

Research on the Influencing Factors of Transaction Costs in Prefabricated Building Projects Based on the WSR Methodology

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Abstract: Prefabricated buildings have advantages such as energy conservation and high efficiency, but the problem of high costs hinders their rapid development. Insufficient collaboration among participants and an imperfect policy system have led to increased costs of prefabricated buildings. From the perspective of transaction costs, this paper establishes an indicator system affecting the transaction costs of prefabricated buildings based on the WSR methodology, and identifies 31 influencing factors through literature review. AMOS software is used to conduct reliability and validity tests, confirmatory factor analysis, and path test analysis on the collected questionnaires to verify the fitness between the theory and hypotheses. The SEM analysis results show that factors such as project characteristics, market environment, decision management, contract management, construction management, personal systems, and enterprise systems have a negative impact on the transaction costs of prefabricated building projects. The model results can provide reference for general contracting enterprises to reduce the transaction costs of prefabricated buildings.

Keywords: Prefabricated buildings; Transaction costs; WSR methodology; Structural equation model (SEM); fsQCA

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1. Introduction

In the construction field, traditional cast-in-place buildings have long faced severe challenges of high pollution and high energy consumption, and have become a key area for energy conservation and emission reduction in China. According to statistics, the energy consumed by the construction industry accounts for 45.5% of the country's total energy consumption, and the carbon emissions of the construction industry account for 50.9% of the national carbon emissions^[1]. This extensive development model is contrary to China's "double carbon" strategic goals, and there is an urgent need to transform towards a green and low-carbon direction. As a modern building production method, prefabricated buildings have received widespread attention and practice nationwide. Under the background of the in-depth advancement of the sustainable development strategy, prefabricated buildings have significantly reduced energy consumption, construction waste, construction dust,

and noise pollution during the construction process through standardized design, factory production, and on-site assembly, achieving remarkable benefits such as a 52% reduction in construction waste, a 15% shortening of construction time, and a 16% reduction in labor demand^[2]. Prefabricated buildings have developed rapidly in China, but their market share has always been low. The direct reason hindering their promotion is the high construction cost^[3].

An in-depth analysis of the cost composition of prefabricated buildings reveals that the problem lies not only in the production costs during the construction phase but also in the transaction costs generated during early coordination and later docking. There is no accurate definition of transaction costs in academia. Coase, the founder of transaction cost economics, precisely defined transaction costs as a series of expenses derived from the process of market economic exchange in his “The Nature of the Firm^[4]”. Williamson believed that different transaction attributes lead to different levels of transaction costs, which in turn determine the choice of market, enterprise, or hybrid governance models^[5]. Xing Huige divided transaction costs into those before and after the signing of engineering contracts^[6]. Zheng Yu pointed out that the transaction costs of engineering bidding and tendering refer to the direct expenses that both parties to the bidding and tendering of construction projects need to pay in the entire process from bidding, tender issuance, bidding, bid evaluation, determination of the winning bidder to the signing of the engineering contract to achieve the transaction purpose^[7]. Combining the content of new institutional economics, the views of major scholars, and practical situations, transaction costs refer to various implicit costs generated in the process of coordination, cooperation, supervision, and management among various project participants. Therefore, increasing the analysis and control of project transaction costs is a necessary guarantee for optimizing the total project cost.

Through the continuous research of domestic and foreign scholars on transaction costs, transaction costs have gradually extended to the field of prefabricated buildings. Hongjuan *et al.* first introduced the transaction cost theoretical framework to address the cost barriers in the promotion of prefabricated buildings in China, and found that transaction costs are mainly concentrated in the conceptual and construction phases, with developers and general contractors bearing a higher proportion^[8]. Wu *et al.* analyzed the cognitive differences of different stakeholders on transaction costs in prefabricated residential buildings through questionnaire surveys and expert interviews^[9]. Xu Zhiqian *et al.* analyzed the transaction costs of prefabricated buildings from the perspective of the entire industrial chain and concluded that they mainly stem from cross-organizational collaboration frictions in links such as raw material supply, component production, logistics and transportation, and on-site assembly^[10].

Prefabricated building projects involve complex factors and multi-subject participation, making it difficult for a single theoretical framework to fully explain and analyze them. The WSR theory provides a comprehensive perspective that can comprehensively capture the key elements and their interactions affecting the transaction costs of prefabricated building projects. Therefore, integrating the WSR methodology into the research on the transaction costs of prefabricated building projects helps to comprehensively consider the interaction of objective laws, management processes, and human relations.

In summary, this paper takes the transaction costs of prefabricated buildings as the research object and analyzes the transaction costs of prefabricated buildings combined with structural equation models. First, on the basis of literature review and questionnaire surveys, combined with the WSR methodology, the influencing factors of the transaction costs of prefabricated building projects are identified, and an indicator system of the influencing factors of the transaction costs of prefabricated buildings is constructed. Then, research hypotheses are proposed based on theoretical foundations and variable definitions. Finally, structural equation models are

used to verify the research hypotheses proposed earlier, and the results of the hypothesis tests and empirical results are discussed.

