



## Article

# Analysis of Provincial Policies on the Development of Prefabricated Construction in China

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**Abstract:** Currently, China has launched an ambitious governmental initiative to promote the development of prefabricated construction (PC). As the target of PC development has been allocated to lower-level government, the responsibility for PC development rests at the provincial level. Therefore, provincial policies are extremely crucial for the development of PC. Despite this, few studies have been conducted to examine the role of provincial policies in promoting the development of PC. With the aim of filling this knowledge gap, a comprehensive analysis of provincial policies on the development of PC was conducted in this study. Firstly, 443 provincial policies for PC development issued by 31 regions were collected and divided into different types according to the policy instrument framework, including environment instruments, demand instruments and supply instruments. By using the approach of content analysis, the spatial and temporal distribution of provincial policies was explored, as well as the similarities and differences in different regions. The results indicate that China initially developed a policy system for PC development with the characteristics of multiple levels, multiple stakeholders and multiple instruments; meanwhile, provincial policy relies heavily on environmental instruments, and the use of supply and demand instruments is grossly inadequate. The existing problems of each policy instrument for PC development have been discussed, and corresponding countermeasures have been put forward. The research findings provide valuable information for policy adjustments in the future and shed light on the effective delivery of policies to promote the development of PC in developing countries.



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**Keywords:** prefabrication construction; policy instrument; provincial policies

## 1. Introduction

Over the past three decades, China has experienced a rapid process of urbanization, with the urbanization rate increasing from 17.9% in 1978 to 59.58% in 2018. [1]. Along with the booming demand for housing, China's construction sector, heavily reliant on on-site construction, is facing great challenges in the pursuit of sustainable urbanization [2]. On the one hand, based on the National New-type Urbanisation Plan (2014–2020), around 30 billion m<sup>2</sup> of building area will be newly constructed [3]. The labor shortage caused by intensive workloads, long working hours and poor living conditions exerts substantial pressure on the timely provision of building construction [4]. On the other hand, on-site construction has contributed to various environmental issues, ranging from high resource and energy consumption to high construction waste and heavy environmental burden [5,6]. This is at odds with the goal of sustainable urbanization put forward by China's government regarding the New-type Urbanization Plan [7]. In light of this, finding a new approach that satisfies the surging demands of housing timely and alleviates the environmental impacts of conventional on-site construction is urgent in China.

Prefabricated construction (PC) refers to the practice of producing construction components in a manufacturing factory, transporting complete components or semi-components to construction sites and finally assembling the components to create buildings [8]. Since

the construction process is improved by industrialization, mechanization and automation, the approach of PC holds the promise to replace conventional on-site construction given its inherent benefits ranging from productivity improvement, cost and time reduction, less construction waste, less emission and reduction in energy and water consumption to less labor demand and better safety [4,9,10]. Lessons from countries with a higher development level of PC show that the approach of PC can meet housing demand timely and is a vital method for alleviating adverse environmental burdens from on-site construction [5,11]. Meanwhile, it has been viewed as an effective tool to facilitate the shifting of the dependence of the construction industry on labor towards a “knowledge-based” industry [9].

Despite the approach of PC being introduced in China in the 1950s, the holistic level of PC development in China is currently low [12]. This is mainly due to the fact that the construction sector in China has been locked into the traditional method of on-site construction [13]. According to Geels et al. (2016), the development of PC requires significant structural changes within the construction sector and is characterized by radical shifting from one socio-technical configuration to another [14]. The locked-in effect of conventional on-site construction prevents the transition from on-site construction to prefabricated construction from occurring. As a result, the development of PC faces multiple barriers ranging from high cost, poor quality and aesthetic performance and insufficient suppliers and manufacturers to a lack of codes and standards, poor market demand and a lack of social cognition [8,9,15–17]. These multiple barriers suggest that the development of PC requires strategic policy efforts; otherwise, the regime stability of on-site construction will be enforced and prevent the transition from happening [18]. With the decline of the demographic dividend and ecological civilization construction, the development of PC has been given policy priority by China’s government. The central government and 31 provincial governments have issued a series of related policies to promote the development of PC.

Driven by top-down government promotion, the responsibility of PC development largely rests at the provincial level [12]. In other words, provincial governments assume responsibility for implementing policies to promote the development of PC. According to Zhao and Li [19], the policy performance of PC development depends on numerous provincial governments, and therefore, provincial policies are extremely critical for the development of PC. However, the development of PC is a long-term process, which is inconsistent with the short-term-oriented interests of provincial governments [20]. Policy implementation means that the government will input related administrative and economic resources to achieve the policy targets [21]. If the expected utility is lower than the implementation cost, local governments may inactively take on the responsibilities assigned to them. This will lead to poor policy design and implementation for the development of PC [20]. Meanwhile, insufficient policy support has often been argued as a barrier to PC development. For instance, Zhai and Reed [16] pointed out that less governmental emphasis has been paid to the development of PC compared to other innovations. The insufficiency of proactive incentives, regulatory mechanisms and supervision systems has impeded the development of PC [15]. In this context, it is necessary to examine the provincial policies for the development of PC.

Currently, numerous studies have been conducted on the subject of PC development from various perspectives. These studies cover a range of research topics, including identifying barriers and motivators [15,16], exploring environmental performances [11], measuring development levels [12,22] and examining development measures and opportunities [4,7]. Various research methodologies, such as proxy models [23], econometric models [24], game theory [25], social networks [26] and others, have also been employed. This research provides a solid foundation for the development of PC. Although the crucial role of policy intervention in PC development has been acknowledged [13,17,27], there have been limited quantitative studies that examine provincial policies related to PC development based on policy text attributes. In order to fill this knowledge gap, this study takes the provincial policies in China as a research sample and adopts the approach of content analysis to

analyze them from the perspective of policy instruments. As a result, the holistic status of provincial policies on the development of PC can be examined, and the problems can be discussed. Finally, corresponding solutions can also be provided for policy revision in the future development of PC. As one of the largest construction industries in the world, research on the provincial policy on the development of PC in China can provide valuable lessons for other emerging economies.

