

EMPIRICAL ARTICLE

Unlocking the Growth of Prefabricated Construction in China: Policy–Market Synergy as a Strategic Driver

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Abstract

Purpose - This study investigates the interplay between policy instruments and market dynamics in shaping the development and perceived effectiveness of prefabricated construction (PC) in China. While extensive top-down policy support exists, adoption remains fragmented due to cost barriers, technological challenges, and uneven market demand. The study aims to conceptualize and empirically test how policy–market synergy—the alignment between formal government support and informal market responsiveness—acts as a strategic lever for industry development.

Design/Methodology/Approach - A mixed-methods approach was employed. Study 1 consists of a qualitative case study of a high-profile and large-scale affordable housing development project with PC activity, incorporating 10 semi-structured interviews. This stage identifies core variables and mechanisms underpinning policy–market interactions. Study 2 uses structural equation modeling (SEM) based on a national survey of 246 PC firms in China.

Findings - The synergy between policy and market factors serves as a critical mediating mechanism, enhancing the impact of institutional drivers. The strength of this synergy is conditioned by the degree of industry chain synergy and technological and cost feasibility. The case study revealed that even under strong policy mandates, implementation success hinges on alignment with market demand, stakeholder coordination, and digital integration tools such as Building Information Modeling (BIM). The influence of both policy and market demand on PC in such a large and high-profile construction project, and the testing more widely through a questionnaire survey across the construction industry provides evidence that can be extended beyond the Chinese context.

Practical implications - For policy-makers, the study emphasizes the need for adaptive policy frameworks, performance-based incentives, and feedback loops that adjust to market signals. For firms, it highlights the strategic importance of engaging with both regulatory expectations and consumer trends, which drive market demand. Investments in supply chain coordination, digital technologies, and modular innovation can improve institutional alignment and project success.

KEYWORDS

Prefabricated construction, Policy–market synergy, Institutional theory, Modular construction, Innovation adoption, Green building, Institutional complementarity.

1 | INTRODUCTION

In the context of global supply chains being challenged by local sustainability imperatives (Bonet Fernandez and Lissillour 2023, Boyer 2024), China has made significant policy commitments to sustainable development, including a strategic emphasis on low-carbon urbanization and environmentally friendly building practices. Among the most promising

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innovations in this domain is prefabricated construction (PC), which offers potential benefits such as reduced waste, enhanced efficiency, and lower carbon emissions (Wang et al. 2024, Zhang et al. 2022). Despite these advantages and robust top-down policy support, the adoption of PC technologies in China has remained uneven. Numerous obstacles, such as high initial costs and technological immaturity to weak market demand, have prevented the sector from achieving its full potential (Hong et al. 2018).

While existing research has examined the policy side of PC (Su et al. 2023, Yan et al. 2023) and the market barriers to adoption (Hong et al. 2018), there remains a significant gap in understanding how these two domains of policy development and market activity interact, and the importance of synergy between them. Most prior studies have treated policy and market forces in isolation, failing to capture the complexity of how they influence each other in practice. This paper addresses that gap by examining the mechanisms of synergy between public policies and market responses in shaping the development of China's PC industry.

To do so, we adopt an institutional theoretical framework, with particular attention to the concept of *institutional complementarity*—the idea that institutions in different domains, such as government policy and market structure, can mutually reinforce one another to enhance organizational performance and technological diffusion (Aoki 2001, Hall and Soskice 2001). Institutional theory emphasizes that organizations are embedded in broader social, regulatory, and economic environments, which exert coercive and normative pressures on behavior (DiMaggio and Powell 1983, Scott 2014), but also more tacit ones (Lissillour et al. 2021). In this view, policy instruments such as subsidies, targets, and regulations serve as formal institutions that influence firm strategy, while market signals such as demand trends, financing conditions, and supply-chain maturity operate as informal or semi-formal institutions. When these domains align, policy–market complementarity can emerge, leading to more effective implementation and faster industry transformation (Campbell 2004, Jackson and Deeg 2008).

The decision-making context for construction firms is whether to continue with traditional on-site methods or to commit to PC, thereby incurring the managerial, organizational, and cultural changes that a strategic shift to off-site construction requires (Pan et al. 2012). Furthermore, building the information systems to implement PC also represents a cost and a perceived risk for firms making the commitment to switch to PC (Tan et al. 2019) because of an important rate of implementation failure of these information systems (Lissillour 2021).

In the case of PC, complementarity implies that policy support alone may be insufficient unless it is matched by favorable market conditions and active firm participation. Conversely, even a receptive market may struggle without clear, consistent, and supportive public policies. Understanding how these factors interact—and under what conditions they become mutually reinforcing—is essential for improving the effectiveness of PC promotion strategies in China and other developing markets.

To investigate this interaction, we pose two interrelated research questions: How do policy incentives and market responses interact to

influence the implementation of PC in practice? What are the effects of policy support and market conditions on firms' perceived effectiveness of PC promotion strategies, and what are the mediating or moderating mechanisms involved?

In this study, our specific objectives are to: (1) examine the influence of policy incentives on the implementation of PC in China; (2) assess how market conditions moderate the relationship between policy support and the adoption of PC; and (3) analyze firms' perceptions of PC promotion strategies and identify the mediating or moderating mechanisms that shape their effectiveness.

We address these questions through a two-stage, mixed-methods research design. First, Study 1 uses a qualitative case study of the *Shenzhen Meilin Affordable Housing Project* to identify real-world mechanisms of policy–market interaction. This case was selected due to its prominence as an early exemplar of large-scale government-led PC under China's dual-carbon agenda. Based on insights from this case, we develop key constructs and variables for Study 2, which consists of a large-scale survey of Chinese PC firms and a SEM analysis. This allows us to empirically test the influence of institutional factors on perceived promotion effectiveness, with a focus on mediation pathways such as technological readiness, cost perceptions, and collaborative practices.

By combining contextual depth with empirical generalizability, this study makes two key contributions. First, it extends institutional theory by providing an operational model of policy–market complementarity in the context of a sustainability transition. Second, it offers practical insights for government agencies, urban planners, and construction firms aiming to improve prefabricated-building adoption through better-aligned institutional strategies.

2 | LITERATURE REVIEW

Prefabricated construction (PC) refers to the manufacturing of building components in off-site facilities under controlled conditions and their subsequent assembly at the construction site. This approach spans component manufacturing, non-volumetric and volumetric pre-assembly, and whole-building modular systems such as *Modular Integrated Construction* (MiC) and *Prefabricated Prefinished Volumetric Construction* (PPVC) (Abdelmageed and Zayed 2020).

The benefits of PC include improved quality control, reduced on-site disruption, shorter construction timelines, and better environmental performance due to decreased waste and energy consumption (Hong et al. 2018, Wuni and Shen 2020b, Mao et al. 2016). Comparative studies also emphasize PC's potential to mitigate carbon emissions and enhance lifecycle efficiency, particularly when aligned with green building initiatives (Wang et al. 2024, Zhang et al. 2022). However, adoption barriers persist and vary across countries given differing policy frameworks and firm-level strategies for off-site construction. These issues are documented in reviews of MiC frameworks and processes (Abdelmageed and Zayed 2020) and in comparative studies of modular practices in China, Hong Kong, and Singapore (Xu et al. 2020).

2.1 | Historical and Policy Context in China

The evolution of China's PC industry mirrors broader transitions in urban development and industrial policy. Early experimentation during the mid-20th century drew on industrialized construction practices from the Soviet Union and later Europe (Wang et al. 2021). Despite these beginnings, widespread adoption was limited by technological constraints, inconsistent policy support, and weak market incentives.

A renewed push emerged with rapid urbanization and environmental concerns at the turn of the 21st century. The 1990s were pivotal: the government's *Outline for the Development of Industrialized Buildings* promoted industrialized construction as a national strategy, emphasizing technological upgrading, standardization, and alignment with international practice (Wang et al. 2021). From 1999 to 2015, policy innovation and market experimentation accelerated. Central and local governments introduced financial incentives, mandatory standards, and pilot projects to boost prefabrication, targeting reduced environmental footprints and improved resource efficiency via standardization and mechanization (Chang et al. 2018).

