Critical Policy Drivers for Modular integrated Construction Projects in Hong Kong

Abstract

Given the increased importance of identifying the critical Policy Driving Forces (PDFs) to uptake Modular integrated Construction (MiC) practices in Hong Kong (HK), this study aims to identify and examine the critical PDFs associated with MiC projects in HK from the perspective of industry experts. After drawing on the plentiful relevant literature and conducting a pilot study, an expert opinion survey was conducted to gather the necessary data for this study. The collected data were analysed using relevant significance analysis and factor analysis to identify critical PDFs and appropriate groupings. The results revealed 23 critical PDFs under seven critical components in three stages of the MiC process. Regulative PDFs show the highest criticality for up-taking the MiC in the initiation and planning and design phases, while Greater Bay Area development PDFs are critical in the construction phase. The PDF related to the COVID-19 pandemic is the only critical PDF that appeared in all three stages. As the first study that explores PDFs for MiC uptake throughout all project phases, this study contributes substantially to theory and practice while better informing policymakers on how to initiate MiC-related policies to boost MiC practice in HK, where MiC is achieving greater prominence in application.

Keywords: Modular integrated Construction (MiC); Policy Driving Forces (PDFs); Policy; Greater Bay Area; Hong Kong

Introduction

Modular integrated Construction (MiC) is an innovative and effective manufacturing-based mode of construction and an alternative to the traditional on-site construction method. It has been adopted progressively worldwide in recent years (Zhao Xu et al., 2020). By adopting the concept of 'on-site installation after factory assembly', MiC helps alleviate some of the challenges currently faced by the local construction industry. The superior performance of MiC in saving construction time, better controlling the quality of buildings, enhancing overall productivity and durability, reducing the pressure of construction site waste, having fewer requirements for a skilled on-site workforce (Yin *et al.*, 2019) and improving occupational health and safety (Y. Chen et al., 2010; Jankovic, 2019) make it an appropriate solution for the entire construction industry to promote green sustainable development.

With the increasing acceptance of the importance of MiC to improve construction quality and efficiency as well as its strong environmental performance, many countries and regions have attempted to promote MiC uptake by releasing relevant policies and regulations (X. Jin et al., 2021; Y. Wang et al., 2019). Although these areas involve different construction contexts and social backgrounds, their MiC promotional policies universally focus on mandatory requirements and incentive schemes. In Hong Kong (HK), given the overwhelming demand for high-quality, affordable housing in recent years, the HK government has implemented compulsory regulations and incentive schemes to adopt MiC. Since the mid-1980s, the Hong Kong Housing Authority (HKHA) has mandated the use of prefabricated units, together with standard modular integrated design, for all public housing projects (Mak, 1998), which has greatly enhanced the development of modular construction applications in HK (HKHA, 2019). Currently, the HKHA continues to invest in MiC technology and is committed to increasing the rate of adopting prefabricated components. In addition to the widely used prefabricated components of precast panel walls and volumetric precast bathrooms, since 2011, the HKHA has adopted precast ground floor water tanks, precast roof water tanks and precast roof parapets for applicable buildings. Precast acoustic balconies were also introduced to pilot projects in 2013.

Architectural elements such as façades, slabs, stairs, partition walls, beams and prefabricated blocks for public housing construction are good examples of prefabricated modules that help to improve construction efficiency (HKHA, 2016). Apart from that, recently, infrastructure such as immersed tunnels, the HK-Zhuhai-Macao Bridge (HZMB), and the HK Shenzhen Corridor have widely used prefabricated modules. Private sector developers have also initiated the use of precast concrete modules since 2002.

In 2001, the HK government began providing a Gross Floor Area (GFA) exemption for building projects that adopt MiC and green technologies (HKBD, 2001; Joint Practice Note No. 2, Second Package of Incentives to Promote Green and Innovative Buildings, 2002). These incentive schemes enabled real estate developers to access additional floor areas (L. C. Jaillon, 2009) with expenditure savings up to 4%-6% (Tam et al., 2014). Besides, greater use of MiC was also promoted in the Chief Executive's 2017 Policy Address (HKSAR, 2017). As stated above, the HKHA has encouraged MiC to provide a more effective platform to enhance construction productivity.

However, policy implications for promoting the adoption of MiC invariably focus on incentive schemes and compulsory requirements while ignoring the real-life impact of Policy Driving Forces (PDFs) on MiC processes, which significantly impedes the efficient management of MiC. The adjustment of policies or regulations is neither entirely a function of market demand nor a simple government operation but rather is mediated by a range of stakeholders and influenced by the socioeconomic environment and dynamic interactions among PDFs. To establish a foundation to identify the dynamics of PDFs, it is essential to identify critical PDFs associated with MiC that are currently absent in the literature. Since MiC policies are jurisdiction-specific and MiC supply chain configurations differ across countries (Ekanayake et al., 2020), an HK-specific study is needed. Therefore, this study aims to identify and examine the critical PDFs associated with MiC projects in HK from the perspective of industry experts.

Literature Review on PDFs in MiC projects

Several previous studies have focused on identifying the success factors of MiC. Therefore, this study conducted a comprehensive systematic literature search to identify the PDFs associated with the MiC projects as explicated in the research methods section. As identified from the literature search, Han and Wang (2018) conducted a study on offsite construction issues and suggested specific managerial implications for policymakers to uptake industrial practice using grey DEMATEL analysis from six main perspectives: policy, publicity, technology, supply chain coordination, training and education, and market demand. The authors further indicated government regulations and incentives as essential aspects to uptake MiC adoption. A study conducted by Lu et al. (2018) developed an analytical framework to seek the optimal level of prefabrication adoption in a certain political, economic, social and technological (PEST) context, highlighting political factors. Luo et al. (2021) analysed 24 risk factors associated with industrialized buildings and emphasized the government's leading role in enforcing adequate policies and regulations in MiC promotion. Further research has highlighted the importance of government policy changes to better manage supply chain risks in prefabricated building projects (Xiao Li, Chi, et al., 2021). Mao et al. (2018) grouped the 18 critical factors that influence the use of off-site construction into five categories, government regulations and policies, technological innovation, industry supply chain, cost, and market demand, with government regulations and policies as the most dominant grouping.

However, none of these studies explored the implications of prevailing prefabricated construction-related policies to improve industry performance, which is essential in the MiC sector. More importantly, MiC is not simply off-site and prefabricated construction; instead, it represents the highest level of off-site or prefabricated construction (Zheng, Zhang, & Pan, 2020) and contributes significantly to increased construction industrialization. Moreover, no previous studies have identified and listed the PDFs associated with MiC implementation. Therefore, the authors first identified the PDFs through a comprehensive literature search. Accordingly, a total of 26 PDFs in the development of MiC in HK were identified. Table 1 presents the identified PDFs from the comprehensive literature review. All of the identified PDFs were pretested and then tested through a pilot study and empirical research to determine the critical PDFs, their appropriate groupings and their levels of criticality for MiC practice in HK.

