion of various concepts such as carbon neutral buildings, net-zero energy building, zero emission buildings, etc.

Meanwhile, the construction industry has been reported as one of the dangerous industries due to poor safety performance [4,5]. In addition, delays and cost overruns are very common in construction projects [6,7]. As a result, a number of initiatives have been introduced to minimize the negative environmental impacts of construction activities, e.g., waste, emissions, and to improve the safety, time, and cost performance. Prefabrication is one of these initiatives.

There are many terms related to prefabrication. These include: off-site manufacturing, modular construction, industrialized building, etc. In this study, these terms are interchangeable so “prefabrication” is used to avoid any confusion. In essence, prefabrication is “a manufacturing process, generally taking place at a specialized facility, in which various materials are joined to form a component part of the final installation” [8].

A number of benefits of prefabrication have been reported in previous studies. For instance, Jaillon [9] suggested that around 52% of construction waste could be reduced by means of adopting prefabrication. They did acknowledge “difficulty for professionals to estimate the impact of prefabrication on waste reduction”. Based on two case studies, Mao [10] reported that the greenhouse gas (GHG) emissions per square meter can be reduced by as high as 9% derived from the adoption of prefabrication. Other benefits of prefabrication include: time savings, cost savings, and better quality and safety performance during the construction [11–15]. For instance, the cost savings can be achieved by repetitive and mass production in the factory environment [16]. This also contributes to better quality due to a well-managed factory environment [17,18].

In China, the government has introduced stringent measures to facilitate the prefabrication. For instance, all affordable housing projects have to use prefabrication. At least 30% of the new construction has to adopt prefabricated construction by 2026 [19]. However, it is striking to note that the proportion of prefabricated buildings in the existing building stock is still comparatively low in China. Existing studies predominately focus on identifying driving forces and impeding factors related to prefabrication. However, there is a lack of further investigation of how the identification of critical factors could lead to strategies.

This study employs an Importance-Performance Analysis approach to investigate the critical factors associated with prefabricated buildings in China. Corresponding strategies are proposed to deal with these critical risks. These findings provide useful inputs for the development of the prefabrication market in the future.

## 2. Research Methodology

In this study, a critical review was conducted with literature related to prefabrication. Academic databases were searched using keywords such as: prefabrication, prefabricated building, module construction, off-site manufacturing, etc. As a result, a list of critical factors associated with prefabrication is identified.

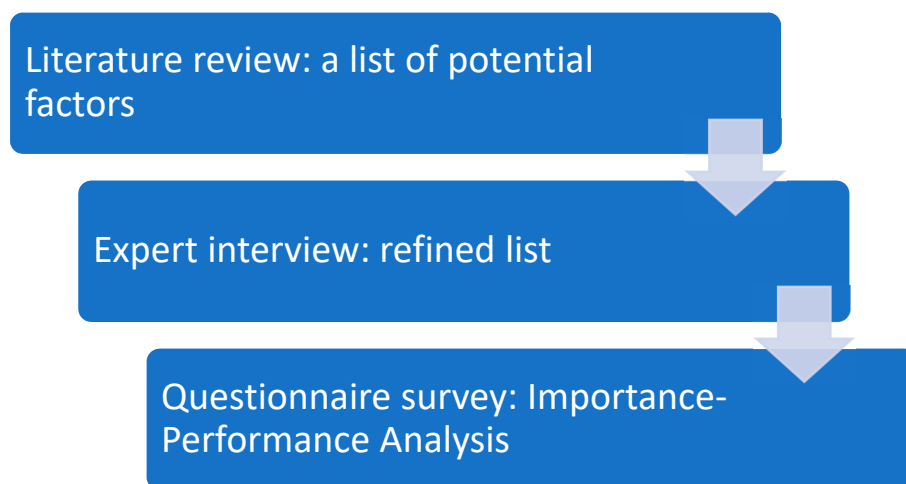
This is followed by semi-structured interviews with experts in the prefabrication sector. The purpose of these interviews is to refine the list of critical factors drawn from the critical literature review. Ten experts were interviewed (see Table 1). They were shown the preliminary list of risk factors derived from the literature review in the first instance. Consequently, they were asked to comment on: (1) Are these risks related to the implementation of prefabrication in China? (2) Are there any other risks that are not included in this list? (3) Is the expression of each risk factor clear? In particular, interviewees were encouraged to reflect on potential risks throughout the various life cycle stages of prefabricated buildings, e.g., feasibility study, design, manufacturing and transportation, construction, and operational stages. All interviewees confirmed that the preliminary list of risk factors provided during the interview captures the general situation of prefabricated buildings in China. They also confirmed that there is no ambiguity issue associated with the expression. In addition, interviewees suggested some new risk factors that are not covered in the existing literature.