Since 2016, PC has been embedded in the national sustainability agenda. Under the 13th Five-Year Plan (2016–2020) and the ongoing 14th Five-Year Plan (2021–2025), ambitious targets were set—for example, making prefabricated buildings at least 30% of new urban construction in key regions, with some localities aiming higher (Gan et al. 2022, Yan et al. 2023). These initiatives are backed by regulatory frameworks, fiscal incentives, and measures such as increased floor-area ratios and preferential land-use policies, particularly visible in demonstration cities like Shenzhen (Gan et al. 2022). Nonetheless, implementation challenges persist: uneven local enforcement, unclear municipal guidelines, and misalignment between incentives and market capabilities contribute to patchy uptake across regions and sectors (Li et al. 2021, Hong et al. 2018).

2.2 | Market Dynamics in China

China's PC market has grown rapidly, shaped by macroeconomic conditions, technology progress, consumer acceptance, and competition. Estimates value the market at about US\$15.45 billion in 2022, growth closely linked to supportive government measures promoting sustainable, efficient, and low-carbon construction through financial incentives and relaxed lending conditions (Wang et al. 2024). Yet barriers remain: substantial upfront investment in specialized production, standardization/maturity gaps, and slower short-term returns deter especially small and medium enterprises (Hong et al. 2018, Li et al. 2021).

Competitive dynamics show marked differentiation among leading firms. Large players—including Shanghai Construction Group, China State Construction Engineering Corporation, Broad Homes, and Zhuyou Intelligent Manufacturing—shape standards and drive innovation, sustaining influence on market expansion and acceptance. Broad Homes,

for instance, specializes in prefabricated concrete for high-rise residential markets, while Hangxiao Steel Structure and Beixin Building Materials hold strong positions in steel and lightweight steel segments, respectively (Gan et al. 2022). Despite these leaders, the market remains fragmented: the top five firms held only about 36.8% of market share in 2022, indicating notable dispersion (Gan et al. 2022).

On the demand side, acceptance is uneven: adoption is concentrated in government-led public projects and lags in private residential markets. Limited consumer awareness and developers' underestimation of PC's economic and environmental benefits contribute to this disparity (Wang et al. 2024). PC also faces competition from traditional construction methods entrenched by legacy supply chains, design flexibility, and market familiarity. Emerging technologies (e.g., 3D printing; advanced wood/steel systems) present potential substitutes that may offer greater flexibility, cost efficiency, or speed, adding pressure to PC's diffusion (Gan et al. 2019).

Even so, rapid urbanization and a policy push for low-carbon growth continue to support PC's expansion. Ongoing improvements in technical standards and construction quality are expected to increase PC's appeal across broader market segments, including private developers and end users (Wang et al. 2024, Zhang et al. 2022). Importantly, differences in local demand profiles and policy regimes shape firms' willingness to shift from traditional on-site methods to PC models such as MiC (Abdelmageed and Zayed 2020) and to adopt the information systems needed to manage PC effectively (Tan et al. 2019).

2.3 | Theoretical Framework: Institutional Theory and Policy–Market Complementarity

Institutional theory provides a foundational lens for analyzing how formal and informal structures shape organizational behavior and system-wide change. At its core, institutional theory posits that organizational actions are embedded within broader social, political, and regulatory contexts that constrain or enable strategic choices (DiMaggio and Powell 1983, Scott 2014). In the context of industrial transformation, institutions—including policies, norms, and market logics—play a central role in directing technological change, guiding resource allocation, and shaping adoption behaviors (North 1990, Greenwood et al. 2011, Lissillour and Rodríguez-Escobar 2020). These have included firstly the coexistence of institutional logic, which tends to support the continuation of traditional practices, with sustainability logic, which provides the impetus for the implementation of new practices aimed to foster and facilitate market engagement (Viainon 2024). The institutional logic of Chinese firms has competing pressures and impacts their willingness or abilities to absorb new technologies and shift to new paradigms (Wang 2024).

A key advancement within institutional theory is the concept of *institutional complementarity*, which holds that institutions in different domains—such as public policy and market structure—can mutually reinforce one another to enhance system performance (Aoki 2001, Hall and Soskice 2001). This idea is especially relevant in sectors where

innovation diffusion relies not only on market demand but also on strong public coordination and regulation. When policy instruments and market mechanisms align, they can unlock synergies that accelerate adoption, reduce uncertainty, and foster sustainable growth (Rothwell 1985, Campbell 2004, Jackson and Deeg 2008).

In China's PC sector, which remains in a formative phase, institutional support is critical to overcoming structural bottlenecks such as high up-front costs, technological immaturity, and low consumer awareness. At the same time, market responses—firm investments, competitive strategies, and customer uptake—feed back into how policies are implemented and adapted. Thus, the interaction between policy incentives and market receptivity constitutes a form of institutional complementarity that shapes the industry's development trajectory.

2.3.1 | Evolution of Policy Support in China

China's central government has long promoted prefabrication as part of broader goals for industrial upgrading and environmental sustainability. Policies such as the *National Plan on New Urbanization (2014–2020)* and the *Green Building Action Plan (2013)* emphasized industrialized building practices to improve efficiency and reduce environmental impact (Gan et al. 2022, Yan et al. 2023).

Compared with international exemplars (e.g., Singapore's mandatory PPVC framework), China's policy landscape often faces limited enforceability, inconsistent local adaptation, and fragmented administrative responsibilities (Su et al. 2023, Wuni and Shen 2019). Local governments may set ambitious targets, yet enforcement mechanisms can be weak and regional disparities persist (Li et al. 2021, Hong et al. 2018).

2.3.2 | Market Maturity and Synergy with Policy

As observed in Hong Kong (Jaillon and Poon 2009), China's PC market exhibits uneven demand: uptake is stronger in government-led projects and weaker in the private sector. Policy effectiveness depends not only on top-down mandates but also on market readiness. Without complementary demand from developers, end-users, and financiers, policy incentives may not translate into sustained adoption (Wuni and Shen 2020a). Fragmented supply chains, unclear value propositions for consumers, and uncertain returns on investment limit traction in many regions (Hong et al. 2018, Li et al. 2021).

Institutional theory suggests policy and market mechanisms must interact synergistically to enable effective implementation (Hall and Soskice 2001, Jackson and Deeg 2008). In practice, however, these forces often operate in parallel rather than in concert, resulting in partial or symbolic compliance (Hong et al. 2018).

2.3.3 | Cost and Financial Barriers

Echoing UK evidence (Goodier and Gibb 2007), the success of prefabrication hinges on both capital investment in modular infrastructure and wider industry readiness for process innovation. One of China's most significant barriers is high up-front cost: factory equipment, molds, specialized logistics, and workforce training require substantial capital (Hong et al. 2018, Mao et al. 2016). Studies report prefabricated projects can cost 2%–17% more per unit than conventional construction, with some estimates as high as 27%–109% for large-scale precast projects (Mao et al. 2016).

These premiums are compounded by customization demands, fragmented procurement, and limited economies of scale. While labor savings and faster timelines can offset costs, benefits tend to materialize in large or repeat projects. Lifecycle cost–benefit analysis remains underused, and lenders rarely price in long-term savings when underwriting loans (Hong et al. 2018, Wuni and Shen 2020a).

2.3.4 | Role of Technology and Management Tools

Advanced technologies such as building information modeling (BIM), digital design platforms, and automated systems are critical enablers of prefabrication. BIM supports clash detection, precise coordination, and optimized scheduling—capabilities essential for modular implementation (Tan et al. 2019). Yet BIM implementation in China remains uneven due to limited domestic software tailored to PC, interoperability gaps, and steep learning curves (Tan et al. 2019). Despite its potential to reduce errors, waste, and delays, adoption is inconsistent, particularly among small and mid-sized firms (Hong et al. 2018).

Recent developments—such as the Product Architecture Model (PAM) for integrating digital tools with modular workflows—offer promise but remain underutilized in practice (Ramaji and Memari 2016). More broadly, BIM (a digital representation of a built facility (Eastman et al. 2011)) has been shown to assist PC through tighter integration across design, manufacturing, and assembly (Chen et al. 2018, Jiang et al. 2022). While technical, managerial, environmental, financial, and legal barriers can impede BIM roll-out, evidence suggests that once learning curves are overcome, efficiency gains follow (Tan et al. 2019).