## 2. The Development of PC in China

The development of PC in China was initially influenced by the Soviet Union's large boardroom building technique in the 1950s in order to meet increasing housing demand and promote the transformation of the construction industry [15]. Due to the fact that the boardroom method had many serious problems, such as poor earthquake resistance, poor quality sealants, etc., prefabricated technology gradually fell into disuse and was replaced by cast-in-situ construction technology, which benefits from cheap labor [28]. From the mid-1980s to the early 1990s, the concept of PC was once again pursued, and the development of PC underwent systematic and fruitful exploration. For instance, several national standards regarding construction industrialization were issued, which improved the level of standardization and assembly in building and construction [29]. However, in the late 1990s, the development of real estate entered a golden era, which highlighted the ability of developers to obtain the resources of capital and land needed [15]. As a result, PC development was gradually neglected, even basically stagnant, in the following ten years [29].

With the sustained and rapid development of the national economy, growing labor costs and an increasing demand for energy savings and environmental protection, the utilization of prefabricated technology has gradually increased since the mid-2000s [15]. In 2013, the development of PC was officially put forward by the "12th Five-year Plan for Green Building and Green Ecological Regional Development". From then on, a series of specific policies on the development of PC have been issued by China's central government, as shown in Figure 1. In 2016, the goal of PC development was clearly put forward in the "Guiding opinions on the vigorous development of prefabricated construction". The goal is to have 30% of the nation's annual new construction be built in a prefabricated manner by 2025. In 2017, the "Action Plan for PC development in the 13th Five-Year period" further set the goal that 15% of the nation's annual new construction be built in a prefabricated manner by 2020. Meanwhile, more than 50 demonstration cities, more than 200 industrial bases, more than 500 demonstration projects and more than 30 science and technology innovation bases will be built. Since then, a series of measures, standards, etc., have been implemented by China's central government in order to promote the development of PC.

Based on the hallmark policies mentioned above, the ambitious target of PC development has been allocated by China's central government to the lower-level government. For instance, more than 20% of new construction will be built in a prefabricated manner by 2020 in three major city clusters, namely Beijing-Tianjin-Hebei, the Yangtze River Delta and the Pearl River Delta. According to Li and Yang [20], the ambitious plan with the target responsibility system makes provincial governments have to echo the strategy of the central government by implementing a series of policies to achieve the target allocated to them. Consequently, the development of PC has improved. According to a survey by the Ministry of Housing and Urban-Rural Development, the national floor area of prefabricated buildings increased from 114 million m<sup>2</sup> in 2016 to 418 million m<sup>2</sup> in 2019 [30]. This indicates that 13.4% of the nation's annual new construction was built in a prefabricated manner in 2019 [31]. Meanwhile, 30 demonstrative cities in PC have been developed, as have 195 industrial bases [30]. In light of this, it can be concluded that nearly half of the mandatory policy objectives for the development of PC have been completed. In order to complete the remaining policy target, a comprehensive analysis of provincial policies is necessary to explore the policy status quo and provide countermeasures for policy optimization by discussing existing problems.

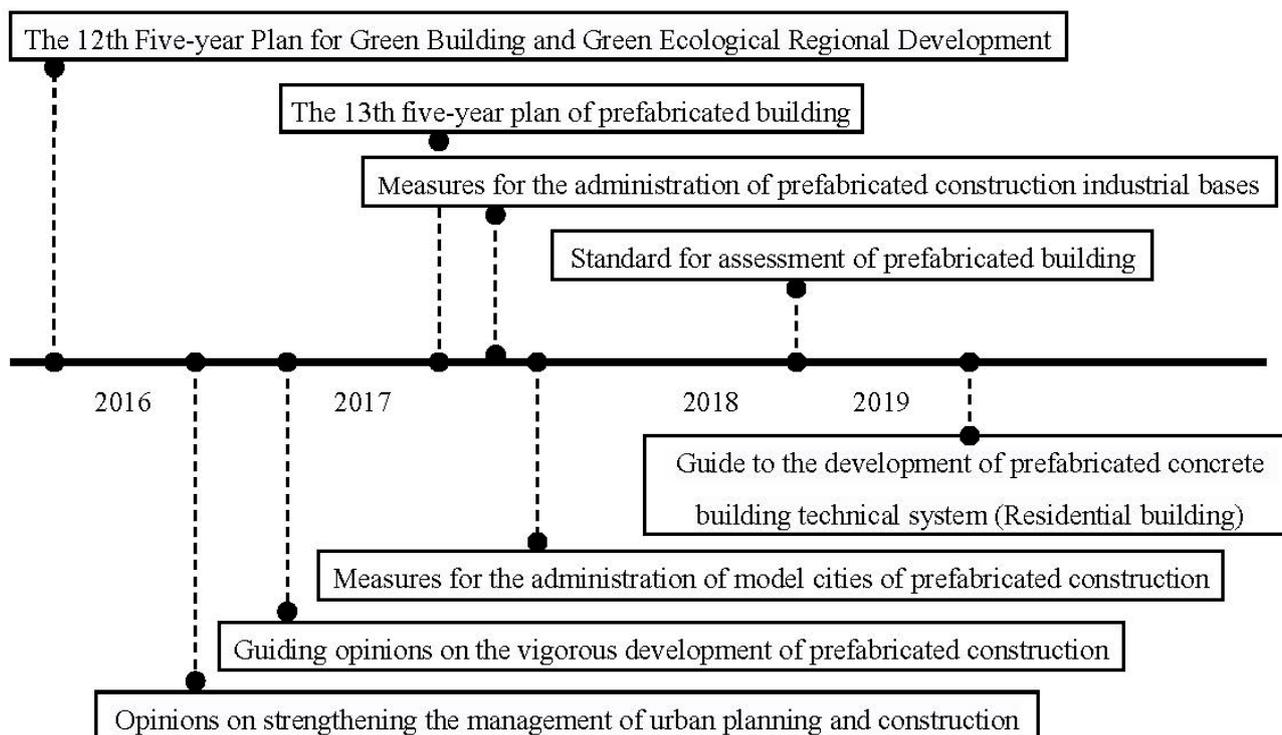


Figure 1. Key policies on the development of PC issued by China’s central government.