**Table 1.** Profile of interviewees.

Interviewees	Organization	Prefabrication Related Experience (Years)
A	Contractor	7
B	Contractor	8
C	Contractor	7
D	Design institute	9
E	Design institute	9
F	Modular manufacturer	8
G	Modular manufacturer	7
H	Developer	6
I	Government	7
J	Government	8

Consequently, a questionnaire survey was conducted with professionals in the prefabrication sector to gauge their expert opinion of how those critical factors are applicable in the Chinese market. Meanwhile, the Importance-Performance Analysis was conducted in order to develop corresponding strategies. Importance-Performance Analysis was proposed by Martilla and James [20] on the purpose of developing strategies based on identified critical factors. The Importance-Performance Analysis consists of following steps: (1) a list of critical factors are identified, (2) each critical factor is evaluated from two dimensions, i.e., level of importance and level of performance, (3) all factors are classified into four groups according to their level of importance and level of performance, i.e., concentrating here, keeping up the good work, low priority, and possible overkill. Since then, Importance-Performance Analysis has been widely employed in management studies [21–23]. In the construction context, Importance-Performance Analysis has been conducted in order to understand the sustainability attitude and initiatives of construction enterprises and their employees [24–26]. The entire research process is shown in Figure 1.

It is a common approach to employ a quantitative approach in previous studies related to Importance-Performance Analysis. One of most common approaches is to employ a five-point Likert scale to measure importance and performance [25–27]. Therefore, a five-point Likert scale was employed in this study to measure the importance and performance levels of the management of each individual risk perceived by industry practitioners. Each survey participant was required to evaluate the relative importance of the management of every single risk associated with prefabrication, i.e., from 1 (“very unimportant”) to 5 (“very important”). Similarly, a 5-point Likert scale from 1 (“very insufficiently”) to 5 (“very sufficiently”) was used to measure the performance of the management of every single risk associated with prefabrication. The mean value of all responses to each risk factor was calculated in terms of perceived level of importance and the perceived level of management performance (Table 3). These mean values were consequently used for Importance-Performance-Analysis.



**Figure 1.** The research process adopted in this study.

### 3. Findings: Identification of Potential Risks

It is well-recognized that a life cycle approach needs to be employed to evaluate benefits and costs of prefabricated buildings [15,17]. Life cycle stages of prefabricated buildings include feasibility study, design, manufacturing and transportation, construction, and operational. Therefore, the identification of risks associated with prefabricated buildings is according to these life cycle stages.

A total of 154 valid responses were received. Nearly 60% of these respondents were aged 26–40. The majority of survey respondents have more than five years of experience related to prefabricated buildings (Table 2). Therefore, these respondents provide valid and valuable inputs for this research.

**Table 2.** Profile of survey respondents.

Respondents	Distributions
Gender	Male: 117 Female: 37
Age	18–25: 40 26–40: 92 >40: 22
Organization	Construction: 45 Design: 59 Modular manufacturer: 14 Developers: 7 Government: 5 Others: 24
Prefabrication related experience	1–5 years: 24 5–10 years: 126 >10 years: 4

### 3.1. Feasibility Study Stage

Risks exist in the feasibility study. According to Jiang [13], top-down policy support plays a crucial role in the promotion of prefabricated construction. These include: preferable taxes, subsidy, and loan. The mandate policy on the adoption of prefabrication in certain sectors also encourages the implementation of prefabricated construction [28]. Therefore, changes to these preferable policies will present a significant risk to the prefabricated construction. Similarly, changes to related laws and market condition may pose severe risks to prefabricated construction.