2.3.5 | Institutional Complementarities and Stakeholder Coordination

Prefabrication relies on coordinated action among diverse stakeholders—developers, contractors, manufacturers, regulators, and end users. Institutional theory emphasizes that such coordination depends on complementarity among formal rules, technical systems, and social norms (Scott 2014, DiMaggio and Powell 1983).

Absent shared standards, synchronized workflows, and early contractor involvement, the full potential of prefabrication is difficult to realize

(Wuni and Shen 2020b). In particular, weak integration between off-site production and on-site assembly often produces bottlenecks and quality issues (Tan et al. 2019). International best practices such as *Integrated Project Delivery (IPD)* and *Design for Manufacture and Assembly (DfMA)* remain rare in China despite demonstrated effectiveness in modular contexts (Hong et al. 2018), signaling a gap between policy aspirations and organizational routines.

A learning curve characterizes PC uptake, tied to both cost issues and supply chain maturation (i.e., institutional complementarities). Adoption of MiC and BIM is still sporadic; thus, policy needs to align with market demand to support and incentivize PC so that all stakeholders can perceive and experience its benefits.

2.3.6 | The Effectiveness of PC Policy in China

Policy is effective when it addresses constraints across all stakeholders. Although China has established and implemented a comprehensive PC policy framework, its effectiveness still requires systematic evaluation (Jiang et al. 2019). At the micro level, the PC industry exhibits moderate efficiency; further gains would require technological innovation and higher levels of standardization, mechanization, and automation. At the macro level, industrial efficiency remains low and indicative of an early development stage; small industrial scale and comparatively weak policies restrict rapid and efficient growth (Shang et al. 2022).

In developing countries, environmental concerns drive residential-building policy. Supportive PC policies—including land, fiscal, and financial incentives for developers adopting PC methods—significantly increase labor productivity and reduce material use (Gao and Tian 2020). By contrast, purely directive policies (i.e., targets without enforcement or incentives) do not yield similar effects when implemented in isolation. Evidence also shows off-site construction benefits from environmental policies, with the market environment playing a mediating role; nurturing that environment can improve developer adoption and accelerate sectoral development, highlighting environmental policy instruments as key levers (Xue et al. 2021).

In China, documented effects of PC include reduced carbon emissions and resource consumption, productivity gains, and positive associations with regional technological innovation (Wang et al. 2024, Zhang et al. 2022). The success of directive policy often rests on supportive policy: supportive measures raise labor productivity and minimize material waste, whereas directive measures alone lack bite without enforcement or incentives (Gao and Tian 2020). Again, the market environment mediates policy impact, suggesting complementary measures are essential (Xue et al. 2021).

Because prefabricated buildings involve many participating enterprises, challenges arise across technology, cost, construction management, supply chain management, and sustainability. Improving the entire supply chain is therefore vital; when synergy is achieved, development of the PC industry becomes more favorable (Liu et al. 2024). More broadly, developing PC requires structural changes in both policy

design and the capabilities of suppliers and manufacturers (Geels et al. 2016).

Provincial policies have been important catalysts in China, spanning environmental, demand-side, and supply-side instruments; however, Chinese policy has leaned heavily on directive environmental tools, with demand/supply policies relatively underused. Given PC's potential to replace conventional on-site construction – through productivity improvements, cost and time reductions, lower waste, emissions, energy and water use, reduced labor intensity and improved safety – a rebalancing towards demand and supply instruments is warranted. PC can help meet time-bound housing needs and shift the construction industry from labor dependence toward a more knowledge-based model. However, lock-in to traditional methods, gaps in codes and standards, and limited technological capabilities among suppliers and manufacturers remain barriers to transition. A portfolio of demand- and supply-focused policy initiatives can help reduce these barriers and foster adoption (Yan et al. 2023).

3 | METHODOLOGY

3.1 | Study One: Qualitative Case Study

3.1.1 | Case Selection and Rationale

In the spirit of indigenous scholarship (Rodriguez-Escobar 2024), to explore how policy support and market conditions interact in practice, we conducted an in-depth case study of the Shenzhen Meilin Affordable Housing Project (Futian District, Shenzhen). This project was selected due to its prominence as a government-led demonstration of PC under China's 14th Five-Year Plan. It embodies a convergence of top-down policy intervention, technological innovation, and evolving market expectations—a rich site for examining institutional complementarity in action (Aoki 2001, Hall and Soskice 2001).

Case study methodology is well suited to complex social phenomena in real-life contexts (Stake 1995, Yin 2018). Given the exploratory nature of our research questions, a single-case design supports deep contextual understanding and process tracing that can inform theoretical generalization (Flyvbjerg 2006). Within the broader historical and policy context, the Shenzhen Meilin project exemplifies the interplay between policy instruments and market responses, providing an ideal context for identifying mechanisms that facilitate or impede policy-market synergy in PC.

3.1.2 | Data Collection and Fieldwork

Fieldwork was conducted between February and April 2025. So as to get close to the actual practices of those who embody this supply chain (Lissillour and Silva 2024), we employed a qualitative approach combining site visits, document analysis, and semi-structured interviews with key stakeholders.

TABLE 1 Interview list (per-person duration shown)

Stakeholder	Number of Interviews	Duration
Shenzhen Anju Group (developer/client)	2	30–45 minutes
China State Hailong Technology Co.	3	45–60 minutes
China Overseas Construction Ltd.	3	45–60 minutes
Shenzhen Housing and Construction Bureau	2	30–45 minutes

Interviewees were selected for their direct involvement in planning, design, policy compliance, and implementation. A semi-structured interview guide probed themes including policy support, standard setting, technological adaptation, market responsiveness, cross-organizational coordination, and cost–benefit perceptions (Rubin and Rubin 2012, Kvale and Brinkmann 2015). The guide was informed by institutional theory and policy–market complementarity (Scott 2014, Hall and Soskice 2001, Greenwood et al. 2011) and tailored to the project context via pre-interviews with academic and industry experts. Open-ended questions enabled narrative responses while maintaining thematic consistency across interviews (Eisenhardt 1989, Stake 1995, Yin 2018).

All interviews were transcribed, coded, and thematically analyzed, identifying patterns across stakeholder groups and triangulating with project documents and site observations (Miles et al. 2014).

3.1.3 | Analytical Focus

The analysis traced the interplay between policy instruments and market responses across the full project lifecycle—from initiation and planning through structural completion. We paid particular attention to how institutional dynamics shaped strategic decisions on technology use, design choices, stakeholder coordination, and operational efficiency (Greenwood et al. 2011, Scott 2014). We also examined how actors interpreted and negotiated regulatory expectations (e.g., green building standards, prefabrication quotas) and market imperatives (e.g., consumer preferences, project feasibility), to identify enablers and constraints of policy–market synergy and to inform the conceptual framework tested in Study 2 (DiMaggio and Powell 1983, Jackson and Deeg 2008).

3.2 | Study Two: Quantitative SEM (Survey of Firms Across China)

3.2.1 | The SEM Model

Study 2 builds on the qualitative findings of the Shenzhen Meilin case (Study 1) by testing relationships among institutional drivers, mediators, and outcomes via structural equation modeling (SEM). The goal is to validate the conceptual model of policy–market synergy and identify boundary conditions in China’s PC industry. A survey was used to capture perceptions and practices across firms spanning design, manufacturing, and construction. This sequential explanatory design (Creswell and Plano Clark 2017) enables theoretical insights

from Study 1—particularly the interaction of policy, market, technology, and collaboration—to be generalized empirically with a larger industry sample.

The instrument drew on institutional theory and was refined from themes emerging in the case study. Items were inspired by prior literature and adapted to the Chinese PC context. All constructs were measured using multiple items on a five-point Likert scale (1 = *strongly disagree*, 5 = *strongly agree*).

Reliability analysis indicated all constructs had Cronbach’s $\alpha > 0.78$, demonstrating acceptable internal consistency (see Table 7).

3.2.2 | Sampling and Data Collection

A structured questionnaire was administered from February to April 2025 to firms engaged in PC across multiple regions in China. We obtained 246 valid responses from developers, contractors, technology providers, and design consultancies directly involved in PC projects. The sample covers first-tier cities (e.g., Shenzhen, Shanghai, Beijing), second-tier urban centers, and several policy pilot cities.