In previous attempts, Han and Wang (2018) indicated that the economic factors were closely related to the development of industry, society, technology, and regulations, which should be regarded as one of the top important factors for implementing MiC. Through the strengths, weaknesses, opportunities and threats (SWOT) analysis, Jiang et al. (2018) identified that financial incentives should be considered primary drivers. Financial policies and tax reduction policies should be listed as key policy measures to underpin the strategic purpose of promoting MiC. Liu et al. (2017) also emphasized that financial incentives and taxation could stimulate construction companies to enhance modularization. Chen et al. (Q. Chen et al., 2017) mentioned that enterprises are keen on the government's preferential policies due to the high extra costs of adopting MiC. Since the high initial investment was listed by some researchers as one of the top five risks for implementing MiC, the PDF in terms of investment becomes even more important.

Similarly, the uncertainty of property market demand is an obstacle for the MiC development (X. Jin et al., 2021). Housing programmes were highlighted by Mare (2018) as a solid impetus for innovation and a catalyst for a comprehensive reform of traditional building techniques. Han and Wang (2018) suggested that at the land transaction or planning stage for new buildings, mandatory requirements for MiC could be considered to scale up its practices, which is closely linked to land supply policies and national urbanization plan (Jiang et al., 2018; W. Jin et al., 2020). Jiang et al. (2018) added that the hidden value of MiC would eventually be reflected and recognized by the public and industry if publicity, social awareness and public opinions are controlled and strengthened. As Lu and Yuan (2012) pointed out, Government policy has been playing an important role in promoting current construction waste management, with MiC being a significant measure that will ultimately impact the environment and contribute to environmental protection. Lu et al. (Lu et al., 2018) noted that the demand and supply of prefabricated modules and related materials influenced the adoption of MiC, as they were necessary to keep production and on-site installation running smoothly. Pan et al. (2012) provided further evidence that the decision to adopt traditional or MiC technology solutions is primarily based on material, labor and transportation cost considerations. Thus, policies related to labor and the import of materials should be concerned. Many scholars have proved that the popularity of MiC cannot be achieved without technological support and advancement (Jiang et al., 2018; X. Jin et al., 2021). In 2002, the proportion of prefabricated components in the concrete consumption of public housing projects reached 17% (Chiang et al., 2006). This proportion has been continuously increased in the past 20 years due to the higher adoption of MiC (Jiang et al., 2018) with the continuous expansion of the scope and type of module design.

Further, Zhou and Ren (2020) indicated that the lack of authoritatively designed standards, codes and guidelines for MiC is a major hindrance to MiC practices. Accordingly, 26 PDFs were identified from the systematic literature search. Considering the real-life practice and experts' interviews, the authors added additional seven PDFs (Table 1), which will be further discussed in subsequent sections.

Research Methods

Identification of critical PDFs in MiC projects in HK

First, this study conducted a comprehensive systematic literature search to identify the PDFs associated with the MiC projects given that the merits of exploring the published articles (Kamali & Hewage, 2016; Z. Wang et al., 2019) on the concerned research domain The authors selected the Web of Science (WoS) core collection and Scopus as the databases to search for articles that were applicable in this study. Considering that this study focuses on the field of MiC policy research, combinations of keywords were set as 'construction industrialization', 'industrialized building/housing', 'modular construction/building', 'prefabrication', 'prefabricated construction/building', 'precast concrete', 'off-site construction' and 'policy*' (where * means policy or policies in searching) as the basic searching criterion. Documents consisting of these phrases in their title or abstract, or keywords were examined. The purpose was to acquire just the original and review papers on MiC, making the results more accurate and convincing. The rest, such as proceedings papers, were excluded because they contribute very little to the outcomes and yet would not be beneficial to the analytical practice (Butler & Visser, 2006). Therefore, the search results were further purified by refining the document types as article or review. The authors of this study eventually filtered and retrieved MiC-related papers for further review to identify PDFs, and the final list and corresponding literature are shown in Table 1.

Thereafter, considering the positivist research philosophy, a deductive research approach was mainly used. Accordingly, the list of PDFs that affect the success of MiC projects in HK identified through the comprehensive literature review was tested by conducting a pilot study. The PDFs were tested for applicability, comprehensiveness, and significance to MiC in HK during the pilot study. Five experts who had the experience of more than 20 years in academia and industry were involved in the pilot study. After careful consideration of all the PDFs, the experts recommended adding seven more PDFs to the current MiC context in HK. Therefore, a total of 33 PDFs were found to affect the development of MiC in HK. Table 1 presents the finalized list of PDFs based on the literature review and the pilot study.

Table 1. A list of PDFs that improve MiC uptake in HK

Because the impact of each PDF is not the same in different phases of MiC projects, the PDFs were appropriately distributed among three different stages of MiC projects, namely, initiation, planning and design, and the construction phase. By thoroughly analysing the influence and role of PDFs in the different stages, 33 identified PDFs were categorized into these three stages. Some PDFs occurred in different stages, while other PDFs appeared only in a specific stage. In stages I, II, and III, there were a total of 12, 12, and 23 identified PDFs, respectively. Stage I (Initiation Phase) includes the identification of potential prefabricated projects, financial analysis, the preparation of feasibility study reports and decision-making. Stage II (Planning and Design Phase) includes acquiring land-use rights, project design and planning approval. Stage III (Construction Phase) includes the tendering of project contractors, prefabricated module design/manufacturing/transportation/on-site installation, other construction work, acceptance of the completed construction quality and project handover. Further, stage III comprises the phases of MiC supply chains: manufacturing, logistics and on-site assembly, which is the main difference between MiC and traditional cast-in-place buildings. Remarkably, this study focuses on the MiC in HK. Due to the specific geographic location of HK (within the Greater Bay Area), coupled with high labor costs and limited land availability related to sustainable development issues, almost all manufacturing plants are located in various regions of Guangdong Province, such as Huizhou and Dongguan. Hence, prefabricated modules and components are manufactured in Mainland China, then transported to HK through customs, and finally installed on site.

Data Collection

A questionnaire survey was conducted as the main data collection method in this empirical research since a well-designed questionnaire obtained through appropriate measures can provide researchers with excellent research opportunities (Labaw, 1980). A questionnaire was therefore developed by including the 33 confirmed PDF factors in the pilot study. The questionnaire included two parts. The first part contained the background information of the respondents, such as their current professional affiliation, work organization, years of experience and educational background. The second part was developed based on the preliminarily identified PDFs. To gather professionals' opinions on PDFs, the five-point *Likert scale* was used in the questionnaire due to its simplicity, versatility and reliability (Dörnyei & Taguchi, 2010). Therefore, the experts were required to evaluate the degree of impact of each MiC-related PDF during the three phases mentioned above on a five-point Likert scale.