The other risk during the feasibility study stage is the lack of market and social acceptance. This is mainly due to the negative public perception of prefabrication [29] and the general risk-averse attitude of the construction industry [30,31]. In addition, previous studies have reported concerns of potential high capital cost or even high overall cost in prefabricated building projects [9]. The capital cost is high because the specialized factory has to be established to manufacture the required components as well as the associated production and maintenance cost [32].

Interviewees suggested two extra risk factors during the feasibility stage. These two risks are: lack of appropriate transport and environmental support around the site, and lack of appropriate planning of production capacity of prefabricated components. For instance, some interviewees highlighted the high concentration of air pollutants in the prefabrication factory environment.

### 3.2. Design Stage

There are a number of risks during the design stage. It can be understood that many of these factors are associated with the design professionals. Indeed, there are a number of design issues associated with the prefabricated buildings. These include: lack of uniqueness or customization in prefabricated building design and poor consideration of geological conditions [33]. To enhance the constructability, it is necessary to use information technologies such as Radio-frequency identification (RFID) and Building Information Modelling (BIM) [34,35]. This will help to clearly understand the information flow associated with the entire process and assist the material selection.

Interviewees revealed that it is a common practice in China that a design institute is engaged in the project to undertake the design of prefabricated buildings. It is not unusual that the design is not conducted according to prefabrication principles. This is attributed to the fact that many design institutes lack deep design capability and experience in integration design of prefabricated building. Rather, traditional design is performed and consequently a specialist design consultant is engaged by the client to decompose the original design into various prefabricated components. According to interviewees, violation of design specifications has occurred in some cases. Interviewees commented

that this is because of flaws in technical specifications and poor structural design. In addition, there have been concerns of designers on the seismic performance of prefabricated buildings as well as waterproof and anti-seepage treatment of joints.

### 3.3. Manufacturing and Transport Stage

Prefabricated components need to be manufactured in the factory and then transported to the site for assembly. A number of risks are involved in this process. However, these upstream processes are largely overlooked in existing studies [36].

The manufacturing and transport of prefabricated components require a highly skilled workforce [37,38]. For instance, a number of machineries and devices are used in a prefabrication factory. These machineries and devices include: Computer Numerical Control (CNC) marking machine, concrete distributor, vibrator, concrete conveyor, demoulding machine, etc. The operators of these machineries and devices have to be highly skilled to keep up the efficiency of the operation [13]. This could be a result of a low level of factory management.

In terms of transportation, a lot of risk factors have been reported in existing studies such as: improper stacking of components, lack of professional stacking tools, and lack of professional transportation tools [10,36]. In addition, the transportation network plays a crucial role. Lack of logistics network or too long distance of transport present significant risks to prefabricated building projects [39]. Similarly, the insufficient transport road conditions (including the radius of gyration of the road and the limit of the bearing capacity of the bridge) is another risk during the transport stage. Other risks in this stage include: transport vehicles not meeting the requirements, or no fixed measures were taken when transporting components [40]. For example, transport vehicles should satisfy requirements on the size and weight of prefabricated components (or volumetric units/pods).

Interviewees revealed a large number of risk factors during the manufacturing and transport stage of prefabricated building projects. These include: deviation in component sizes, and deviation in specification of prefabricated components. They also suggested potential strength issues, e.g., insufficient strength of prefabricated concrete components and insufficient strength when lifting the prefabricated concrete component. In addition, interviewees have reported a number of cases in which delays and extra costs are the consequences of the lack of coordination of the construction team during the transportation phase.

### 3.4. Construction Stage

Some studies have been undertaken to identify potential risks in the construction stage. As a large number of workforces and machinery are involved in the construction stage, a lack of related resources will pose a significant challenge to the prefabricated building [41]. Insufficient radius of crane operation and insufficient lifting capacity of lifting machinery are critical issues, especially in volumetric prefabricated buildings [42]. There are safety risks during the construction process such as failure of lifting connection and lifting operation error [43].

Interviewees suggested other risks during the construction stage such as: lack of quality inspection methods, lack of technologies to test the quality of connections, lack of quality acceptance method and standard system, and lack of catalogue of building parts and components. Some interviewees also revealed that in some cases, materials and accessories used for component installation have not been tested. Similarly, there have been some concerns about insufficient coordination between prefabricated construction and other components of construction, and insufficient concrete strength after in-situ cast of joint connections.