### 3. Policy Instrument

Policies are generally a set of principles to guide decisions and direct actions to achieve rational outcomes [32]. They are normally built based on a policy instrument, which is defined as a set of techniques by which governmental authorities wield their power in attempting to ensure support and effect social change [33]. Policy instruments represent a set of policy measures targeting a common problem and are often considered the methods used by governments to achieve a desirable objective [34]. As the carrier of policy, the choice of policy instruments constitutes a part of the formulation of the policy, and the instruments themselves form part of the actual implementation of the policy [33]. It deserves to be highlighted that policy instruments are technically substitutable, i.e., many alternative instruments can be employed to achieve the same policy objective [35]. Meanwhile, policy instrument choice is a political issue instead of a purely technical one, as the selection of a particular instrument affects whose interests will be served and the distribution of benefits and costs and entrenches institutional procedures and resources that are difficult to redeploy [36]. Therefore, the selection of the specific policy instrument most suitable among the wide range of different possible instruments is crucial in policy-making.

Attention has been given to the classification of policy instruments, which helps to analyze the reasons for instrument adoption, explore the governing ideas and implementation effects of relevant policies and prescribe better advice for policy-making. Despite this, no consensus has been reached on the classification of policy instruments. Schneider and Ingram [21] created a framework based on the behavioral assumptions associated with the policy instruments, including authority instruments, incentive instruments, capacity instruments, symbolic instruments and learning instruments. According to the involvement of statements in offering goods and services, Howlett and Ramesh [37] classified policy instruments into mandatory instruments, mixed instruments and voluntary instruments. Regarding the determinants of innovation, Rothwell [38] categorized instruments into three types: demand, supply and environment. Currently, the idea of Rothwell [34] has been extensively used in innovation policy analysis, which provides an overview of the interactive relations among each type of instrument and introduces the causal process. Demand and supply instruments play a direct pull and push role, while the role of the

environment instrument is to alter the overall environment in which innovation takes place and has an indirect effect by influencing both demand- and supply-side instruments [39,40]. In light of this, the classification framework of Rothwell [38] is suitable and applicable to analyze the policy instruments employed by provincial governments to promote the development of PC.

### 3.1. Demand Instruments

Demand is a major potential source of innovation and plays a critical role in the diffusion of innovation [41]. Demand instruments emphasize stimulating an emerging market or constructing a new market, which mainly includes government procurement and guide information [39]. As Edler and Georghiou [41] highlighted, government procurement is extremely important for innovation and can increase the demands for innovation and then speed up the diffusion of innovation. Guide information can boost the knowledge diffusion of PC in order to guide consumers to purchase housing built in a prefabricated manner [42].

### 3.2. Supply Instruments

The supply instrument plays a push role in innovation, involving the government directly enlarging the supply, increasing market output and related elements of innovation [42]. Four items are included in this type: talent support, infrastructure construction, technical support and public services. Talent support refers to improving the system of training and education or attracting high-level talent from overseas to return for domestic work [42]. Infrastructure construction emphasizes updating related infrastructure and facilities, especially R&D activities [43]. Technology supports R&D activities through national science and technology projects and scientific programs [42]. Setting up information databases and publishing related information, as well as providing scientific and technological support for innovation, has been highlighted in public services [44].

### 3.3. Environmental Instruments

Environmental instruments highlight the need to create a favorable environment for PC development via goal-planning, political instruments, economic incentives and regulatory controls. As the common instrument used by China's government, goal-planning refers to the government setting a goal and determining a plan or strategic measures to achieve it [39]. Political instruments are backed by the legitimate authority of the government and grant permission, prohibit or require action under designated circumstances [38]. Economic incentives, as the most effective way to boost the diffusion of innovation, include items ranging from financial subsidies and preferential loans to tax preferences [45]. Regulations and controls emphasize that the government enacts a series of laws and regulations to restrict market behavior, maintain market order and create a fair and orderly competitive environment for the market [39,44].

Based on the classification framework of Rothwell [38], this research divides provincial policies into demand instruments, supply instruments and environment instruments. Subsequently, policy priorities for PC development in each province can be obtained by using the approach of content analysis, which is highly suitable for conducting cross-province comparative studies.

## 4. Research Methodology

### 4.1. Data Source

This study analyzed provincial policies on the development of PC. Policies were collected from the official websites of provincial governments, including 22 provincial governments, 4 municipal governments directly under the central government and 5 autonomous regions. At the same time, policy databases and professional websites were also reviewed as supplementary, such as precast.com.cn (accesses on Date October 2021), the Peking University law database, etc. With the references of Liao [39], Rui-dong

and Veronica [46], due to the large number of policy texts available, the policy review was rigorously conducted by adhering to the following principles to ensure the reliability and validity of the selected policies:

1. The validity of the selected policies was first checked, as some policies are being dismantled and therefore meaningless in this study. With the help of the Peking University law database, the timeliness of each selected policy could be examined. Consequently, the validity of the selected policies could be guaranteed, and the dismantled policy texts were abandoned.
2. The selected policies had to directly reflect each provincial or municipal government’s attitude toward the development of PC, such as laws, regulations, plans, measures and notices. The replies and approvals were excluded. At the same time, the policies issued by the central government as well as sub-provincial governments were also excluded.
3. Policies had to contain specific measures for the development of PC. Hence, policies that simply mentioned PC without any specific measures were excluded.