Regarding experience, 34.15% of firms reported >10 years in PC, 16.67% had 5–10 years, and 36.59% had 1–5 years. In terms of size, 69.11% had <100 employees, 22.76% had 100–500, and 8.13% had >500. Notably, 42.3% of respondents held senior managerial or technical leadership roles.

This diverse and experienced sample supports the validity and generalizability of the SEM analysis and allows robust testing of how institutional drivers and organizational capabilities shape perceptions of PC promotion effectiveness.

3.2.3 | Analytical Strategy

Data were analyzed using SEM in AMOS 28.0. The procedure followed three stages:

1. **Confirmatory Factor Analysis (CFA)** to assess construct validity, reliability, and convergent/discriminant validity.
2. **Structural model estimation** to test hypothesized relationships among policy support (X1), market awareness (X2), policy–market synergy (M), and industry expectations (Y).
3. **Moderated mediation analysis** to examine whether industry chain synergy (m1) and technology/cost conditions (m2) moderate the indirect paths from X1 and X2 to Y via M.

TABLE 2 Interview guideline: core themes and sample questions

Theme	Focus Area	Sample Questions
1. Policy Support	Perception and impact of policy instruments	– Are current policies (e.g., subsidies, tax breaks, FAR incentives) sufficient to support PC? – Which specific policies most influenced your firm’s decisions?
2. Market Fit and Demand	Market alignment, consumer preferences, design adaptation	– How well do standard housing units match target-population needs? – To what extent did market trends or consumer preferences inform planning?
3. Industry Chain Synergy	Supply chain coordination and production–construction integration	– Where in the PC supply chain did coordination challenges arise? – Did component standardization match on-site installation needs?
4. Technology and Cost Conditions	Technological readiness, innovation adoption, financial viability	– How did you assess technical and economic feasibility of modular construction? – What role did innovations (e.g., C-MiC, smart cranes, robots) play in cost control or productivity?
5. Institutional Coherence and Expectations	Strategic outlook, alignment, future prospects	– How did alignment (or misalignment) of policy and market conditions shape long-term expectations? – Have your views on PC changed during the project? If so, why?

All latent variables were modeled reflectively. Overall model fit was evaluated using standard indices (CFI, RMSEA, SRMR). Indirect effects were tested with bootstrap confidence intervals.

3.2.4 | Ethical Considerations

Participation was voluntary and all responses were anonymized. The research design was approved by the academic ethics committee of PSB Paris School of Business, and informed consent was obtained from all participants.

4 | RESULTS OF STUDY

4.1 | The Case of Shenzhen Meilin Housing Project

4.1.1 | Context and Origins

The Shenzhen Meilin Project, located at No. 6 Meilin Road, Futian District, Shenzhen, was developed amid rapid urbanization, rising housing

demand, and a stronger emphasis on sustainability in construction. Traditional on-site methods—with long build times, intensive resource use, and notable environmental impacts—were increasingly inadequate to meet contemporary needs (Gan et al. 2022). Prefabricated construction (PC) emerged as a viable pathway to shorten timelines, reduce environmental footprints, and improve quality (Wang et al. 2021). Aligned with national sustainability goals and supportive policies, the Shenzhen Meilin project both addresses affordable housing needs and serves as a demonstration of PC innovation in a dense urban context.

4.1.2 | Project Overview

Jointly undertaken by China State Hailong Technology Co. Ltd. and China Overseas Construction Ltd., the project occupies approximately 44,500 m², with two basement levels and 30 floors above ground (nearly 100 m in height). Scheduled for completion in June 2025, it will provide 696 affordable rental units in two standardized sizes: 40 m² (singles/small households) and 70 m² (families of three to four). Upon delivery, the project is expected to alleviate local affordable housing shortages and improve living standards in Futian District.

TABLE 3 Questionnaire constructs

Construct	No. of Items	Sample Item	Source
Policy Support (X1)	4	"Current subsidies and incentives reduce the risks of prefabrication adoption."	(Pan et al. 2012)
Market Awareness (X2)	4	"Our firm has noticed increasing market demand for green prefabricated buildings."	(Jaillon and Poon 2009)
Industry Chain Synergy (m1)	4	"There is effective coordination across design, production, and on-site assembly."	(Zhu et al. 2024, Xu et al. 2020)
Technology and Cost Conditions (m2)	4	"Current technology maturity enables cost-effective modular construction."	(Goodier and Gibb 2007)
Policy–Market Synergy (M)	4	"Government policy and market signals are aligned in promoting prefabricated construction (PC)."	(Bird et al. 2005, Kivimaa and Kern 2016)
Industry Expectations (Y)	4	"We expect the prefabricated construction (PC) sector to grow rapidly over the next five years."	(Greenwood et al. 2011)

TABLE 4 Sample characteristics

Category	Subcategory	Frequency	Percentage (%)
Firm Type	Precast component manufacturing	4	1.63
	Architectural design and consulting	86	34.96
	Construction and installation	98	39.84
	Tech R&D and services	38	15.45
	Other	20	8.13
Region	Eastern China	211	85.77
	Central China	12	4.88
	Western China	21	8.54
	Northeast China	1	0.41
	Overseas	1	0.41
Firm Size (Employees)	< 100	170	69.11
	100–500	56	22.76
	> 500	20	8.13
Years in PC Business	< 1	31	12.60
	1–5	90	36.59
	5–10	41	16.67
	> 10	84	34.15

4.1.3 | Technical Innovation and Development

From inception, the project prioritized modular methods suited to high-density urban settings. Following R&D and scheme comparison, the team adopted a proprietary Concrete Modular Integrated Construction (C–MiC) approach. The building is segmented into ~800 modules—each completed off-site (structural components, plumbing, electrical, interior finishes)—and then transported for on-site assembly.

Key technical challenges included high-precision modular manufacturing, safe transport/assembly, and reliable module connectivity. Investments in advanced CNC processing and rigorous quality protocols ensured manufacturing precision. Specialized transport and hoisting

equipment, alongside detailed procedural guidelines, supported safe assembly. Innovative connection systems combining high-strength bolts with welding enhanced structural reliability and integrity (Jiang et al. 2022).

4.1.4 | Policy Support and Market Awareness

The Shenzhen Meilin Affordable Housing Project illustrates how institutional drivers—namely policy support and market awareness—jointly initiate and shape the implementation of PC. As part of the 14th Five-Year Plan’s national demonstration initiatives, the project received a

TABLE 5 Descriptive Statistics, Correlations, and Reliability Coefficients

	Mean	SD	1	2	3	CR
1. Meaning	4.09	0.77	1			0.93
2. Competence	4.30	0.51	.355**	1		0.86
3. Self-Determination	3.65	0.75	.170 (ns)	.164 (ns)	1	0.74
4. Impact	3.50	0.70	.007 (ns)	-.056 (ns)	.248*	0.68

* $p < .05$, ** $p < .01$, ns = non-significant ($p > .05$)

Source: Survey Data, 2024

strong suite of policy interventions, including financial subsidies, favorable land-use conditions, density bonuses, and green building performance mandates (Gan et al. 2022, Yan et al. 2023). These instruments provided both coercive and enabling pressures, reducing uncertainty for participating firms and aligning the project with China's broader low-carbon urbanization agenda.

Interviewees from both the public and private sectors confirmed the crucial role of policy instruments in enabling project initiation and technological experimentation. For example, executives from China State Hailong emphasized that financial subsidies and technical guidance allowed them to absorb the high up-front costs of adopting the C-MiC modular system, while officials from the Housing and Construction Bureau highlighted the project's symbolic role as a proof-of-concept for next-generation green construction.

Simultaneously, the project's market orientation emerged through demand-side analysis. Before construction, Shenzhen Anju Group conducted research into the preferences of target residents—primarily young professionals and low- to middle-income families—which informed the adoption of 40 m² and 70 m² standardized apartment layouts. These were further enhanced via award-winning interior designs featuring foldable furniture, space-saving configurations, and hidden storage systems, reflecting proactive sensitivity to evolving consumer expectations.

However, interviews revealed that policy support and market awareness often operated in parallel rather than fully synergistically. While many firms recognized the reputational and strategic value of participating in a government-backed project, not all were equally attuned to granular end-user demands. Some respondents noted that firms complied with prefabrication quotas to meet formal requirements but were hesitant to embrace user-centric design innovations due to cost or technical constraints.