Considering the unstable situation of COVID-19 in HK, data collection was mainly completed in a web-based form (Internet/email). Nonprobability sampling was employed, given that it is impossible to select construction practitioners with the same probability from samples (Robson & McCartan, 2016). In this study, stratified sampling was necessary to ensure various samples from diverse subpopulations of construction organizations, such as government departments, clients, contractor companies, manufacturers, transporters, design and consultant companies, subcontractor companies, and professional organizations. All participants were practitioners who worked in or had vast knowledge and experience with MiC projects in HK. A total of 212 questionnaires were sent via email with online links, and 89 were collected, 85 of which were deemed valid for further analysis. The valid return rate was 40%, which is considered appropriate and adequate (Nulty, 2008) to develop significant conclusions in a subject area of this nature.

Data Analysis

The Statistical Package for Social Sciences (SPSS), IBM-SPSS Version 26.0, was used to analyse the questionnaire data collected for the PDFs. Descriptive means with normalization, reliability analysis, a normality test, and factor analysis were utilized in data analysis. Data normalization analysis was conducted prior to SPSS analysis to determine the critical PDFs, following Adabre and Chan (2019). Accordingly, the mean scores of the impact degree of all the PDF factors in the three stages were calculated. Further, factor criticality was ascertained according to the normalization values. The factors with a normalized value ≥ 0.50 were considered as critical factors and screened out for further analysis (Adabre & Chan, 2019). Internal consistency reliability test is mandatory to justify the data analysis results (Adabre & Chan, 2019; Darko, 2018), especially when using Likert-type scales (Gliem & Gliem, 2003). Cronbach's alpha is the most straightforward logistical strategy for estimating reliability (Brown, 1997) and the effective limit for Cronbach's alpha values is between 0.70 and 0.90 (Tavakol & Dennick, 2011). On the other hand, the Shapiro-Wilk test is one of the most powerful and commonly used normality tests to assess the data normality (Owusu & Chan, 2019; Razali & Wah, 2011). Hence, this study proceeded with the Cronbach's Alpha test and the Shapiro-Wilk test prior to the factor analysis to test the data reliability and the normality.

Factor analysis helps to find interrelationships among a large number of variables and categorize them into a smaller set of more significant and underlying variable constructs using factor points of responses (Pallant & Manual, 2010). Given that exploratory factor analysis is a powerful and popular method for identifying the response patterns of respondents in questionnaire surveys and revealing the underlying factor structure of a set of variables (De-Vaus, 2001; McNeish, 2017), this study proceeded with exploratory factor analysis. Prior to beginning the factor analysis, the Kaiser-Meyer-Olkin test (KMO) and Bartlett's test of sphericity were conducted. KMO is a measure of sampling adequacy (Dziuban & Shirkey, 1974), and Bartlett's test of sphericity is a measure of variance homogeneity (Tobias & Carlson, 1969). KMO ranges between 0-1, where 0 indicates an inappropriate data set and 1 indicates a perfectly appropriate data set for factor analysis (Dziuban & Shirkey, 1974). The eigenvalue was set as the criterion for variable selection during the factor analysis, where variables with eigenvalues greater than one were extracted (Owusu and Chan 2019). Besides, factor loadings greater than 0.50 are considered important and extracted to be used in component interpretation (Chan, Darko, Olanipekun, & Ameyaw, 2018). After factor extraction, the factor components were named. The naming was performed using the common theme on which the variables were based (Owusu & Chan, 2019; B. Zhang, Le, Xia, & Skitmore, 2017).

Results

Following the data analysis methods presented in the previous section, based on the normalization values ($N \geq 0.50$), in Stage I, 7 out of 12 PDFs were identified as critical PDFs; in Stage II, 6 out of 12 PDFs were identified as critical PDFs; and in Stage III, 10 out of 23 PDFs were identified as critical PDFs that significantly influence the success of MiC projects in HK. Comprehensive statistical mean (*M*) and normalization (*N*) values for these PDF factors in different stages were computed and presented in Table 2.

Table 2. Cluster matrix after varimax rotation & final statistics of PCA

In this study, Cronbach's alpha coefficient value for all the PDFs in the three stages was 0.937, and the Cronbach's alpha coefficients of stages I, II, and III were 0.840, 0.887 and 0.940, respectively. All Cronbach's alpha coefficients were between 0.70 and 0.95, indicating that the five-point scale measurement adopted had high reliability or consistency. Table 2 presents the results of Cronbach's alpha data obtained from SPSS V 26.0. Table 2 also shows the statistical results of the Shapiro-Wilk test, which suggest that the data in this research are nonnormally distributed since the test value is less than the stipulated p-value (0.05).

The values obtained for KMO in this study were 0.803, 0.778 and 0.798 in Stages I, II and III, respectively, which were greater than the required minimum of 0.50. Additionally, Bartlett's test of sphericity statistics for Stages I, II and III were 140.521, 120.985, and 413.195, respectively, with an associated significance level of 0.000. These results implied that the sample data were acceptable and suitable for factor analysis and that the correlation matrixes were not identity matrixes. With these results, this study proceeded with factor analysis as explicated in the previous section.

Thus, varimax rotation was conducted for the 7, 6, and 10 retained critical PDFs (eigenvalue>1) in Stages I, II, and III, which yielded two, two and three-factor groups (components), respectively In Stage I, the two extracted components accounted for 58.925% of the total variance. In Stage II, the two extracted clusters explained 64.675% of the total variance. In Stage III, the three underlying components explained 71.265% of the total variance (as displayed in Table 2). The factor loadings of all variables in Table 2 were above 0.50; hence all the factors were considered appropriate for this study. In total, seven PDF factor components in three stages were identified during the analysis and are discussed in the next section. Based on the examination of the internal relationships among the main PDFs in the three stages of MiC, two, two and three components were extracted in Stages I, II and III, respectively. Table 2 shows the details. Fig. 1 presents an overall profile of the critical PDFs with the level of criticality to MiC projects in HK derived from relevant significance analysis. As derived from the analysis, the PDF components include Promotional and Sustainable PDFs, Regulative PDFs, Sustainable PDFs, Greater Bay Area Development PDFs, Technical and Regulative PDFs, and Promotional PDFs.

Discussion

According to Fig. 1, PDFs at different stages have their own characteristics, but commonalities are also there. The component 'Regulative PDFs' is involved in all three stages, indicating the magnitude of this construct to the MiC in HK. 'Promotional PDFs' is included in Stages I and III but is not mentioned in Stage II. 'Sustainable PDFs' is identified as an essential component in Stages I and II, but little attention is given to it in Stage III. Due to geographical and political superiority, it is believed that the 'Greater Bay Area Development PDFs' and 'Technical PDFs' have a significant impact on MiC in Stage III rather than Stage I or II, as further explicated as follows.