### 3.5. Operational Stage

Each building has a service life and prefabricated buildings are no exception. Different from traditional construction, prefabricated buildings need to be maintained properly and the facility management consultant need to have related experience [34,44]. Similarly, previous studies have reported various operation issues associated with prefabricated buildings such as: sound insulation and waterproof performance [45,46]. In addition, real-time data are required to enable an efficient operation of prefabricated buildings [40,47].

Risks during the operational stage suggested by interviewees mainly include the lack of actual cases to prove the benefits (i.e., environmental, social, and economic) of prefabricated buildings. They have shown concerns that it is not sustainable to purely rely on the governmental policies if there is a lack of real cases to demonstrate such benefits to the industry, especially to the client and end users. This is also the case for engineers and regulators [48]. A recent review article also highlighted the lack of evidence that the life cycle performance of prefabricated buildings is better than conventional buildings [49]. Indeed, there is a lack of consideration of the operational stage in the current studies related to prefabricated buildings [50]. Some interviewees also reported cases with poor adaptability of prefabricated building during the operation stage.

Following the research process defined in Figure 1, a preliminary list of potential risks associated with prefabrication was developed as a result of the literature review. This preliminary list was refined via interviews with industry practitioners with extensive experience. All these risk factors are grouped according to the life cycle stages (see Table 3). It is assumed that the perception of these risk factors will lead to a reluctance to adopt prefabricated construction.

**Table 3.** Risks associated with prefabrication.

		Importance	Performance
<b>Feasibility study stage (Stage A)</b>			
Changes to preferable policies	A1	3.85	3.66
Lack of consultants on prefabrication	A2	3.68	3.54
Lack of funds	A3	3.42	3.41
Change to related laws	A4	3.73	3.57
Changes to the market condition	A5	3.7	3.5
Lack of related standards	A6	3.79	3.48
Low social acceptance	A7	3.56	3.42
Low market acceptance	A8	3.6	3.58
High capital cost	A9	3.82	3.62
High overall cost	A10	3.86	3.65
Lack of appropriate transport and environmental support around the site	A11	3.58	3.53
Lack of appropriate planning of production capacity of prefabricated components	A12	3.71	3.53
<b>Design stage (Stage B)</b>			
Lack of uniqueness or customization in prefabricated building design	B1	3.84	3.56
Concerns of designers on the seismic performance of prefabricated buildings	B2	3.63	3.47
Violation of design specifications	B3	3.09	3.27
Design institute lacks deep design capability	B4	3.51	3.47
Poor consideration of geological conditions, resulting in failure to put into use	B5	3.16	3.28
Poor constructability	B6	3.34	3.42
Lack of experience in integration design of prefabricated building	B7	3.6	3.59
Improper material selection	B8	3.18	3.37
The decomposition of building design is not standardized and not modularized	B9	3.58	3.49
Flaws in technical specifications	B10	3.56	3.48
Lack of information technology	B11	3.55	3.53
Improper decomposition system	B12	3.45	3.5
Poor structural design	B13	3.5	3.52
Waterproof and anti-seepage treatment of joints is insufficiently considered in design	B14	3.5	3.53

Table 3. Cont.