This empirical distinction supports the model's conceptual separation of Policy Support (X_1) and Market Awareness (X_2) as distinct yet complementary forces. The Shenzhen Meilin project thus demonstrates how formal institutional pressures and market-driven logics co-exist but do not automatically align. Their interaction—or lack thereof—influenced firm behaviors, stakeholder coordination, and the perceived legitimacy of PC, justifying our treatment of policy and market as independent variables whose effects should be analyzed both individually and in relation to their potential synergy.

4.1.5 | Synergy between Policy and Market

Although policy support and market awareness were both present, their interaction was uneven—oscillating between coordinated alignment and superficial compliance. In segments where government mandates (e.g., prefabrication quotas, green building certifications) converged with genuine market incentives (e.g., demand for affordable, livable housing), implementation was smoother and more innovative. For instance, the integration of solar PV and rainwater harvesting technologies aligned with national carbon-reduction goals and local expectations for energy efficiency and comfort.

In other segments, coordination across institutional domains was limited. Interviews indicated that some developers and contractors complied with the letter of the policy—meeting minimum prefabrication ratios—while avoiding deeper investments in technological upgrading or quality improvements. Respondents cited risk aversion, unclear cost-recovery mechanisms, and insufficient downstream market feedback as reasons for a compliance-oriented rather than innovation-driven approach.

Stakeholders frequently highlighted a disconnect between formal policy incentives and actual market behavior. Although housing authorities promoted standardized modular designs, some firms struggled to reconcile these with nuanced spatial and lifestyle preferences of target residents. Similarly, while green building standards were enforced, developers sometimes prioritized cost savings over full integration of green technologies under tight delivery schedules.

Such inconsistencies indicate that synergy is conditional, requiring operational alignment of policy and market drivers across design, production, and delivery. The Shenzhen Meilin case therefore supports conceptualizing Policy-Market Synergy (M) as a mediating variable shaped by the degree of mutual reinforcement between formal institutional pressures and market responsiveness.

4.1.6 | Industry Chain Synergy

The project revealed the critical role of supply-chain integration and inter-organizational collaboration in determining PC outcomes. While policy frameworks and technological blueprints provided an enabling foundation, alignment across design, production, logistics, and on-site assembly ultimately shaped performance.

Interviewees consistently pointed to coordination between China State Hailong Technology (off-site modular production) and China Overseas Construction (on-site installation) as pivotal. Where early collaboration occurred—for example, co-design workshops to harmonize module dimensions, interface standards, and delivery sequencing—implementation proceeded efficiently, aided by shared digital tools (notably BIM) that supported real-time adjustment and cross-functional coordination.

Conversely, weaker collaboration produced execution bottlenecks: mismatches between production timelines and site readiness, gaps between design specifications and actual hoisting conditions, and inconsistent understanding of installation protocols. These issues led to idle equipment, rework, and elevated costs. Some developers reported that although upstream suppliers optimized workflows, downstream contractors remained reliant on traditional practices, undermining system-wide synergy.

Accordingly, we identify Industry Chain Synergy (m_1) as a critical moderating variable in the institutional model. Even with strong policy and market conditions, fragmented supply chains and siloed actors can dilute the transformative potential of prefabrication. Projects that integrate early supplier–contractor coordination and emphasize digital integration tools are more likely to translate institutional pressures into meaningful performance gains.

4.1.7 | Technology and Cost Conditions

Technological innovation played a pivotal role in shaping the implementation trajectory of the Shenzhen Meilin Affordable Housing Project. The project adopted the C–MiC system—a proprietary high-rise prefabrication technology developed by China State Hailong. This system subdivided the building into approximately 800 high-precision modules, each factory-assembled with structural, plumbing, electrical, and interior elements before being transported and installed on site. These modules exemplify the “car-like manufacturing” concept, promoting standardization, quality control, and rapid assembly (Wang et al. 2024).

However, while the C–MiC system significantly improved productivity and environmental performance, firms involved in the project faced multiple technical and financial barriers. Interviewees consistently highlighted three key concerns: (1) high upfront costs associated with mold fabrication, CNC machining systems, and transport logistics; (2) a shortage of skilled workers familiar with modular design and robotic assembly; and (3) long cost-recovery cycles typical in affordable housing development.

Smart construction technologies, such as automated tower cranes and construction robots, were also deployed. These innovations increased safety and precision while reducing on-site labor needs. Additionally, an integrated digital traceability system—using a “one module, one code” (一模块一码) model—enabled real-time monitoring of production and installation, enhancing quality assurance. Yet, the financial return on such investments remained uncertain in the absence of large-scale market replication.

These observations illustrate that even under favorable policy and market conditions, technical readiness and economic viability remain critical boundary conditions. Technology and cost conditions (m_2) thus function as a moderating factor in the conceptual model, conditioning the relationship between market awareness and construction firms’ perceptions of promotion effectiveness. This aligns with contingency theory (Donaldson 2006) and recent literature highlighting the capital intensity and skill dependency of modular building innovation (Guo et al. 2023, Hong et al. 2018).

4.1.8 | Industry Expectations Evolution

Stakeholders’ expectations regarding the future of PC evolved significantly over the course of the Shenzhen Meilin project. Initial attitudes among developers, contractors, and policy actors were mixed—tempered by concerns over high capital costs, uncertain returns, and operational unfamiliarity with modular systems.

As the project progressed and technical milestones were achieved—including the first module hoisting on 15 August 2024 and full structural topping-out in just 148 days (by 10 January 2025)—stakeholder sentiment became markedly more positive. These outcomes compared favorably with traditional methods, where similar structures typically require over a year to reach comparable stages. The speed, precision, and reduced disruption associated with the C–MiC system enhanced confidence in both the feasibility and scalability of PC.

Expectations shifted most in contexts where policy direction, market acceptance, and technical delivery were mutually reinforcing. For instance, developers who integrated consumer-oriented design features—such as award-winning compact apartment layouts and modular customization—reported stronger alignment with market preferences and greater confidence in long-term demand. Meanwhile, government representatives emphasized how lessons from the Shenzhen Meilin case were informing refinements to Shenzhen’s prefabrication policy guidelines, indicating the emergence of a policy learning loop.

This evolving perception supports the designation of *Expectation of Industry Development and Promotion* (Y) as the dependent variable. Firms perceiving greater institutional coherence—where policy instruments, technological systems, and market logics converged—developed more optimistic projections for the industry’s future. Conversely, stakeholders operating amid poor coordination or limited financial return expressed persistent skepticism.

The findings from Study 1 provide empirical grounding for the design of Study 2’s structural model. They suggest that policy support and market conditions are critical institutional drivers of promotion effectiveness, while cost perception, technological readiness, and stakeholder coordination act as mediating or moderating mechanisms. The themes identified here are translated into testable constructs in the next stage of the analysis.

TABLE 6 Conceptual linkage from case evidence to SEM constructs

Finding	Case Evidence (Shenzhen Meilin)	SEM Construct	Role
Strong but uneven policy implementation	Government subsidies, land-use perks, density bonuses	Policy Support (X_1)	Independent variable
Market responsiveness varies with awareness	Apartment mix decisions and user feedback shaping layouts	Market Awareness (X_2)	Independent variable
Policy–market alignment determines effectiveness	Coordinated work between CSCEC & Hailong; green mandates plus livability goals	Policy–Market Synergy (M)	Mediator
Supply-chain (industry chain) misalignment affects implementation	Timing mismatches, interface standards gaps, installation protocol variance	Industry Chain Synergy (m_1)	Moderator
Cost & technology readiness condition adoption	C–MiC investment, cost amortization, factory production capacity	Technology & Cost Conditions (m_2)	Moderator
Stakeholders' forward-looking views vary	Optimism after rapid topping-out; positive policy-learning loop	Expectation of Industry Development (Y)	Dependent variable

4.2 | Study 2—Survey and Structural Equation Modeling

This study adopts an institutional-complementarity perspective to examine the mechanisms through which policy and market factors jointly influence the diffusion and perceived effectiveness of prefabricated construction (PC). Specifically, Study 2 employs a structural equation modeling (SEM) approach to test how policy support and market conditions impact key mediators such as technological adoption, cost perception, and stakeholder collaboration, which in turn affect firms' assessment of the effectiveness of industry-promotion strategies.