Figure 1. Mean score and longitudinal distribution pattern of PDFs across various stages of MiC

Stage I: Initiation Phase

Component I-1: Promotional & Sustainable PDFs (PSPDFs)

Component I-1 comprises five critical PDFs, three of which are closely related to the impacts of changes in economic incentives and one of which involves MiC publicity, which are all promotional policies, while the other is relevant to sustainable policy. Hence, this component is named promotional and sustainable PDFs (PSPDFs). In stage I, this component accounts for the highest percentage of variance, 43.667%, with the highest variable content. However, the mean score value of this component is lower than that of component I-2. According to the respondents' arguments, although these PDFs may affect the performance of MiC projects in HK to a large extent, these PDFs have a lower occurrence frequency, so they are often ignored in practice. Currently, the effect is not very high but is substantial. The lack of preferential policy was considered a main obstacle and challenge for the widespread adoption of MiC (Xiaodan Li et al., 2017). In early 2002, the HK government began to offer some preferential interest to promote MiC adoption. For example, under the provisions of the Building Ordinance, green/innovative features such as MiC may be exempt from the calculations of GFA and/or Site Coverage (SC) when applied and subject to conditions (Joint Practice Note No. 2, Second Package of Incentives to Promote Green and Innovative Buildings, 2002).

The adjustment of taxation and revenue in MiC also impacts its adoption, which constitutes the second-highest factor loading but the lowest mean score. This may be because this adjustment is not frequent; for example, the GFA/SC exemption has not been further adjusted since its implementation in 2002, but its influence cannot be denied. Investment in the MiC project is another significant variable (L. Li et al., 2018) within the PSPDF component, with the highest mean score. This is not surprising since the government's direct investment in the MiC project is undoubtedly the most immediate boost to its development, especially in Stage I, and the change in investment strategy has a great impact on it.

Liu et al. (2017) noted that the government should bolster the publicity and guidance of the MiC industry as society lacks timely awareness of the latest technical knowledge. In HK, there are many avenues for publicity, such as publicity brochures accompanying iconic successful projects (e.g., MiC Display Centre in CIC - Zero Carbon Park), public propaganda activities within the construction industry, the promotion of MiC on social networking platforms (e.g., Facebook, Instagram, Twitter), visits to the MiC factories and sites, and establishing relevant MiC courses in universities.

In addition to the four promotional risks mentioned above, another risk factor related to sustainability was taken into account in Stage I. The HKHA has actively promoted environmental protection through MiC systems (Wong et al., 2015). Moreover, minimizing environmental effects and excellent sustainable performance are highlights of its MiC programmes (Chen et al., 2017; Jin et al., 2018). Therefore, the more the government pays attention to the environmentally friendly development of the construction industry, which is reflected in the adjustment of environmental protection policies, the more inclined the entire construction industry will be to adopt MiC technology. The most influential phases of environmental policy impact are the project feasibility study and project evaluation in Stage I.

Component I-2: Regulative PDFs (RPDFs)

Regulative PDFs (RPDFs) refer to the driving forces associated with mandatory government policies and regulations that have an impact on MiC in the initiation phase. Component I-2 includes two critical PDFs with a total variance of 15.258%. RPDFs have a higher mean score than PSPDFs, which indicates that these PDFs are influential and occur frequently. This is reasonable because, during the COVID-19 pandemic, some mandatory policies changed frequently, especially in HK. The highest factor loading in RPDFs is the variable related to COVID-19 pandemic policies, which shows high factor significance. According to the World Health Organization (WHO), COVID-19 patients must be quarantined appropriately or isolated for treatment, which requires a comfortable and safe space to facilitate their rapid recovery (WHO, 2021). However, due to the severity of the epidemic, many hospitals and clinics were inadequate; therefore, there was a need for new buildings that could quickly provide isolation in the short term. Compared with the traditional method of house construction, the advantages of MiC technology include rapid construction in a short time and excellent flexibility (Abdelmageed & Zayed, 2020), which is in line with the requirements of the current epidemic. Gbadamosi et al. (Gbadamosi et al., 2020) also proposed off-site and modular solutions for the construction industry and the built environment to respond to emergencies. This is why respondents assigned a considerable mean value of 3.882 within the component RPDFs to the variable 'change of government policy related to the COVID-19 pandemic', especially during this period. However, this should be considered a conditional driving force given its negative influence on the construction industry and the global economy.

Another significant variable is the adjustment related to the macro housing policy. HK has a unique housing market. Housing policy in HK is currently formulated, coordinated and monitored by the Secretary for Transport and Housing (Transport and Housing Bureasu, 2016). The Housing Department supports the Transport and Housing Bureau in handling all housing-related policies and issues. Modular housing, as a modern and innovative housing type, is strongly recommended for use in HK, especially in public housing (Modular Social Housing, 2021). The public/private split of the new housing supply for the ten years from 2019-20 to 2028-29 has been revised from 60:40 to 70:30 (Legislative Council Panel on Housing, 2019). Moreover, MiC has been widely adopted in public housing to speed up the construction cycle to meet the housing policy requirements mentioned above. In general, the adjustment of macro housing policy has a considerable impact on MiC in Stage I, particularly in public housing (Q. Chen et al., 2017; Chiang et al., 2006).

Stage II: Planning & Design Phase

Component II-1: Sustainable PDFs (SPDFs)

Component II-1 exhibits 46.750% of the variance in Stage II, including three underlying factors, all of which reflect a socioecological process characterized by the pursuit of a sustainable idea and are named sustainable PDFs (SPDFs). This component possesses higher variable content but with a lower mean score value than the other component in Stage II. Similar to the PSPDFs in Stage I, this may be because these PDFs occur less frequently and are sometimes ignored in practice. The 'environmental protection'-related PDF factor holds the highest mean score among SPDFs, signifying the importance of this variable for MiC projects. The environmental impact mainly includes three aspects: resource depletion, energy consumption and construction waste discharge (Cao et al., 2015). MiC can utilize resources more effectively (Han & Wang, 2018) by reducing resource depletion by 35.82% (Cao et al., 2015). The extensive usage of prefabricated components in MiC enables the possibility to decrease energy consumption (J. Li et al., 2018). MiC can help to save 4%-14% of the total life-cycle energy consumption in addition to reusability. A considerable amount of effort has been made to reduce construction waste discharge, and MiC has outstanding performance in this regard (Lu et al., 2018). The charging scheme policy that promoted waste minimization actions in the building industry in HK (W. Zhang et al., 2018) entered operation on 1 December 2005. MiC buildings tend to produce less construction waste (Q. Chen et al., 2017; Ghisellini et al., 2018), and adopting this technology allows construction contractors to pay lower waste disposal charges to the government.