All the authors participated in the process of policy screening. Finally, 443 policies issued by provincial or municipal governments on the development of PC were selected, as shown in Table 1. As a result, a provincial policy database was developed for further analysis.

**Table 1.** Number of PC policies issued by provincial governments.

Liaoning	Heilongjiang	Jilin	Shaanxi	Gansu	Ningxia	Xinjiang	Qinghai
13	23	8	8	13	4	13	5
Chongqing	Tibet	Yunnan	Sichuan	Guizhou	Jiangsu	Zhejiang	Jiangxi
30	2	6	21	9	11	13	11
Anhui	Fujian	Shandong	Shanghai	Henan	Hunan	Hubei	Guangdong
15	29	31	16	6	18	18	22
Guangxi	Hainan	Beijing	Tianjin	Hebei	Shanxi	Inner Mongolia	
15	14	14	15	14	21	5	

#### 4.2. Content Analysis

The approach of content analysis was adopted in this study to analyze the 443 provincial policies on the development of PC selected. It is often used to systematically evaluate the symbolic content of texts, news, public speeches and other verbal or nonverbal units [47]. By transforming the qualitative symbolic contents into systematic quantitative data, content analysis provides an empirical starting point for generating new research evidence from historical sources of data [48]. Meanwhile, it can find meaningful patterns from various kinds of information, which helps people find the essence of phenomena, thus ensuring the right direction of these policies [49]. With reference to previous studies, e.g., Wang and Li [32], Zhang and Xu [48] and Liao [39], the process of content analysis includes the following three steps:

1. Policy characteristics description. By checking these 443 provincial policies, the policy characteristics of each region for PC development can be examined, such as policy number, policy issuing year and policy issuing organization. This can reveal the policy status of PC development in each region.
2. Policy instruments classification. As suggested by Rui-dong and Veronica [46], the policy theme of each provincial policy should first be identified. Then, based on the policy theme, these selected policies can be categorized into three dimensions: demand-oriented policy, supply-oriented policy or environment-oriented policy.
3. Policy instruments analysis. Following the research of Elo and Kyng [50], the texts of the 443 selected policies were systematically analyzed. By accounting for the number of each type of policy issued by each provincial or municipal government, the policy

priorities for the development of PC can be obtained. By comparing each type of policy at the province level, the similarities or differences among the 31 regions can be discussed, as can related problems or challenges.

## 5. Results

### 5.1. Number of Policy Instruments and Policy Types

Using the approach of content analysis, the selected 443 provincial policies were divided into three types of instruments, as shown in Table 2. The most adopted instrument was the environmental instrument, accounting for more than 80% of the total instruments. This was followed by supply instruments, which accounted for 17.8% of the total instruments. The demand instrument was the least employed. Generally, regulatory control, goal-planning and political instruments were ranked as the top three most-used instruments. The three least-used instruments were technical support, economic incentives and government procurements.

**Table 2.** Number of provincial policy instruments for the development of PC.

Type	Instruments	Number (Percent)	Total Number (Percent)
Environment-oriented instrument	Goal-planning	84 (19.6%)	357 (80.6%)
	Political instruments	43 (9.7%)	
	Economic incentives	11 (2.5%)	
	Regulatory controls	219 (49%)	
Supply-oriented instrument	Infrastructure construction	33 (7.5%)	78 (17.8%)
	Technical support	12 (2.7%)	
	Public services	18 (4.1%)	
	Talent support	16 (3.6%)	
Demand-oriented instrument	Government procurement	3 (0.7%)	7 (1.6%)
	Guide information	4 (0.9%)	

Table 3 summarizes the policy instruments adopted in the 31 regions. Three types of instruments were not comprehensively used in all 31 regions. Environment instruments were adopted in all the regions, while supply instruments were missed in 4 regions and demand instruments were neglected in 25 regions. Regulatory control was used by all the regions except Tibet. Goal-planning was the second-most-used instrument and was adopted by 29 regions. Political instruments, infrastructure construction, guide information and technical support were relatively more commonly used. Economic incentives, public services, talent support and government procurements were used by less than 10 regions. The most types of instruments were found in Heilongjiang, Chongqing and Shandong, as seven kinds of instruments were used to promote the development of PC. This was followed by Hubei, Fujian, Gansu and Shanxi, where six types of instruments were used. Two types of instruments were found in Inner Mongolia and Jiangsu. Tibet only issued policies that belonged to goal-planning. For the rest of the regions, from three to five types of instruments were adopted, as shown in Table 2.

**Table 3.** Types of provincial policy on the development of PC in 31 regions.

Regions	Goal-Planning	Environment Instruments		Regulation Control	Infrastructure Construction	Supply Instruments		Talent Support	Demand Instruments		Total
		Political Instruments	Economic Incentives			Technical Support	Public Services		Government Procurement	Guide Information	
Beijing	✓		✓	✓		✓					4
Hebei	✓			✓					✓		3
Tianjin	✓	✓	✓	✓							4
Shanxi	✓	✓		✓	✓	✓	✓				6
Inner Mongolia	✓			✓							2
Liaoning	✓			✓	✓		✓				4
Heilongjiang	✓	✓		✓	✓	✓	✓			✓	7
Jilin	✓	✓		✓	✓						4
Shaanxi	✓	✓		✓	✓						4
Gansu	✓	✓	✓	✓	✓	✓					6
Ningxia	✓		✓	✓							3
Xinjiang	✓	✓		✓		✓		✓			5
Qinghai	✓			✓				✓			3
Chongqing	✓	✓	✓	✓	✓			✓		✓	7
Tibet	✓										1
Yunnan	✓	✓		✓		✓					4
Sichuan	✓			✓	✓	✓					4
Guizhou	✓	✓		✓		✓					4
Jiangsu				✓		✓					2
Zhejiang		✓		✓	✓	✓					4
Jiangxi	✓	✓		✓	✓						4
Anhui	✓	✓	✓	✓	✓						5
Fujian	✓	✓		✓	✓		✓	✓			6
Shandong	✓	✓		✓	✓	✓		✓			7
Shanghai	✓			✓			✓		✓		4
Henan	✓			✓				✓		✓	3
Hunan	✓	✓		✓			✓	✓			5
Hubei	✓	✓		✓	✓			✓		✓	6
Guangdong	✓			✓	✓	✓			✓		5
Guangxi	✓			✓	✓	✓					4
Hainan	✓	✓		✓		✓		✓			5
Total	29	18	6	30	16	14	7	9	3	3	

The symbol ✓ represents whether the region has used the policy instruments of that type. If it has been used, the symbol ✓ is placed; otherwise, it remains empty.