		Importance	Performance
<b>Manufacturing and transport stage (Stage C)</b>			
Deviation in component sizes	C1	3.46	3.36
Insufficient strength of prefabricated concrete components	C2	3.03	3.23
Insufficient strength when lifting the prefabricated concrete component	C3	3.18	3.26
Low level of factory management	C4	3.46	3.49
Shortage of industrial technology management personnel during production and transportation	C5	3.51	3.57
The quality assurance system does not work	C6	3.46	3.46
Lack of professional stacking tools	C7	3.33	3.34
Lack of professional transportation tools	C8	3.27	3.42
Transport distance is too long	C9	3.41	3.38
Lack of logistics network	C10	3.41	3.4
The lack of coordination of construction team during the transportation phase which leads to delays and extra costs	C11	3.4	3.36
Transport vehicles do not meet the requirements	C12	3.33	3.37
Insufficient transport road conditions (including the radius of gyration of the road and the limit of the bearing capacity of the bridge)	C13	3.35	3.34
Improper stacking of components	C14	3.36	3.38
No fixed measures were taken when transporting components	C15	3.24	3.37
Deviation in specification of prefabricated components	C16	3.36	3.46
Defects of component system	C17	3.42	3.47
Insufficient training to industrial workers	C18	3.74	3.57
<b>Construction stage (Stage D)</b>			
Insufficient coordination between prefabricated construction and other components of construction	D1	3.72	3.49
Construction company lacks relevant experience	D2	3.67	3.53
Shortage of industrial technology management personnel during construction	D3	3.75	3.59
Shortage of industrial workers during the construction stage	D4	3.7	3.52
Instable mechanical supply market	D5	3.57	3.45
Insufficient professional tools and machinery	D6	3.66	3.49
Insufficient industrial training and education	D7	3.71	3.56
Failure of connection during lifting	D8	3.31	3.38
Hoisting machinery does not work properly	D9	3.31	3.4
Lifting operation error	D10	3.27	3.39
Fall from height	D11	3.39	3.36
The materials and accessories used for component installation have not been tested	D12	3.24	3.29
Insufficient radius of crane operation	D13	3.25	3.27
Insufficient lifting capacity of lifting machinery	D14	3.31	3.26
Insufficient concrete strength after in-situ cast of connection	D15	3.36	3.3
Rebar corrosion	D16	3.22	3.32
Impact of climate factors	D17	3.24	3.33
Lack of quality inspection methods	D18	3.56	3.56
Lack of technologies to test the quality of connections	D19	3.6	3.53
Quality acceptance method and standard are missing	D20	3.55	3.58
No catalogue of building parts and components	D21	3.45	3.53
<b>Operational stage (Stage E)</b>			
Property company lacks experience	E1	3.44	3.42
Insufficient parts production and sales system	E2	3.42	3.41
Lack of public awareness and knowledge of prefabrication	E3	3.64	3.58
Failure to maintain properly	E4	3.5	3.47
Poor sound insulation in prefabricated building	E5	3.18	3.36
Poor waterproof performance of prefabricated buildings	E6	3.29	3.41
Poor adaptability of prefabricated building during the operation stage	E7	3.47	3.45
Did not achieve the expected return	E8	3.51	3.5
Lack of actual cases to prove the environmental benefits of prefabricated buildings	E9	3.48	3.51
Lack of actual cases to prove the social benefits of prefabricated buildings	E10	3.51	3.49
Lack of actual cases to prove the economic benefits of prefabricated buildings	E11	3.51	3.51
Difficulties to collect real-time energy consumption and emissions data for prefabricated buildings	E12	3.55	3.55

#### 4. Importance-Performance Analysis: Critical Risks and Corresponding Strategies

In terms of importance, all risks listed in Table 1 received a score of higher than 3. This indicated that the list developed from the literature review and tested in interviews is valid. All risks listed in Table 1 are applicable in the context of China. Results showed that top ten risks are:

- High overall cost (A10)
- Changes to preferable policies (A1)
- Lack of uniqueness or customization in prefabricated building design (B1)
- High capital cost (A9)
- Lack of related standards (A6)
- Shortage of industrial technology management personnel during construction (D3)
- Insufficient training to industrial workers (C18)
- Change to related laws (A4)
- Insufficient coordination between prefabricated construction and other components of construction (D1)
- Lack of appropriate planning of production capacity of prefabricated components (A12)

Half of these top ten risks are located in the feasibility study stage (Stage A). There are a large number of risks during the feasibility study of prefabrication projects [13]. This clearly indicated the concerns of the industry professionals on the potential risks from the very early stage of prefabrication projects. Respondents reported their concerns on not only the associated cost but also the lack of policies and standards. Indeed, the policy which mandates the implementation of prefabricated buildings has largely facilitated the development of the prefabrication sector in China [28]. The cost can be lowered with the volume of prefabricated buildings. It is also interesting to note that resources have been identified as a critical risk of prefabrication projects, e.g., human resources, machinery, and production facilities. Considering China has vast areas, proper planning is required to ensure the production capacity of prefabricated components is provided for each region. This will avoid excessive transportation, which is also associated with the environmental impacts such as energy consumption and GHG emissions. Interviewees commented that the current production capacity is concentrated in a few cities. They suggested to further developing some production bases around regions with rapid urbanization.