Change involving the micro-housing policy is another notable variable within the SPDF component, mainly reflected in housing type planning and residential/building density guidelines. The housing policy mentioned here aims to ensure an appropriate balance between the resident population living in a certain area and the capacity of existing or planned facilities and infrastructure required to serve the area (Planning Department, 2018), which is a manifestation of sustainability. Since the mid-1980s, the HKHA has recommended using prefabricated modules and reusable formwork in all public housing contracts, while the private sector still relies heavily on the traditional cast-in-situ construction method (L. Jaillon & Poon, 2009). Therefore, in different areas in HK, planning restrictions on housing types affect the application space of MiC to a certain extent. Constraints on residential/building density is also a factor related to this phenomenon. The plot ratio is a way to guide the density of development in public and private residential areas in HK, and its controls govern the amount of GFA in buildings (Hui, 2001). These indicators affect the planning and design phase of MiC, particularly the size of prefabricated modules.

Component II-2: Regulative PDFs (RPDFs)

Regulative PDFs (RPDFs) include three critical PDFs that require contractors and designers of MiC to comply with compulsory regulations, with a total variance percentage of 17.925. This is the component with a high mean score of 3.672, signifying the importance of the construct to the development of MiC in HK. Experts highlighted the factor 'proportion of prefabrication in public housing projects' as a common PDF in MiC. Prefabricated modules, such as precast façades, precast staircases, and volumetric precast bathrooms (Housing Authority, 2019), are widely used in the construction of public housing blocks for better workmanship and quality control and to maximize construction efficiency (L. Jaillon & Poon, 2009). In 2002, the use of prefabricated facades became mandatory in all Harmony Block and Concord Block building contracts (D. W. M. Chan & Chan, 2002). Moreover, the HKHA announced that further MiC applications would increase the use of prefabricated concrete components from 70% to approximately 90%, according to the plan (HK Housing Authority, 2019). The improvement of this proportion expands the development of MiC housing in HK.

The COVID-19 epidemic situation in HK is unstable, and related mandatory policies have affected all areas of life, including the construction industry. Especially in the planning and design phase of MiC, designers and contractors need to focus on the impact of the COVID-19 epidemic on the entire modular supply chain and strive to mitigate losses as much as possible through certain measures. First, construction organizations need to address employee safety and welfare issues to prevent widespread fear and economic uncertainty (Raoufi & Fayek, 2021). Under the city lockdowns, construction corporations are required to evaluate the possibility of delaying or suspending material provision from suppliers and ensure the availability of labour, equipment and materials (Raoufi & Fayek, 2021). Interregional policy coordination is essential to reduce the economic losses caused by lockdowns (Inoue et al., 2020). During this global pandemic, the construction industry should accelerate the implementation of modular manufacturing platforms, where components can be shared across production lines and manufacturing sites.

Another factor in RPDFs is related to the procurement system. Designer-led procurement practices, which have dominated the local construction industry in HK for more than 100 years, are still widely regarded as the most popular and commonly used procurement system in the world (Major Features, Advantages and Disadvantages of Generic Procurement Categories, 2004). According to the different bases of payment adopted, there are four subcategories under the designer-led arrangement: lump-sum contract, remeasurement contract, term contract, and prime cost contract (Major Features, Advantages and Disadvantages of Generic Procurement Categories, 2004). Governments around the world are searching for innovative procurement systems, such as public-private partnership (PPP), private finance initiatives (PFI), and their variations, to help effectively materialize construction projects (Lu et al., 2013). Different procurement systems affect the planning and design phase of MiC to improve project performance (Starr et al., 2016).

Stage III: Construction Phase

Component III-1: Greater Bay Area Development PDFs (GBADPDFs)

Greater Bay Area Development PDFs (GBADPDFs) are specific to Hong Kong MiC projects due to geographical and political advancement, which has the greatest impact on the transportation process throughout the MiC supply chain and has a considerable effect on modules manufacturing and on-site installation. GBADPDFs accounted for the highest variance percentage (44.645%) in Stage III with the highest variable content. Additionally, this component had the highest mean score value (3.804) among all the stages, indicating the significance of the construct to MiC development in HK. The Greater Bay Area brings two major opportunities for HK: (1) to identify new growth areas for the HK economy and promote the diversified development of its economic industries, and (2) to expand the development and living space of HK residents (News. Gov. HK, 2018). The '14th Five-Year Plan' also states that the construction of the Greater Bay Area will bring unlimited opportunities for HK (News. Gov. HK, 2021), among which the MiC has received great attention. The adjustment of customs clearance between the Mainland and HK has an important impact on the transportation process of MiC modules in the construction phase because most of the manufacturing of prefabricated modules for MiC buildings is located in the Greater Bay Area (X. Jin et al., 2021). In terms of facilitating personnel exchange, the flexible deployment of e-Channels and the adoption of 'smart departures' for identity verification using face recognition technology provide visitors with greater travel convenience. Regarding enhancing the flow of goods, through the use of electronic locks and a global positioning system (GPS), the need for repeated inspections of the same consignment by the two customs authorities during imports or exports has been minimized, thus facilitating the flow of goods such as prefabricated modules (Fang et al., 2020). Since May 2019, the number of clearance points under the 'Single E-Lock Scheme' in Guangdong Province has increased to 52. Another measure is the Mutual Recognition Arrangement for Authorized Economic Operators (AEOs). Goods consigned by enterprises accredited as AEOs by the C&ED and/or Mainland Customs enjoy customs clearance facilitation, such as reduced and prioritized customs clearance, from both authorities (Zhan & Feng, 2019). However, the COVID-19 epidemic has affected these two aspects. For example, the closure of the main customs clearance points affects the communication and negotiation of personnel in the supply chain (McKinsey Global Institute, 2020) and the timely delivery of prefabricated modules.

The transportation and logistics involved in cross-border supply chains are quite complex, leading to risks that significantly affect the performance of MiC (Xiao Li, Wu, et al., 2021). To a certain extent, the improvement of this PDF will also promote the smooth progress of the modules' on-site installation. This may be why the respondents gave the highest comprehensive mean score (3.929) to this variable factor in the lifecycle, as shown by Hsu et al. (2019) and Li et al. (2018). The Greater Bay Area has implemented many practical measures to speed up cross-border infrastructure connections. The Guangzhou-Shenzhen-HK Express Rail Link (XRL) HK Section connects with the national high-speed rail network. It greatly shortens the travelling time between HK and Shenzhen, Guangzhou, and other cities in China (Greater Bay Area, 2021).

Additionally, to emphasize the importance of logistics and supply chain management, Liu et al. (2016) developed a dedicated simulation template based on the Simphony platform to simplify the modelling of module manufacturing, transportation, and assembly processes, which is of great significance for the cross-border transportation of prefabricated modules in HK. The establishment of a globally competitive modern industrial system and jointly cooperation platforms is a further step in taking forward the practice of MiC in HK. JIN et al. (2021) revealed that the flow of data and real-time information on prefabricated modules is of great value to stakeholders in improving the entire MiC supply chain performance. MiC practitioners in the Greater Bay Area should explore collaborative legislation under the central authority, connect the administrative network of the Great Bay Area, promote the soft rule of law of data platform establishment, and constantly improve the mediation system to deal with administrative disputes arising from the data platform (Zhengmin Xu & Feng, 2019).