The model is grounded in three propositions from institutional theory. First, *policy as an enabling institution*: public policies provide incentives and reduce uncertainty, thereby shaping firms' strategic behavior (Scott 2014, Campbell 2004). Second, *market as a legitimizing institution*: market signals—such as customer demand, competitive pressure, and investor interest—contribute to the institutionalization of new practices (Tolbert and Zucker 1983). Third, *synergy through complementarity*: alignment between policy and market logics enhances organizational responsiveness, fosters innovation adoption, and improves perceived outcomes (Hall and Soskice 2001, Jackson and Deeg 2008).

By modeling these relationships empirically, the study contributes to the literature on policy–market interaction in sustainability transitions (Geels 2004, Kivimaa and Kern 2016) and demonstrates how institutional theory can inform the design of more effective promotion strategies in emerging green industries.

4.2.1 | Hypothesis Development

Institutional theory posits that organizations are embedded within formal and informal institutional environments that shape strategic behavior, expectations, and outcomes (Scott 2014, DiMaggio and Powell 1983). In the context of PC in China, *policy support* represents formal institutional pressure—often top-down and regulatory in nature—whereas

market awareness reflects semi-formal and normative pressures arising from societal preferences, competitive dynamics, and consumer demand.

A key concept is *institutional complementarity*—the idea that distinct institutional domains (e.g., policy and market) may interact in mutually reinforcing ways to reduce uncertainty and improve performance (Hall and Soskice 2001, Jackson and Deeg 2008). When policy and market logics are aligned, firms are more likely to adopt innovative and sustainable practices. Building on this lens, we also draw selectively on innovation-diffusion theory, synergy theory, sustainable development theory, industrial organization (SCP), and contingency theory to specify mechanisms and boundary conditions.

4.2.2 | Policy Support and Market Awareness effects on Industry Expectations

In institutional theory, *policy support* acts as a formal structure that shapes organizational decision-making via regulatory incentives, goal-setting, and legitimization (Rothwell 1985, Campbell 2004). Clear signals—through subsidies, quotas, or pilots—reduce uncertainty and coordinate firm behavior toward common goals. This aligns with innovation-diffusion theory (Rogers 1995), which emphasizes policy's role in lowering perceived adoption risk. In PC, instruments such as construction subsidies, technical standards, and land-use policies are designed to accelerate diffusion. Policies also target multiple levers (e.g., adoption goals, implementation control, economic incentives, standards), supporting firms' decisions to move to prefabrication based on perceived strategic relevance (Xu et al. 2020).

H1: Policy support (X_1) has a positive effect on firms' expectations of industry development and promotion (Y).

From an institutional standpoint, *market awareness* reflects cognitive and normative pressures that shape strategic orientations. When firms perceive increasing market receptivity—via consumer demand,

peer competition, or investor interest—they are more likely to invest in new technologies or adapt business models (Greenwood et al. 2011). Sustainable-development theory further suggests that demand for green buildings and lifecycle efficiency can generate demand-side momentum, while innovation-diffusion theory implies that early market interest advances the adoption curve, especially when paired with enabling institutions. In PC, innovation may be driven by process redesign and information systems (Tan et al. 2019) and by evolving cost perceptions (Hong et al. 2018).

H2: Market awareness (X_2) has a positive effect on firms' expectations of industry development and promotion (Y).

4.2.3 | Policy–Market Synergy as Mediator

Institutional complementarity suggests that when policy and market mechanisms are aligned, they can amplify each other's effects. Such alignment reduces uncertainty, increases legitimacy, and encourages strategic investment (Hall and Soskice 2001). Synergy theory (Haken 1977) similarly proposes that nonlinear interactions among system components can produce outcomes greater than the sum of their parts. In PC, feedback loops are evident: policy creates market conditions (e.g., demand for green housing) while market responses (e.g., consumer feedback) refine policy design. This synergy strengthens institutional coherence, accelerating innovation, cost reduction, and performance (Wang 2024). Evidence also suggests that policy–market synergy increases firms' confidence to switch to PC models (Pan et al. 2012).

H3: Policy–market synergy (M) positively affects firms' expectations of industry development and promotion (Y).

H4: Policy–market synergy (M) mediates the relationships between (a) policy support (X_1) and (Y), and (b) market awareness (X_2) and (Y).

4.2.4 | The moderating role of industry chain synergy and technology–cost conditions

Institutional theory recognizes that the strength of institutional effects depends on implementation structures. In the case of policy support, its translation into action hinges on how well the supply chain is integrated. Drawing on industrial organization—especially the Structure–Conduct–Performance (SCP) paradigm—a well-synchronized industry chain (e.g., shared component factories, BIM-based coordination) facilitates information flow, reduces transaction costs, and enables collaborative innovation, thereby amplifying policy effects. Conversely, fragmentation dilutes policy transmission and weakens outcomes (Wu et al. 2021). In short, a developed supply chain and a cost structure with high certainty can strengthen the impact of policy–market demand synergy.

H5: Industry chain synergy (m_1) positively moderates the relationship between policy support (X_1) and policy–market synergy (M).

While institutional theory provides a general framework, contingency theory emphasizes that the success of institutional arrangements depends on context (Donaldson 2006). In PC, technology and cost conditions determine whether firms can respond to market signals in a viable, scalable way. For example, standardized modular systems or 3D printing can reduce costs and improve quality, enabling firms to capitalize on rising demand; when technologies are immature or cost structures prohibitive, even strong market awareness may not translate into strategic investment (Guo et al. 2023). A predictable PC cost structure likewise enhances the effect of policy–market synergy.

H6: Technology and cost conditions (m_2) positively moderate the relationship between market awareness (X_2) and policy–market synergy (M).

Figure 1 presents the conceptual framework grounded in institutional theory and policy–market complementarity. Two core institutional drivers—policy support (X_1) and market awareness (X_2)—jointly influence firms' expectations of industry development and promotion (Y), with policy–market synergy (M) as the mediator. Two moderators reflect key contextual conditions: industry chain synergy (m_1) and technology/cost conditions (m_2). Together, these components form a multi-level framework for testing both direct and conditional relationships while accounting for coordination mechanisms, technological feasibility, and institutional alignment.

4.2.5 | Measurement of variables and validity testing

To operationalize the constructs derived from the conceptual model, we developed a structured questionnaire using multi-item Likert scales (1 = strongly disagree, 5 = strongly agree). Items were adapted from validated instruments and refined for the PC context in China. Table 7 summarizes constructs, codes, items, reliabilities, and sources.

All constructs were modeled reflectively. *Policy support* captured perceptions of subsidies, quotas, and regulatory guidance; *market awareness* reflected responsiveness to demand and competition; *synergy* constructs assessed cross-institutional alignment; and *expectations* gauged strategic outlook.

Psychometric evaluation showed strong properties: (i) internal consistency with Cronbach's $\alpha > 0.70$ for all scales; (ii) composite reliability (CR) > 0.80 ; (iii) average variance extracted (AVE) > 0.50 indicating convergent validity; and (iv) discriminant validity via the Fornell–Larcker criterion, with the square roots of AVE exceeding inter-construct correlations (Nunnally and Bernstein 1994). The measurement model thus supports robust structural analysis.