The survey also solicited respondents' professional judgement on the performance of managing these risks in China. The performance of managing these risks is evaluated via industry experts' scores. In terms of performance, the following risks are less managed:

- Insufficient strength of prefabricated concrete components (C2)
- Insufficient lifting capacity of lifting machinery (D14)
- Insufficient strength when lifting the prefabricated concrete component (C3)
- Insufficient radius of crane operation (D13)
- Violation of design specifications (B3)
- Poor consideration of geological conditions, resulting in failure to put into use (B5)
- The materials and accessories used for component installation have not been tested (D12)
- Insufficient concrete strength after joint pouring (D15)
- Rebar corrosion (D16)
- Impact of climate factors (D17)

It is interesting to note that although most of the top ten risks are located in early project stages (e.g., feasibility study stage and design stage), it is reported by survey respondents that performance of risk management is comparatively poorer in later project stages (e.g., manufacturing stage and construction stage). Indeed, a number of risks exist in the factory environment during the manufacturing stage as well as transporting prefabricated components to the construction site for assembly [35]. The vast majority of these risks are technical issues during the manufacturing stage and the construction stage. These technical issues are associated with the prefabricated concrete components, such as their strength and consequently, the structural integrity. It is worth noting that one of the concerned areas is the lack of a testing mechanism for all materials and accessories used for component installation. Interviewees suggested that the current practices predominately rely on the quality control efforts



made by manufacturers. They suggested that destructive testing is not conducted as the prefabricated components are generally expensive.

Consequently, Importance-Performance Analysis (IPA) was performed. All risks are classified into one of the IPA quadrants (Figure 2). Quadrants are defined according to the average score of the means.

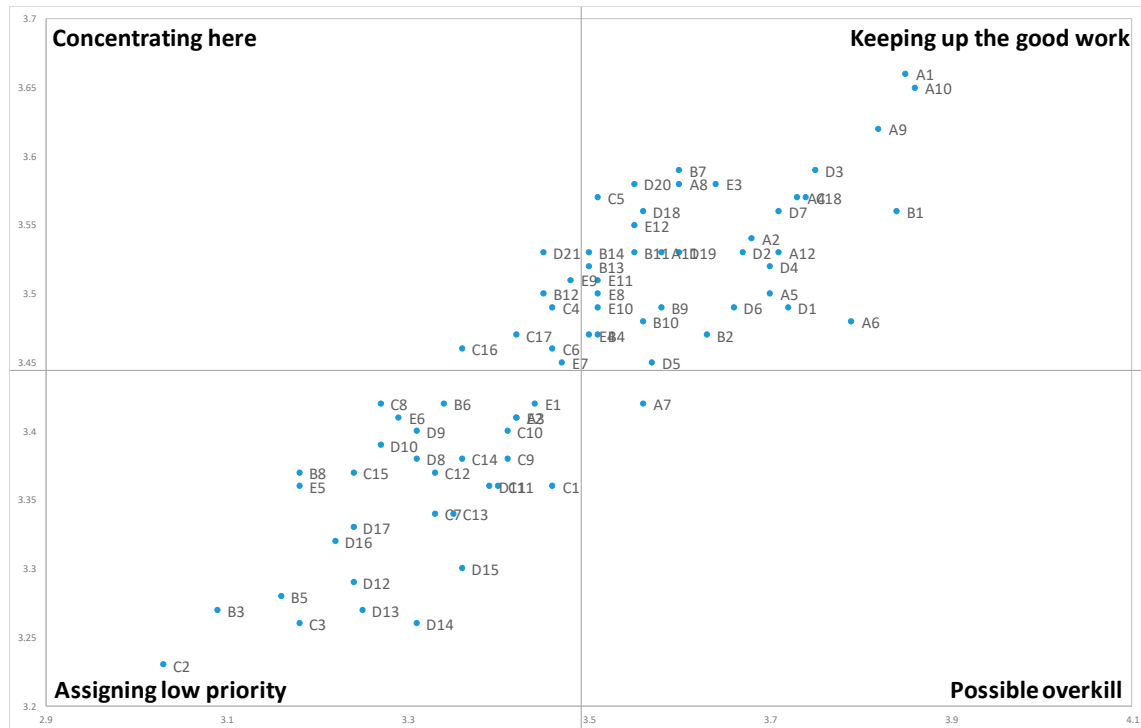


Figure 2. Importance-Performance Analysis (IPA) matrix.