Component III-2: Technical and Regulative PDFs (TRPDFs)

Technical and Regulative PDFs (TRPDFs) refer to the application of technological innovation on MiC and mandatory government policies that impact MiC in the construction phase, especially in the modules manufacturing and on-site installation stage. Component III-2 includes four factors with a total variance of 16.478% but the lowest mean score value (3.740) among the three components in Stage III. This may be because the probability of these factors changing is relatively small, but the effect is still considerable. Rot et al. (2003) indicated that technologies with a higher degree of offsite work, in ascending order from component and subassembly, nonvolumetric preassembly, and volumetric preassembly to the modular building (A. Gibb & Pendlebury, 2005), will be more likely to challenge traditional housing construction practices. Moreover, Pan et al. (Pan, Gibb, et al., 2012) examined the uptake of MiC technologies and proposed strategies to best integrate their use into business processes at the organizational level, highlighting real-time information sharing to support the adoption of offsite technology. This facilitates effective communication between the manufacturer and the contractor, promoting smooth manufacturing modules and on-site assembly as scheduled. Therefore, government adjustment to policies related to this technological development (e.g., expanding their scopes of application) will promote MiC development.

Numerous studies have shown that inappropriate or even absent design codes and standards for prefabricated components in MiC buildings is a critical political factor related to the inefficient adoption and poor performance of MiC (Yanhu Han & Wang, 2018; Lu et al., 2018). Especially, this barrier can have an impact on the manufacturing of the modules. The Buildings Department in HK issued two versions of the Code of Practice for Precast Concrete Construction in 2003 and 2016. The 'Precast Concrete Construction Handbook' was also prepared by the Hong Kong Institution of Engineers (Precast Concrete Construction Handbook- An Explanatory Handbook to Code of Practice for Precast Concrete Construction

2003, 2015) to support MiC guidelines. These actions provide substantial proof that the government has promoted the orderly and smooth progress of MiC. As Lu et al. (Lu et al., 2018) noted, political factors, including policy, standards, codes and guidelines relevant to the MiC, have been regarded as the major factors that directly improve the incentive for MiC adoption. Additionally, expanding the types and scope of precast concrete structural elements is particularly suitable for MiC buildings in HK because precast technology can achieve better quality control (Dinelli et al., 1996). As with the various components already listed above, for promoting the further development and application of MiC, the HK government is devoted to ensuring the durability of whole housing stock through extensive use of prefabricated components and precast elements (L. Jaillon & Poon, 2009), which is reflected by the percentage of precast volume and the different kinds of precast assembly units.

The factor related to the COVID-19 pandemic in this TRPDF component had the highest mean score value of 3.806, evincing its importance to MiC in Stage III. As the COVID-19 epidemic situation in HK remains volatile, the HK government has extended or relaxed social distancing measures in a gradual and orderly manner multiple times under the Prevention and Control of Disease Ordinance (Government Announces Latest Social Distancing Measures, 2021). Other adjustments during this special period include the government's tightening of compulsory quarantine requirements for persons arriving in HK who have stayed in high-risk regions, strengthened restrictions and testing requirements for persons arriving in HK from foreign places, and regulations for cross-boundary conveyances and travellers (Cap. 599C HK Government, 2020). These social distancing measures and mandatory immigration isolation regulations can interfere with regular face-to-face meetings, especially during the whole MiC supply chain, where there are many flows that need to be coordinated, communicated and discussed, especially in regard to cross-border transportation modules. Therefore, it is necessary to encourage the use of new communication modes such as video conferencing within organizations. At the same time, contractors need to improve staff morale and provide support to maintain the physical and mental health of on-site construction workers to ensure the smooth progress of projects (Raoufi & Fayek, 2021).

Component III-3: Promotional PDFs (PPDFs)

Promotional PDFs (PPDFs), as the third component in Stage III, include three critical policy factors, with a mean score of 3.770 and a 10.142% variance percentage. It mainly affects the capital flow of the MiC projects and their final delivery. As the largest contributing factor of this component, financial policy changes occupy the highest factor loading, which also has the greatest mean value within this construct. Financing MiC is challenging because banks are not familiar with the characteristics of this modern industry, which focuses on risk and return (Salama et al., 2018). Common beneficial financial policies related to MiC generally include notifying banks (lenders) of accredited MiC enterprises (borrowers), loosening the covenants/conditions of loans for borrowers, offering special subsidies to approved MiC projects and enterprises, and rewarding MiC enterprises (Jiang et al., 2018). To encourage MiC adoption, financial support such as tax deductions could be offered if a project has met several requirements when applying MiC (Lu et al., 2018).

Another economic PDF is related to the sale of MiC buildings. People in HK often purchase flats before the buildings in which the flats are constructed. The Consent Scheme and the Non-Consent Scheme exist to protect purchasers in case the developer becomes bankrupt before the property is constructed (Community Legal Information Centre, 2020). In August 2010, the HK government put a ban on confirmer transactions on uncompleted properties. On the other hand, developers are looking to reduce construction costs and shorten construction deadlines to achieve successful flat transactions. This preference of developers is driving the growth of prefabricated and modular buildings.

Han and Wang (2018), proper construction quality acceptance criteria could be a possible driving force for MiC adoption. Quality control and safety represent increasingly important concerns for the government and are important for everyone in the construction business. The 'Code of Quality Management' issued by CIOB (2019) aims to provide a single point of information for construction quality management. It should help project stakeholders improve the quality of construction by establishing best practices in quality management and quality planning processes. To a certain extent, the government's improvement of housing acceptance quality standards will also encourage more owners to adopt MiC, as MiC provides a greater degree of production quality control to achieve high-quality construction.

Conclusions, limitations and ways forward

MiC has recently received heightened interest from its stakeholders, especially in the HK construction industry. Furthermore, MiC highlights its inherent technological advancements and potential to address the current 'new normal' during COVID-19 to reduce on-site operations further while enabling a controlled on-site assembly process. In this regard, the policy implications of the driving forces of MiC play a vital role in up-taking MiC adoption in HK. This issue has not been explored to date. In response, an expert opinion survey was conducted, leading to 85 questionnaire responses from industry experts in MiC projects in HK. The results enabled the ranking of critical PDFs for the success of MiC projects in HK based on their importance. In Stage I, II, and III of the MiC processes, a total of 7, 6, and 10 PDFs, respectively, were identified during the data analysis through data normalization and factor analysis. Further, seven components in three stages that consist of the critical PDFs were proposed through factor analysis. Stage I includes two components, namely, Promotional and Sustainable PDFs and Regulative PDFs. In Stage II, Sustainable PDFs and Regulative PDFs are included. In Stage III, there are three components, namely, Greater Bay Area Development

PDFs, Technical and Regulative PDFs, and Promotional PDFs. These findings provide evidence-based pointers to policymakers to better initiate promotional policies to adopt MiC practice in HK as policy support becomes mandatory. Also, industry practitioners will be well informed on policy design and implementation in the construction industry, specifically in the emerging MiC sector. The PDFs can be considered according to their associated groupings to address them in policy design since the grouped components share similar phenomena. Indeed, the PDFs could be supported considering their appropriate levels of criticality to generate substantial benefits.