### 5.2. Temporal Variation in Policy Instruments in Different Regions

Combining the issuance years of the 443 selected policies, it was found that the earliest provincial policy was issued in 2010, and then a remarkable increase was achieved in 2017. As presented in Table 4, the average number of provincial policies on the development of PC was seven per year from 2010 to 2016 and sharply increased since 2017. An average of approximately 100 policies per year were issued by provincial and municipal governments from 2017 to 2020. Thus, the year 2017 could be considered the turning point of PC development at the provincial level. In light of this, the development of provincial policies during the last ten years can be divided into two stages: the exploring stage from 2010 to 2016 and the rapid development stage since 2017.

**Table 4.** Number of policies issued by provincial governments.

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Number of policies per year	1	0	0	2	8	12	20	110	115	112	63
Cumulative number of policies	1	1	1	3	11	23	43	153	268	380	443

Figure 2 presents the number of policies for different regions in different years. It was found that only one region (Shanghai) started exploring the concept of prefabricated buildings in the initial exploring stage. The “Specification for manufacturing, construction and quality acceptance of concrete components for prefabricated residential” policy issued by Shanghai in 2010 was the earliest provincial policy on the development of PC. After that, two policies were issued by Shanghai in 2013, namely the Notice on further development of PC and the specific implementation details. After 2014, and especially after 2016, more regions issued policies on PC development, such as Chongqing, Liaoning, Beijing, Guangxi, Hunan, Hubei, Jiangsu, Jiangxi, Anhui, Fujian, Shandong, Gansu, Xinjiang, Heilongjiang, Hebei and Tianjin. Despite this, the number of provincial policies for PC development was still limited, with 42 provincial policies issued from 2014 to 2016. In the rapid development stage, 90.3% of the provincial policies were issued from 2017 to 2020. A total of 7 regions issued more than 20 policies (Guangdong, Fujian, Shandong, Chongqing, Sichuan, Heilongjiang and Shanxi). Furthermore, less than 10 policies but more than 5 policies were issued in Henan, Jiangxi, Shanghai, Yunnan, Shaanxi and Jilin. Less than five policies were issued in Ningxia, Qinghai, Tibet and Inner Mongolia. Particularly, only two policies were issued in the regions of Tibet.

### 5.3. Policy-Issuing Organizations in Different Regions

The organization that issued most of the 443 selected policies was the provincial Committee on Housing and Urban and Rural Development, with 413 provincial policies issued either independently or jointly with other organizations. This is followed by the Government Office of the provincial or municipal government, which only issued 29 provincial policies. Additionally, 14 provincial departments issued policies jointly with the Committee on Housing and Urban and Rural Development, including the Bureau of Planning and Natural Resources, the Department of Finance, the Bureau of Quality and Technical Supervision, the Commission of Economic and Information, the Commission of Development and Reform, the Tax Administration, the Bureau of Ecology and Environment, the Bureau of Transportation, the Market Supervision Administration, the Finance Department, the Bureau of Auditing, the Department of Science and Technology, the Bureau of Human Resources and Social Security and the Financing Office of the provincial or municipal government.