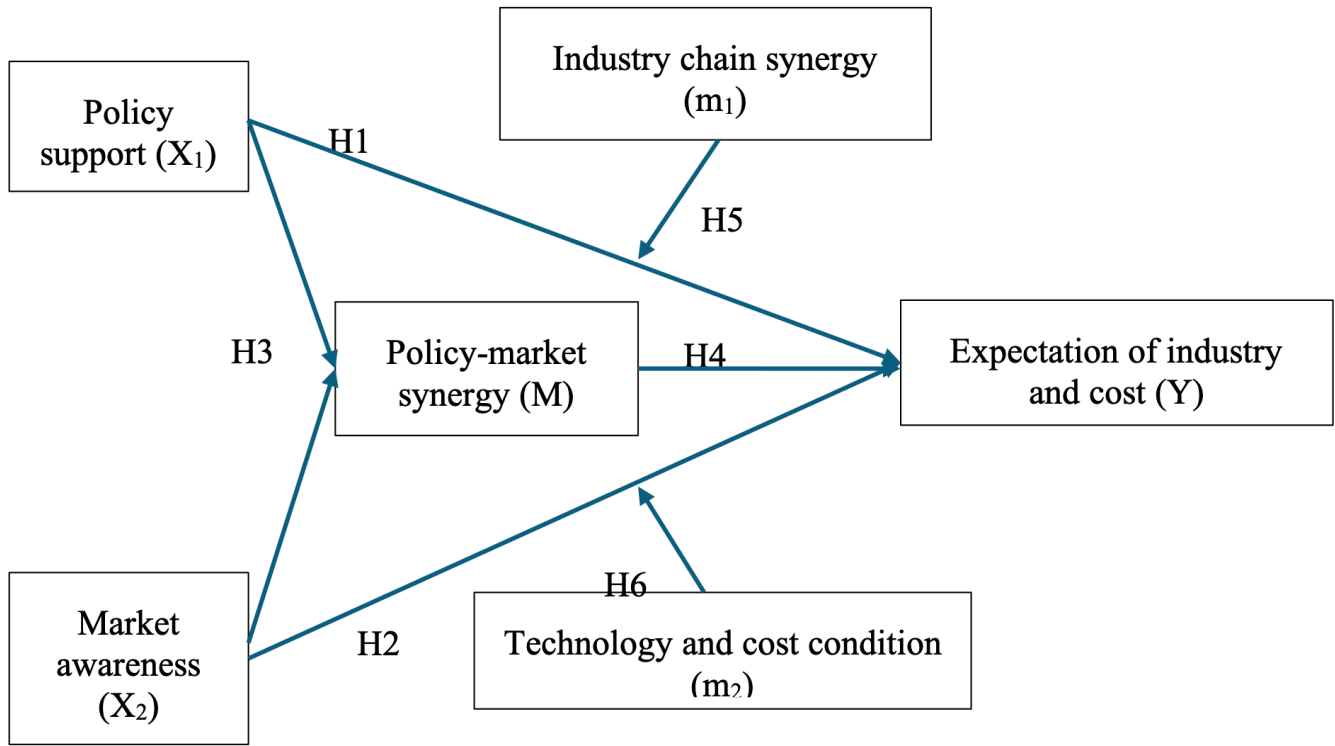


FIGURE 1 Conceptual model.

TABLE 7 Construct operationalization and reliability

Construct	Code	# Items	α	Reference
Policy Support	X1	4	0.951	Cai et al. (2023), Xu et al. (2020)
Market Awareness	X2	4	0.782	Li (2009), Ma et al. (2024)
Industry Chain Synergy	m_1	4	0.897	Zhu et al. (2024), Xu et al. (2020)
Technology and Cost Conditions	m_2	4	0.850	Wang et al. (2019), Shao and Cao (2024)
Policy–Market Synergy	M	4	0.956	Bird et al. (2005), Brewer (1993)
Expectations of Industry Development & Promotion	Y	4	0.922	Developed for this study

TABLE 8 SEM goodness of fit

Fit index	Threshold	Value
χ^2/df	< 3.0	2.136
RMSEA	< 0.08	0.063
CFI	> 0.90	0.944
TLI	> 0.90	0.927
SRMR	< 0.08	0.041

TABLE 9 Hypothesis testing results

Path	Hyp.	Std. Coef. (β)	p-value	Result
$X_1 \rightarrow Y$	H1	0.241	< .01	Supported
$X_2 \rightarrow Y$	H2	0.276	< .01	Supported
$M \rightarrow Y$	H3	0.368	< .001	Supported
$X_1 \rightarrow M \rightarrow Y$	H4a	Indirect: 0.192	< .01	Supported
$X_2 \rightarrow M \rightarrow Y$	H4b	Indirect: 0.210	< .01	Supported
$X_1 \times m_1 \rightarrow M$	H5	Interaction: 0.139	< .05	Supported
$X_2 \times m_2 \rightarrow M$	H6	Interaction: 0.187	< .05	Supported

4.2.6 | Structural model specification and hypothesis testing

Following measurement validation, we estimated the structural model in AMOS 26.0 to test direct, indirect, and moderated paths among latent variables. The model exhibited good fit (Table 8).

All hypothesized relationships were supported (Table 9). Policy support (X_1) and market awareness (X_2) exhibited significant direct effects on expectations (Y) and significant indirect effects via policy–market

synergy (M). Moreover, the $X_1 \times m_1$ interaction strengthened the $X_1 \rightarrow M$ link, and the $X_2 \times m_2$ interaction strengthened the $X_2 \rightarrow M$ link. Indirect effects were assessed with bias-corrected bootstrapping.

These findings indicate that (i) policy and market forces shape expectations both directly and through institutional alignment; and (ii) implementation structures—supply-chain coordination (m_1) and technology/cost conditions (m_2)—condition how policy and market signals translate into synergy.

5 | DISCUSSION

5.1 | Policy-Market Synergy Mediating the Relationship between Policy Support and Market Awareness.

The policy support in Shenzhen Meilin Affordable Housing Project is archetypal of the Chinese Government's policies to promote PC through both national and local levels, aimed at moving China forward to a greener urbanization and away from traditional onsite construction as found by Chang et al. (2018). Our findings that supportive policies are more effective in encouraging take-up of PC, and the limited effects of directive policy support similar findings by Gao and Tian (2020). The adoption of PC in the Shenzhen Meilin project also exemplifies policy of objectives of the Chinese Government in its goals of sustainable development, consistent with Gan et al. (2022).

The distinction in the effectiveness of policy measures which our study identified are consistent with Jiang et al. (2019) in terms of distinguishing between the effectiveness of policy measures, and in particular noting the effectiveness of incentive (supportive) policies. The need for multiple policies to provide the range of incentives necessary to promote the adoption of PC are consistent with Su et al. (2023). The development of policy frameworks and of collaboration between stakeholders, including policy agencies mirrors the findings of Wang et al. (2021). The effectiveness of collaboration between the construction industry and the government along with the developments of effective policy also reflect the findings of Xu et al. (2020). The role of provincial policies, shifting implementation to the lower levels of government shown to be important in Shenzhen Meilin, support those of Yan et al. (2023).

Our findings are also consistent with sustainable development theory (Gan et al. 2022), showing how consumers, in this project mainly younger urban professionals are demanding attributes such as solar energy and waste reduction which are seen to be environmentally sound. Policy has led to innovation, consistent with Tan et al. (2019) as shown by the changes in the construction process that policy-market has brought about in PC. Also, by the perception of costs, although a long-term issue, is consistent with Hong et al. (2018). The market and consumer dimensions affecting the take up of PC in Shenzhen Meilin correspond and contribute to the dimensions of factors affecting adoption and to the development of framework of factors affecting adoption set out in Li et al. (2021).

Our findings are also consistent with ? who found that synergy between institutional coherence, accelerating innovation, cost reduction and performance as the project began to show results. This relates to situations where policy development and market signals are aligned, where they can augment each other. Our findings relate to where market activity leads to improvements in policy design, and where, as a consequence, firms are more likely to adhere to policy compliance Our findings indicated that policy-market synergy was leading to higher enthusiasm for PC, especially at later stages of the project where the

benefits of PC adoption were becoming evident. This supports Pan et al. (2012), who found that policy market synergy increases the confidence of firms to switch to PC

We found that policy-market synergy mediates the relationship between policy support and market awareness, and firms' expectations of industry development and promotion. But adherence to policy and to market demands was not always wholehearted and aligned only partially. This is consistent with literature (Cai et al. 2023, Gan et al. 2022), which have found that uptake of PC is complex. For example, this includes authors who have found that PC take-up is sporadic due to many reasons (Gao and Tian 2020).

For examples, the coordination between China State Hailong Technology and China Overseas Construction, and where collaboration between government and the private sector took place is consistent with the literature which recognizes the complexity of the PC development process (Wang et al. 2019), and also the barriers to PC adoption (Wuni and Shen 2020a).

The finding that where market forces were mutually reinforcing was consistent with the effectiveness of supportive policy rather than directive policy (Wang et al. 2019). This is consistent with the literature on the barriers to entry for PC (Hong et al. 2018, Li et al. 2021).