Furthermore, this research provides valuable implications for the government to anticipate the impact of different revisions and changes in policy on driving MiC uptake. With such supportive policy design, revision and implementation, MiC practices would be uptaken, HK construction performance would be enhanced, and the HK economy would be boosted through this key economic driver. Moreover, other developed countries such as Singapore, which have similar economic systems, advanced MiC technology and development trajectories with Hong Kong, can take this study as a reference to explore PDFs based on their own characteristics to promote MiC better. For developing countries, the construction of MiC buildings was initiated comparatively late. Along with the many concepts, research and application of technologies, specifications, and quality assessment systems for MiC, these countries' MiC practices could be further improved. They can also refer to the PDFs mentioned in this study to see how to drive MiC from the policy perspective and improve related policies to promote the rapid process of local MiC.

However, it is necessary to note some limitations of the study. Although the sample size (85) used in this study was not unduly small, an improved response rate could facilitate better generalization of the results. Also, the PDFs studied in this study may not be the only PDFs that exist. Hence, the developed model should also be tested and verified using actual case studies to avoid unobserved biases. Since the policy implications are jurisdiction-specific, their levels of criticality would necessarily differ, but some interesting core commonalities may emerge. Hence, country-specific case studies would provide more applicable and robust results. Further, the PDFs could be explored from the perspectives of different project stakeholders, which would facilitate stakeholder-focused research implications to the industrial practice. In addition, post-COVID19 industrial regulations and policy interventions under the 'new normal' should be explored in future research to offer timely recommendations. Despite these limitations, the current research contributes substantially to the HK construction industry and relevant theory by clearly identifying critical PDFs and their levels of criticality. Expanding the horizons of this base study, the dynamics of PDFs could be explored to generate more robust outcomes. Finally, these findings would be beneficial to boost productivity in the construction industry and overcome the industry's performance shortfalls while enhancing sustainability through MiC uptake.

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Tables

Table 1. A list of PDFs that improve MiC uptake in HK

No.	Policy Driving Forces	Stage	Source
1	Change of the Government policy related to COVID-19 pandemic	I/II/III	Interview
2	Change of the Government policy related to economic factors	I	(Han & Wang, 2018; Luo et al., 2015)
3	Change of the Government policy related to finance	I/II/III	(Jiang et al., 2018)
4	Change of the Government policy related to taxation and revenue	I/II	(Liu et al., 2016)
5	Change of the Government policy related to the preferential interest of the MiC project	I/II	(Chen et al., 2017; Lu et al., 2018)
6	Change of the Government policy related to investment of the MiC project	I	(Chiang et al., 2006; Jiang et al., 2018)
7	Change of the Government policy related to the restriction of the property market	I	(Jiang et al., 2018; Mao et al., 2015)
8	Adjustment of the Government policy related to housing policy	I/II	(Huang et al., 2018; Mare, 2018)
9	Change of the Government policy related to land supply and usage	I/II	(Jiang et al., 2018; Jin et al., 2020)
10	Change of the Government policy related to the urban plan, e.g. site coverage, height restriction or green ratio	I/II	(Jiang et al., 2018; Jin et al., 2020)
11	Change of the Government policy related to the publicity of MiC	I	(Jiang et al., 2018; Zhang et al., 2017)
12	Change of the Government policy related to environmental protection	I/II/III	(Lehmann, 2011; Lu & Yuan, 2012)
13	Change of the Government policy related to MiC project tendering	III	Interview
14	Change of the Government policy related to construction waste disposal charging scheme	II/III	(Ghisellini et al., 2018; Lu & Yuan, 2012)
15	Change of the Government policy related to the customs clearance facilitation in Greater Bay Area, such as facilitating personnel exchange and enhancing flow of goods	III	Interview
16	Change of the Government policy related to the transportation and logistics in Greater Bay Area, such as expediting cross-boundary infrastructural connectivity	III	Interview
17	Change of the Government policy related to building a globally competitive modern industrial system and jointly	III	Interview

	cooperation platforms in Greater Bay Area, such as flow of data and information		
18	Change of the Government policy related to the Mainland and Hong Kong Closer Economic Partnership Arrangement (CEPA) and Professional Services in Greater Bay Area, such as extending the scope of mutual recognition of qualifications for construction professionals	III	Interview
19	Change of the Government policy related to the construction material supply and price	III	(Lu et al., 2018; Mao et al., 2013)
20	Change of the Government policy related to import of the construction material	III	(Oral et al., 2003; Pan et al., 2012)
21	Change of the Government policy related to labor policy	III	(Gao & Tian, 2020; Pan et al., 2012)
22	Change of the Government policy related to MiC technological support and innovation	III	(Han & Wang, 2018; Tykkä et al., 2009)
23	Change of the Government policy related to the sale of the MiC buildings	III	Interview
24	Change of the Government policy related to the proportion of prefabrication in public housing projects	II	(Chiang et al., 2006; Jiang et al., 2018)
25	Change of the Government policy related to scope/type of the prefabricated elements and components	III	(Chiang et al., 2006; Wuni & Shen, 2020)
26	Change of the Government policy related to the authoritatively designed standards, codes and guidelines for MiC	III	(Han & Wang, 2018; Lu et al., 2018; Mao et al., 2013)
27	Change of the Government policy related to site selection criteria for new precast manufacturing sites	II/III	(Azman et al., 2012)
28	Change of the Government policy related to the restriction of the construction schedule	III	(Lu et al., 2018)
29	Change of the Government policy related to the multi-sector governance of MiC	III	(Luo et al., 2015; Zhang et al., 2017)
30	Change of the Government policy related to project/qualification supervision	III	(Jiang et al., 2018; Luo et al., 2015)
31	Change of the Government policy related to the standard of the acceptance of the completed construction quality	III	(Zhang et al., 2017)
32	Change of the condition on MiC project contracts	III	(Park et al., 2011)
33	Change of the Government policy related to the procurement system	II/III	(Guerzoni & Raiteri, 2015)