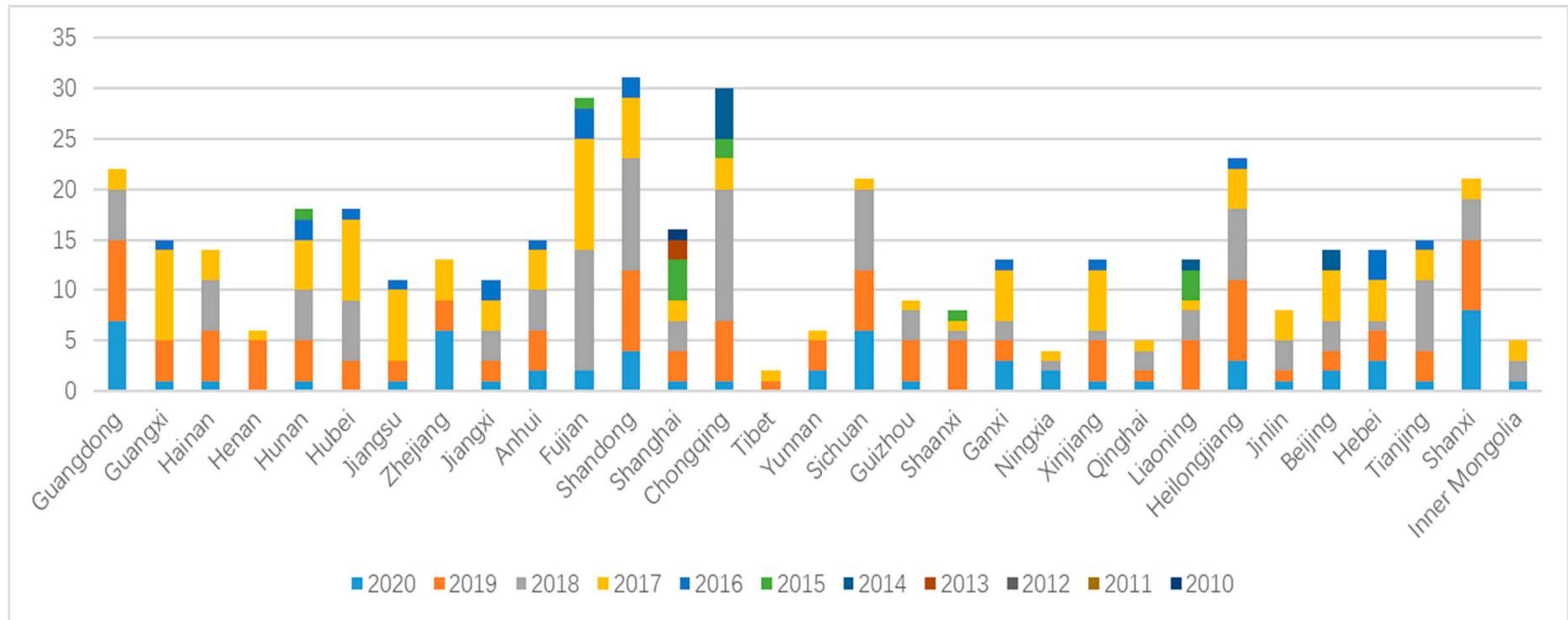


Figure 2. Number of policies issued by provincial governments from 2010 to 2020.

Six types of policy instruments were found to be issued jointly: goal-planning, regulatory controls, economic incentives, public services and government procurement. Related to this, more organizations were found to participate in the policies of goal-planning. For instance, the “Notice of Guiding Opinions on vigorously promoting prefabricated building” and “Promoting modernization development of construction industry in Guangxi” policies were issued by 12 departments. Similar goal-planning policies were issued in Shanghai, Yunnan, Sichuan and Hunan by nearly five departments. Meanwhile, more organizations were involved in the policy issuance of regulatory controls compared with other instruments. Beijing issued the policy “Strengthening the whole process control of design and construction quality of prefabricated concrete buildings” by three organizations: the Bureau of Planning and Natural Resources, the Committee on Housing and Urban and Rural Development and the Market Supervision Administration. In Hainan, the policy of “Regulations on the main stage of prefabricated projects” was issued by the Committee on Housing and Urban and Rural Development, the Commission of Development and Reform and the Bureau of Planning and Natural Resources. As to the rest of the three types of instruments, two organizations were involved in policy issuance. For instance, Anhui issued “Management measures for special funds of green buildings and prefabricated buildings” by the Department of Finance and the Committee on Housing and Urban and Rural Development. In Guangzhou, the policy “Optimizing the implementation scope of prefabricated buildings” was issued by the Committee on Housing and Urban and Rural Development and the Bureau of Planning and Natural Resources. In Beijing, the policy “Regulations on prefabricated building expert committee” was issued by the Committee on Housing and Urban and Rural Development and the Bureau of Planning and Natural Resources.

#### 5.4. Spatial Variation in Policy Instruments in Different Regions

##### 5.4.1. Environment Instruments

A total of 219 regulatory control policies were issued by 30 regions. These policies of regulatory control covered all stages of prefabricated projects, including decision, design, manufacture, construction and acceptance. The policies of the decision stage focused on the issues of price foundation, consumption quota, budget quota, etc. The policies of the design stage mostly highlighted the structure’s design. Meanwhile, the atlases of prefabricated high-rise steel buildings, rural prefabricated housing and prefabricated affordable housing were issued by Inner Mongolia, Sichuan and Guangdong, respectively. Related to the stage of manufacture, policies concentrated on the procedures of production and acceptance for prefabricated components. Fujian issued measures for the certification of prefabricated components. The policies of the construction stage focused on the technical regulations of prefabricated projects. Quality management and safety management were also highlighted. The quality acceptance procedure and evaluation criteria for prefabricated projects were highlighted in the policies of the acceptance stage.

Goal-planning was the second-most-used instrument, as 29 regions issued related plans for PC development. Among these, 28 regions issued opinions on the development of PC, including development goals and related measures. Furthermore, 14 regions issued concrete action plans for PC development during the 13th five-year period. Particularly, Chongqing issued the policy “Development plan of prefabricated steel buildings”. In addition, 10 regions issued the annual working plan for PC development, including Beijing, Hebei, Shanxi, Chongqing, Sichuan, Anhui, Fujian, Shandong, Hubei and Gansu. Related to political instruments, 18 regions issued policies that included issues such as special examinations, performance assessments and leading organizations. For instance, Shandong issued policies for conducting special examinations on the development of PC. Policies requiring the provision of related information for the performance assessment of PC development were issued by 16 regions. Jiangxi and Xinjiang established a special leading organization for PC development.

As to the economic incentives, 6 regions issued 11 related policies, including fiscal awards, fiscal subsidies, fiscal investment and preferential policies. Beijing and Tianjin provided fiscal awards for prefabricated projects with social funds. Specifically, in Beijing, qualified prefabricated construction projects will be awarded with 180 CNY/m<sup>2</sup> (up to CNY 25 million). In Tianjin, the award for prefabricated projects should not exceed CNY 2 million. In Chongqing, a subsidy will be provided for prefabricated projects based on the standard of 100 CNY/m<sup>2</sup> when the assembly rate is higher than 50%. Anhui and Gansu issued specific policies and management measures for fiscal investment in prefabricated projects.