Results of the Importance-Performance Analysis highlighted most critical risks associated with prefabrication. All risk factors located in the quadrant (concentrating here) fall into such category. Therefore, the following risks deserve more attention:

- Improper decomposition system (B12)
- Low level of factory management (C4)
- The quality assurance system does not work (C6)
- Deviation in specification of prefabricated components (C16)
- Defects of component system (C17)
- Missing catalogue of building parts and components (D21)
- Poor adaptability of prefabricated building during the operation stage (E7)
- Lack of actual cases to prove the environmental benefits of prefabricated buildings (E9)

Interviewees revealed that it is a common practice in China that traditional non-modular design is undertaken even in those projects using prefabrication methods. As a result, a special consultant is employed by the client to perform decomposition of a traditional non-modular design. According to interviewees, it is not possible to decompose the non-modular design entirely into modules. In most cases, these components end up with in-situ cast on site. Such practices also present significant challenges for the manufacturers as it is difficult to achieve standardization of module design and manufacturing. This risk is also associated with the defects of the components system, missing catalogue of building parts and components. Interviewees suggested that the government plays a crucial role in leading the industry towards the standardized modular design and system. In addition, the professional body and industry association can facilitate this process via industry-wide training programs.

Similarly, efforts are required to improve the performance of factory management. As all modules are manufactured and tested in the factory environment, the performance of managing resources (e.g., human resources, machinery, storage, etc.) has a significant impact on the quality of prefabricated components. Poor management of a factory will lead to significant wastes of time, cost, and space.

Another two areas to be concentrated on are located in the operation stage. The first risk is related to adaptability of prefabricated building during the operation stage. This is arguably because of the connection system adopted in China. In China, the common practice to connect prefabricated components is through in-situ cast concrete. This makes it very difficult to adapt prefabricated buildings, e.g., removing existing modules or adding new modules. The second risk is related to the evidence for the benefits associated with prefabricated buildings. At the moment, the vast majority of existing studies rely on the subject comments made by industry professionals or simulation results. Some interviewees revealed that some prefabricated building projects actually suffer from cost overruns and delays, predominately due to the lack of necessary human resources and poor management of logistics. A database of actual cases with lessons learnt and benefits will help the industry to gain confidence and further promote the prefabrication sector.

## 5. Conclusions

This study offers a comprehensive list of risk factors associated with prefabricated construction following a life cycle approach. A total of 77 risks were identified from a critical literature review and interview with industry professionals. This comprehensive list covers various life cycle stages of prefabrication projects, i.e., feasibility study, design, manufacturing and transportation, construction, and operation. This list offers a useful starting point for the companies that plan to enter the prefabrication sector.

Importance-Performance Analysis conducted in this study offers four strategies to deal with each corresponding risk (Figure 2). In all four quadrants, “concentrating here” covers all risks factors that should be given higher priority. This provides useful inputs for the decision-making process of the government and industry.

Importance-Performance Analysis revealed eight crucial risks for the implementation of prefabrication, i.e., improper decomposition system, low level of factory management, incompetent quality assurance system, deviation in specification of prefabricated components, defects of component system, missing catalogue of building parts and components, poor adaptability of prefabricated building during the operation stage, and a lack of actual cases to prove the environmental benefits of prefabricated buildings.

Most of these crucial risks are associated with the standardized component system. Therefore, the government should consider engaging experts to develop a catalogue for the most common modules and encourage the industry to use this catalogue as the reference for module design. Similarly, the professional bodies, such as China Construction Management Association, should organize the training sessions to educate the industry practitioners about the proper approach of designing, construction, and operation of prefabricated buildings.

Similarly, technological innovation is required to improve the connection mechanism between prefabricated components, especially with the structural components. This will improve the adaptability of prefabricated buildings. Future research opportunities exist to use a case study approach to investigate the prefabrication issues in real life projects. Meanwhile, a cross-sector comparison will help to make policies and standardized procedures for each sector.

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