Table 2. Cluster matrix after varimax rotation and statistics of PCA

Stage	Code	Policy Driving Forces	**Stage I:** Initiation Phase		**Stage II:** Planning & Design Phase		**Stage III:** Construction Phase			$\bar{x} = \sum xi/n$	SWT	N value
			Components									
			1	2	1	2	1	2	3			
Stage I: Initiation Phase	Component I-1									3.712		
	A5	Change of the Government policy related to the preferential interest of the MiC project	0.840	-	-	-	-	-	-	3.729	<0.001	0.70[a]
	A4	Change of the Government policy related to taxation and revenue	0.777	-	-	-	-	-	-	3.634	0.002	0.52[a]
	A6	Change of the Government policy related to investment of the MiC project	0.722	-	-	-	-	-	-	3.815	<0.001	0.87[a]
	A12	Change of the Government policy related to environmental protection	0.615	-	-	-	-	-	-	3.729	<0.001	0.71[a]
	A11	Change of the Government policy related to the publicity of MiC	0.536	-	-	-	-	-	-	3.653	<0.001	0.56[a]
	Component I-2									3.776		
	A1	Change of the Government policy related to COVID-19 pandemic	-	0.825	-	-	-	-	-	3.882	<0.001	1.00[a]

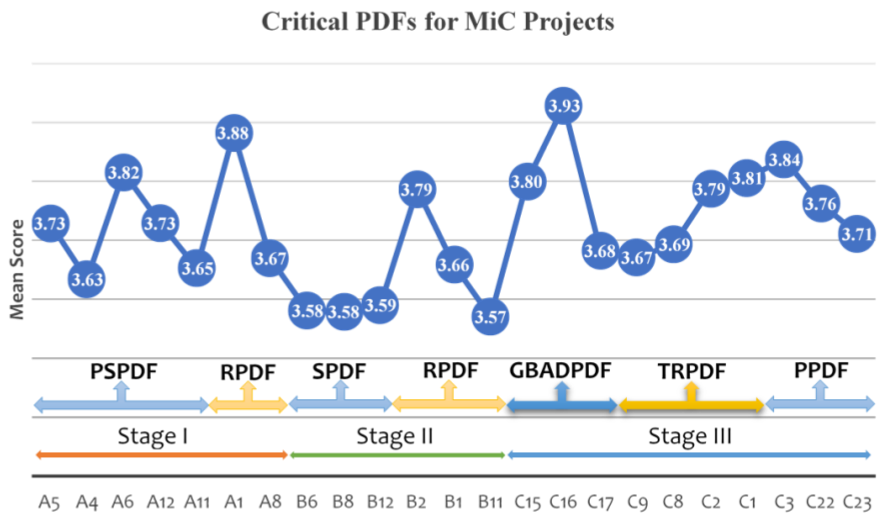
	A8	Adjustment of the Government policy related to housing policy	-	0.790	-	-	-	-	-	3.670	<0.001	0.59[a]
Stage II: Planning & Design Phase	Component II-1									3.583		
	B6	Change of the Government policy related to construction waste disposal charging scheme	-	-	0.866	-	-	-	-	3.581	0.004	0.51[a]
	B8	Change of the Government policy related to housing policy, the restriction on the type and the size of property development	-	-	0.734	-	-	-	-	3.579	0.001	0.50[a]
	B12	Change of the Government policy related to environmental protection	-	-	0.718	-	-	-	-	3.590	<0.001	0.53[a]
	Component II-2									3.672		
	B2	Change of the Government policy related to the proportion of prefabrication in public housing projects	-	-	-	0.881	-	-	-	3.786	<0.001	1.00[a]
	B1	Change of the Government policy related to COVID-19 pandemic	-	-	-	0.658	-	-	-	3.659	<0.001	0.74[a]
	B11	Change of the Government policy related to the procurement system	-	-	-	0.653	-	-	-	3.570	0.003	0.50[a]
	Component III-1									3.804		

Stage III: Construction Phase	C15	Change of the Government policy related to the customs clearance facilitation in Greater Bay Area, such as facilitating personnel exchange and enhancing flow of goods	-	-	-	-	0.900	-	-	3.800	<0.001	0.75[a]
	C16	Change of the Government policy related to the transportation and logistics in Greater Bay Area, such as expediting cross-boundary infrastructural connectivity	-	-	-	-	0.867	-	-	3.929	<0.001	1.00[a]
	C17	Change of the Government policy related to building a globally competitive modern industrial system and jointly cooperation platforms in Greater Bay Area, such as flow of data and information	-	-	-	-	0.839	-	-	3.682	<0.001	0.51[a]
	Component III-2									3.740		
	C9	Change of the Government policy related to the authoritatively designed standards, codes and guidelines for MiC	-	-	-	-	-	0.839	-	3.671	<0.001	0.50[a]
	C8	Change of the Government policy related	-	-	-	-	-	0.754	-	3.693	<0.001	0.53[a]

	to scope/type of the prefabricated elements and components										
C2	Change of the Government policy related to MiC technological support and innovation	-	-	-	-	-	0.683	-	3.788	<0.001	0.72[a]
C1	Change of the Government policy related to COVID-19 pandemic	-	-	-	-	-	0.674	-	3.806	<0.001	0.76[a]
Component III-3									3.770		
C3	Change of the Government policy related to finance	-	-	-	-	-	-	0.794	3.837	<0.001	0.82[a]
C22	Change of the Government policy related to the standard of the acceptance of the completed construction quality	-	-	-	-	-	-	0.655	3.762	<0.001	0.67[a]
C23	Change of the Government policy related to the sale of the MiC buildings	-	-	-	-	-	-	0.566	3.711	<0.001	0.57[a]
Eigenvalue		3.057	1.068	2.805	1.076	4.464	1.648	1.014			
Variance (%)		43.67	15.26	46.75	17.93	44.65	16.48	10.14			
Cumulative Variance (%)		43.67	58.93	46.75	64.68	44.65	61.12	71.27			
KMO Measure of Sampling Adequacy		0.803		0.778		0.798					
Bartlett's Test of Sphericity	Approximated Chi-Square	140.521		120.985		413.195					
	df	21		15		45					
	Significance level	0.000		0.000		0.000					

Note(s): Extraction Method: Principal Component Analysis; Rotation Method: Varimax with Kaiser Normalization; $\bar{x} = \sum xi/n$; where $\bar{x}$= mean, $\sum xi$= summation of sampled frequency; n= number of responses for a variable or the number of items in a specific component**;** **SWT**= Shapiro-Wilk test; **N Value**= Normalization Value = (Mean-Minimum Mean)/(Maximum Mean-Minimum Mean); **a** indicates the normalized value $\geqslant$0.50 and considered as a critical PDF.

Figures



	PPDF	SPDF	RPDF	GBADPDF	TPDF
Stage I: Initiation Phase	☑	☑	☑		
Stage II: Planning & Design Phase		☑	☑		
Stage III: Construction Phase	☑		☑	☑	☑

Figure 1. Mean score and longitudinal distribution pattern of PDFs across various stages of MiC