5.2 | Technology and Cost Conditions in Industry Supply Chain Synergy

We found that supply chain synergy positively moderates the relationship between policy support and policy-market synergy. If the industry supply chain works efficiently, this will help the relationship between policy support and policy market synergy.

C-MiC, which was adopted and was an integral part of the project. The experience of technical challenges due to the high-precision modular manufacturing were consistent with the experience of other MiC projects, and particularly with Wuni and Shen (2020a) who found that multiple factors were necessary to encourage MiC (Abdelmageed and Zayed 2020). Our finding of the need for supply chain integration, noting the alignment or misalignment across the supply chain functions such as design, production, logistics to onsite assembly is consistent with Wuni and Shen (2019). Where there was no co-ordination, the supply chain became too complex for any one firm to adopt, and this is consistent with Cai et al. (2023), Chang et al. (2018). Our findings are also consistent with Wu et al. (2021) who found that fragmentation dilutes policy transmission, reducing its effectiveness. These relate to whether technology and cost conditions positively moderate the relationship between market awareness and policy-market strategy. We found that technology and cost conditions positively moderate the relationship between market awareness and policy market synergy. When technology and cost conditions are in favor for the firm, then this will help the relationship between market awareness and policy-market synergy. The multiple technical and financial barriers including high upfront costs, the need to purchase and incorporate new technology and logistics, lack of skilled workers, long-cost recovery time, are consistent

with the literature on barriers to PC (Hong et al. 2018). In short, PC is complex and our findings are consistent with this. It is perhaps noting the highly coordinated adoption rate of Denmark and the Netherlands and the less coordinated National Policy versus local policy approach of China that have meant that the barriers related to complexity still are important. The fact that as the project progressed and milestones were achieved increased confidence, and where there was poor coordination and low financial returns skepticism was prevalent (as in (Li et al. 2021).

Since institutional arrangements depend on context (Donaldson 2006), when technologies are new and cost structures prohibitive, even strong market awareness may not translate into strategic investment (Guo et al. 2023). For example, while China's central government has created a supportive macro-policy environment for MiC, the uptake has been uneven due to fragmented local implementation and fluctuating market demand. This echoes Abdelmageed and Zayed (2020)'s findings that MiC research and application remain concentrated in a few countries and urban centers, suggesting a mismatch between global diffusion and localized capability.

The mutual reinforcement between policy and market awareness, is really important because without it the policy and market aspects will just operate separately, in parallel, whereas the policy and market dynamics really need to work together, especially in an industry like PC where there is a high cost commitment and requirement for multiple actors to invest in the supply chain to build PC infrastructure, and provide training to make the transition to the knowledge based PC across the industry. Reaching the point of mutual reinforcement is the key, supporting the findings of (Yan et al. 2023).

6 | CONCLUSION

6.1 | Theoretical Contributions

This study makes three theoretical contributions to the literature on institutional theory, innovation adoption, and sustainability transitions. Firstly, it extends institutional theory by operationalizing the concept of policy-market complementarity in the context of PC. While prior studies have explored policy or market barriers in isolation (Hong et al. 2018, Su et al. 2023), our research demonstrates how their alignment, or misalignment, can shape the effectiveness of innovation diffusion. Our research also provides support for refinements to institutional theory, in particular that policy and market forces do not always work with synergy, but in parallel, which can result in partial or less than optimal compliance and commitment (Hong et al. 2018).

Secondly, this research contributes to the growing literature on institutional complementarity in sustainability transitions (Kivimaa and Kern 2016). Our findings show that synergy between formal and informal institutions is not automatic but contingent upon structural moderators such as industry chain integration and technological/cost feasibility, echoing contingency and industrial organization theories, including contingency theory, showing that the effect of policy depends on the

context (Xu et al. 2020). The multi-level framework developed here offers a scalable approach for studying similar transitions in other green industries. Sustainable development theory is also supported as demand has been for green buildings and long-term sustainable solutions such as solar power and water capture and recycling systems and this has driven changes in the construction process (Tan et al. 2019, Hong et al. 2018).

Thirdly, the study builds on Abdelmageed and Zayed (2020)'s call for system-level frameworks that explain the slow and uneven adoption of innovation such as MiC. By embedding MiC adoption within broader institutional environments and using a mixed-methods design to test causal mechanisms, we provide empirical grounding for future cross-national comparisons. Our study has also contributed to the literature on the practical aspects of policy and market synergy on PC (Yan et al. 2023, Wang et al. 2024).

6.2 | Managerial and Policy Implications

For managers, the findings suggest that the success of PC projects depends not only on technical excellence or compliance with policy but on strategic engagement with both institutional logics. The degree to which the firm is centrally placed and open to innovation and new practices is influenced by the environmental uncertainty, which comprises the lack of consistent policy support and the similar lack of stable and consistent industry expectations (Lissillour et al. 2024).

Firms should invest in capabilities that enable them to anticipate and respond to market signals—such as consumer preferences, green branding, and lifecycle cost expectations—while simultaneously navigating evolving regulatory frameworks. Engagement in collaborative platforms, early-stage design integration, and BIM-enabled coordination can improve outcomes and reduce institutional friction.

For policymakers, the results call for a shift from static regulatory targets to adaptive policy ecosystems. Governments should design feedback mechanisms—such as performance-based subsidies, evaluation loops, and public-private learning alliances—that allow for continuous alignment between market conditions and regulatory objectives (Kivimaa and Kern 2016, Abdelmageed and Zayed 2020). Particular attention should be given to regional disparities, supply chain coordination, and incentives that promote long-term investment in innovation.

Furthermore, policy-market synergy should be treated as a policy goal in itself, not merely a background condition. Following Kivimaa and Kern (2016), governments should move from static mandates to adaptive policy mixes that evolve with market feedback. Enhancing this synergy may involve supporting industry standardization, incentivizing training for skilled workers, and investing in public communication strategies to raise consumer awareness and acceptance of prefabricated housing (Li et al. 2021, Wang et al. 2024).

The managerial implications focus on the propensity and ability of firms to perceive the economic advantages of PC, and the costs and benefits to the firm are key to this (Hong et al. 2018, Xu et al. 2020).

Secondly, they relate to the ability of the firm to switch from traditional to PC models (Pan et al. 2012, Abdelmageed and Zayed 2020).

6.3 | Limitations and Future Research Directions

Despite its contributions, this study has several limitations. Firstly, the qualitative study was based on a single project in Shenzhen, a city known for its progressive policies and advanced infrastructure, another context may have pointed at other variables. Thus, future studies may look at other cities or rural regions in China to integrate other factors that this study may have ignored. Secondly, this study did not consider the internal political context that can influence firms' decision, and future research should integrate practice-based methodologies (?) to better understand the power structure within which firms decide to use MiC. Thirdly, the study focuses primarily on firms and institutional structures, leaving out other important stakeholders such as end-users, financial institutions, and community stakeholders. Broader stakeholder perspectives could enrich our understanding of how policy–market synergy unfolds in complex governance systems (Lissillour and FERNANDEZ 2022, Vavřina and Drdla 2024).

Future research can extend this work in several ways. First, comparative studies across regions with different policy regimes and market maturity levels could shed light on context-specific enablers and barriers to PC. These would lead to the focus on adoption rates and critical mass of skills, resources and practices necessary for successful (large-scale) adoption of PC. Secondly, further work is needed on the demand-side dynamics, particularly consumer attitudes, willingness to pay, and housing preferences, which remain underexplored in the literature. Thirdly, scholars should examine institutional learning and evolution—that is, how feedback from market actors and implementation outcomes reshape future policies. This would benefit from longitudinal designs and multi-stakeholder governance analyses (Fulconis et al. 2021). Finally, the generalizability of the dynamic policy–market synergy framework should be tested in other domains of sustainability transitions, such as renewable energy, smart mobility, and circular economy, to validate its applicability and refine its constructs.

AUTHOR CONTRIBUTIONS

The first author contributed to conceptualization, data collection and data analysis. The second and third author contributed to writing, reviewing, editing and addressing reviewer comments.

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None reported.

CONFLICT OF INTEREST

The authors declare no potential conflict of interests.

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SUPPORTING INFORMATION

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