#### 5.4.2. Supply Instruments

Among the supply instruments, infrastructure construction was the most commonly adopted, as 16 regions issued 33 related policies. Most of these policies focused on the industrial base of prefabricated buildings in order to cultivate related enterprises in prefabricated technology. For instance, the “Regulation of industrial base for prefabricated buildings” was issued by Chongqing, Sichuan, Jiangxi, Shandong, Guangdong, Gansu, Liaoning, Heilongjiang and Jilin. Some regions issued policies for applying the industrial base of prefabricated buildings. The public service was adopted by 7 regions with 12 policies. Specifically, Liaoning issued policies to improve the quality of public services in prefabricated enterprises. Shanghai issued concrete policies on the pre-sales of prefabricated housing and the prefabricated project approval system. Heilongjiang, Fujian and Shandong highlighted the need to investigate the problems with the development of PC. Technical support was used by 14 regions, with 18 policies mainly focused on providing information on suitable prefabricated technologies and establishing committees of experts. As to the talent support, it was adopted by 9 regions, and 16 related policies were issued. Xinjiang, Qinghai, Fujian, Shandong, Hunan and Hubei issued policies that proposed to hold professional training in prefabricated technologies mainly for managers and technicians. Surprisingly, Chongqing constructed a professional-skill standard for prefabricated concrete construction technical workers. A construction talent training base for prefabricated buildings was highlighted by Henan.

#### 5.4.3. Demand Instruments

Demand instruments were found to be used less than the other two types of instruments. As shown in Table 3, only three related policies on government procurement and three on guide information were issued. To be specific, Shanghai and Guangdong implemented policies that clearly defined the scope of public projects that required the adoption of the PC approach. Hebei issued a policy requiring the adoption of prefabricated housing in rural housing reconstruction after a disaster. Chongqing and Heilongjiang issued policies that proposed participation in a conference on prefabricated buildings. In addition, a policy with publicity programs for prefabricated buildings was issued in Hubei.

### 6. Discussion

Under the target responsibility system, most lower-level governments actively echoed the strategy of the central government, and provincial policies on the development of PC increased rapidly after 2017. Meanwhile, it deserves to be highlighted that the target responsibility system was also adopted by all the provincial governments. In other words, sub-provincial governments are required to implement related policies to achieve the target allocated by the provincial government. For instance, in Jiangsu, the city of Nanjing implemented the policy “Further development of prefabricated buildings in 2017”, and the city of Suzhou issued the “Specifications for promoting the development of prefabricated buildings and strengthening construction supervision” policy. Generally speaking, as presented in Table 2, these provincial policies included all types of instruments, and 16 organizations were involved in the policy issuance. Therefore, it can be included that China initially developed a policy system for PC development with the characteristics

of multiple levels, multiple stakeholders and multiple instruments. The involvement of multiple levels of government indicates China's confidence and determination to promote the development of PC. The adoption of multiple instruments suggests multi-faceted policy interventions are required to overcome the barriers to PC development, and the participation of multiple stakeholders suggests that policy implementation needs more governmental resources.

As presented in Table 2, less developed regions issued fewer policies on the development of PC. For instance, less than five policies were issued in Ningxia, Qinghai, Tibet and Inner Mongolia on the development of PC. According to Chang and Hong-jun [42], limited policy numbers suggest poor policy stability and continuity. Due to the fact that policy stability and continuity are critical indicators for investors to judge the attractiveness of PC development, it is reasonable to suggest that more policies must be issued, especially in less developed regions, in order to improve the attractiveness of PC development. Meanwhile, as shown in Table 4, the policies issued in each region did not include all types of instruments, which implies that the diversity of policy instruments should be enhanced. In fact, multiple barriers that hinder PC development can be divided into various categories, including cost and benefit, technology, project organization and social environment, among others [13,15]. This suggests that various policy instruments should be adopted to overcome all market, system and institutional failures, including barriers and bottlenecks. Furthermore, jointly issued policies are limited, accounting for 5.8% of the total provincial policies issued in five regions. Generally, the Committee on Housing and Urban and Rural Development takes a leading role in policy issuance, and some critical organizations that possess critical governmental resources for policy implementation are excluded. It is therefore urgent to involve the related organizations in the policy issuance, which is conducive to policy implementation.

Successfully overcoming the locked-in effect of on-site construction requires policy mixes that combine instruments that can destabilize existing regimes and create space for innovation [51]. Related to this, according to Lin and Yang [40], the environmental, supply and demand instruments are all indispensable to overcome the locked-in effect of on-site construction for PC development. Among the 443 policies, environmental instruments were found to be adopted most frequently, while supply and demand instruments were grossly insufficient. Particularly, regulatory control, goal-planning and political instruments were extensively used, accounting for nearly 80% of the total policies. This implies that the priorities of provincial policies were given to the improvement in the industrial environment by issuing related codes, standards and management measures for PC development. Meanwhile, the complementary effect between goal-planning and political instruments can effectively promote the development of PC by motivating sub-provincial governments to achieve the target allocated to them. As Li and Yang [20] pointed out, motivated by career advancement, local officials will commit to achieving organizational objectives and guaranteeing policy implementation. This is probably the main reason for the rapid uptake of PC technology when there is poor implementation of supply and demand instruments. Therefore, it can be said that currently, provincial governments are likely to implement short-term policies for the development of PC and ignore comprehensively addressing the barriers that hinder its development. The development of PC is a complex socio-ecological change that is a long-term process. Therefore, China's policy system for the development of PC needs to be improved from a systematic and long-term perspective by strengthening the supply and demand instruments.

As to the supply instrument, more attention should be given to improving the production capacity of PC, which was criticized for not meeting the demand that 30% of annual buildings be constructed in a prefabricated manner [4]. According to the survey of Dou and Xue [12], less than 10 prefabricated-construction-related companies were found in Inner Mongolia, Ningxia, Xinjiang, Qinghai, Tibet, Yunnan and Hainan. Meanwhile, as shown in Table 3 infrastructure construction was totally neglected by these regions, as mentioned above. Therefore, the policies of infrastructure construction should be imple-

mented timely in these regions. Similarly, the R&D of PC has been neglected by technical support, which has been focused on the provision of technical guidance. On the one hand, 17 provinces were found not to have any research institute or association for the R&D of PC [12]. On the other hand, related technology for PC is not mature enough, and some fundamental research is still lacking, such as earthquake resistance and shock absorption [27]. In light of this, the R&D of prefabricated technology should be given more priority by all regions. In addition, the education and training of construction workers should be strengthened, as the current policies concentrate on managers and technicians. In most cases, construction work in China is the preferred occupation of migrant workers with little advanced training [15]. As a result, the lack of qualified labor has been regarded as one of the critical barriers to the development of PC. Moreover, the provision of a curriculum related to PC in higher education institutions has also been neglected, and obviously, a greater emphasis on PC technologies in higher education is an urgent issue. Otherwise, the sustainable development of PC will be affected as the demand for experts cannot be satisfied. Meanwhile, public services need to be further enhanced, as only Liaoning and Shanghai have highlighted the need to provide high-quality services for construction enterprises. Due to the fact that the business model of prefabricated projects is totally different from on-site construction, it is urgent to update public services. More preferential services, such as the green channel of the project approval system, should be provided for prefabricated projects.

Only under half of the mandatory policy objective of having 30% of the nation's annual new construction in a prefabricated manner has been completed. For this reason, demand instruments should be strengthened in the future development of PC. Specifically, the policies issued by Shanghai and Guangdong, which clearly define the scope of the mandatory adoption of the PC approach, can be replicated in other regions. This can not only destabilize the regime of on-site construction but also increase the demand for prefabricated technology. Furthermore, based on the policies issued by Hebei, the demand for PC construction in rural areas should be highlighted. In fact, according to the Notice on carrying out the Pilot Work of Rural Housing Construction issued by MHURD, prefabricated rural housing has been required to conduct pilot work, which was regarded as an effective way to improve the living quality of rural people. Meanwhile, some regions have issued related policies for rural prefabricated housing, such as Sichuan. Under the strategy of rural revitalization and building an ecologically sound and beautiful countryside, there is an explicit demand for the use of PC in rural areas. Thus, it is necessary to implement related policies to promote the development of rural PC. Furthermore, Chongqing, Tianjin, Beijing and Ningxia have provided fiscal awards or subsidies for prefabricated projects with social funding. This can effectively upscale the demand for prefabricated technology, as current prefabricated projects are mainly funded by public funding. Thus, it is necessary for other regions that have implemented similar policies to improve the market demand for PC. In addition, the publicity surrounding prefabricated buildings should be highlighted, as related policies were only issued in Hubei. In fact, the development of PC will be impossible without a change in attitude and behavior among stakeholders, where consciousness is the starting point [48]. Their consciousness towards prefabricated technology is largely determined by their understanding and acceptance of PC. Therefore, improving the social recognition of PC should be highlighted in the future.

## 7. Conclusions

This study examined provincial policies on the development of PC from the perspective of policy instruments. A total of 443 provincial policies issued by 31 regions were collected, and policy number, temporal issuance and policy types were first analyzed. The result suggests that a policy system of multiple levels, multiple stakeholders and multiple instruments was initially developed in China to promote the development of PC. Despite this, fewer policies on the development of PC were found in less developed regions, and a few policies were issued jointly by more than two government departments.

By using the approach of content analysis, the 443 provincial policies were divided into 358 environment-oriented policies, 78 supply-oriented policies and 7 demand-oriented policies. This indicates that, generally, current attention has been paid to improving the industrial environment of PC development while supply and demand instruments are grossly inadequate. Moreover, it was found that the policy system of each region needs to be improved, as not all types of policy instruments, namely the environment instrument, the supply instrument and the demand instrument, have been included in all 31 regions.

This study is the first attempt to systematically analyze provincial policies on the development of PC in China. The research findings suggest that a policy system for the development of PC was initially developed with the help of multiple hierarchical political systems and target responsibility systems. In this context, the extensive utilization of plans and political instruments indicates that most provincial governments implemented short-term policies to promote the development of PC. As a complex socio-ecological process, the development of PC needs comprehensive and systematic policy interventions to address the multiple barriers that hinder PC development. Different instruments play different roles in overcoming the locked-in effect of on-site construction, and all of them are indispensable for the development of PC. Thus, it is strongly recommended that the policy system be designed and implemented from a systematic perspective.

This study has important implications for policy-making at the provincial level. First, each region should improve its policies on the development of PC, as the supply- and demand-oriented policies were found to be grossly inadequate. Second, for less developed regions, more policies should be implemented in order to enhance policy stability and continuity. Third, strengthening the production capacity of OC should be highlighted, especially for developing regions. Fourth, R&D should be strongly supported (it was completely missed in 31 regions). National science and technology projects and scientific programs should be focused on prefabricated technology. Fifth, the training of construction workers should be emphasized in order to provide prefabricated skill workers, and a related curriculum of PC could be provided in higher education to train PC technicians. Sixth, public services should be updated for prefabricated projects and provide preferential government services. Seventh, the market for rural prefabricated housing could be further explored with more economic incentives for social funding in order to increase the demand for PC. Eighth, the publicity of PC should be strengthened to improve social consciousness regarding PC. This can cultivate the potential demand for prefabricated housing.

Furthermore, this research offers valuable insights for international progress. Firstly, the formulation and application of PC policies are closely linked to global environmental sustainability, a crucial and universal concern. The study of PC policy implementation and effectiveness can provide practical strategies and experiences for countries and regions. Secondly, the PC industry is an emerging sector that not only significantly contributes to environmental protection but also plays a vital role in advancing economic development and generating employment. Analyzing the implementation of PC policies in various countries and regions can provide guidance and assistance for the growth of the PC industry. Finally, as more countries and regions prioritize environmental issues and take concrete measures to combat them, researching the development and application of PC policies can offer crucial policy references for strengthening environmental protection worldwide.

This study is based on a taxonomy of policy instruments with equal weight attached to each instrument, assuming an equal impact on promoting PC. However, in practice, policy instruments will have varying impacts based on their implementation. Therefore, efforts should also be made to examine the effectiveness of policy enforcement in combination with the achievement of the development of PC. This can help explore the effect of different policy instruments on the promotion of the development of PC.

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