2. Establishment of the indicator system

To ensure the scientificity and rationality of the literature research in this paper, the following steps are taken when collecting the influencing factors of the transaction costs of prefabricated building projects: First, based on the research object of this paper, comprehensive searches are conducted in authoritative domestic and foreign databases such as CNKI, VIP, and Web of Science using keywords such as “prefabricated building project cost”, “transaction cost”, and “construction project transaction cost”; second, high-quality articles are selected from the screened literature, with reference standards including core journals, key project support, and the number of citations of the literature. Based on the above literature screening principles, 38 highly relevant and academically advanced literatures are finally selected.

Using the WSR method to classify the influencing factors of the transaction costs of prefabricated buildings from three dimensions: Physics, Matter, and People, can ensure the comprehensiveness and depth of the analysis. The Physics dimension covers the objective environment in which the transaction process of prefabricated building projects is located and the project characteristics they possess; the Matter dimension focuses on the management rules and operation mechanisms of the entire construction process and transaction process of the project, including organizational processes, management mechanisms, contract design, etc.; the People dimension emphasizes human factors, including the quality, communication, and coordination capabilities of various participants in prefabricated building projects, and the impact of these factors on transaction costs cannot be ignored.

Therefore, on the basis of the research of scholars such as Liu Minfei, this paper applies the WSR theory to the transaction cost control of prefabricated projects, divides indicators from three dimensions: the Physics dimension is divided into objective environments such as project characteristics and market environment; the Matter dimension is divided into decision management, contract management, and construction management according to the project process; the People dimension is divided into personal systems and enterprise systems from individual capabilities and organizational relationships. Finally, the factor indicators involved in the literature are sorted out, as shown in **Table 1**.

Table 1. Indicator system of influencing factors of transaction costs in prefabricated building projects based on the WSR methodology

Dimension	First-Level Indicators	Second-Level Indicators
Physics (W)	Project Characteristics	Standardization degree of prefabricated components
		Application level of BIM and RFID technologies
		Completeness of collaborative management system
	Market Environment	Uncertainty of construction environment
		Improved bidding and tendering and credit system
		Improved industry standard system
		Completeness of industrial chain and economies of scale
		National policy support and guidance

Matter (S)	Decision Management	Preliminary project feasibility study
		Preliminary engineering field investigation
	Contract Management	Preliminary market and policy research
		Preliminary capital flow management
		Subject and boundary of risk division
		Incentive and punishment system
		Performance guarantee agreement
		Change and claim clauses
		Fund payment rules
		Provisional valuation and provisional amount clauses
Construction Management	Reasonable worker scheduling	
	Improved performance appraisal system	
	Special hoisting plan management for prefabricated components	
	Construction risk emergency plan management	
	On-site civilized construction management	
People (R)	Personal System	Technical level of special operation personnel
		Leadership and decision-making capabilities of managers
	Enterprise System	Collaborative cooperation capabilities among various trades
		Work efficiency of operators
		Similar project experience of project participants
		Information sharing degree among project participants
		Information feedback capability of project participants
		Reputation and professional quality of project participants

3. Structural equation model and data analysis

3.1. Structural equation model

As an integrated multivariate statistical research method, structural equation models can solve the relationships between multiple causes and effects simultaneously without the problem of variable measurement errors. Therefore, this paper uses AMOS to construct a structural equation model to study the relationships and path coefficients between the influencing factors of the transaction costs of prefabricated buildings.

Based on previous scholars' research on prefabricated building projects, this paper proposes the following hypotheses, as shown in **Table 2**.

Table 2. Summary of model hypotheses

Hypothesis	Research hypothesis content
H1	Factors related to project characteristics have a negative impact on the control of transaction costs of prefabricated building projects
H2	Factors related to market environment have a negative impact on the control of transaction costs of prefabricated building projects
H3	Factors related to decision management have a negative impact on the control of transaction costs of prefabricated building projects
H4	Factors related to contract management have a negative impact on the control of transaction costs of prefabricated building projects

H5	Factors related to construction management have a negative impact on the control of transaction costs of prefabricated building projects
H6	Factors related to personal systems have a negative impact on the control of transaction costs of prefabricated building projects
H7	Factors related to enterprise systems have a negative impact on the control of transaction costs of prefabricated building projects

3.2. Data sources

The questionnaire survey method is often used to obtain data in empirical research, which has the advantages of simplicity and flexibility.

This questionnaire takes the influencing factors identified in the previous chapter as the main content of the measurement items and draws on mature scales from previous studies to ensure the validity of the scale. The questionnaire uses a 5-point Likert scale to score the importance of each influencing factor.

To ensure the reliability of the data, the questionnaire respondents are professionals related to the research on prefabricated building projects. A total of 406 questionnaires are distributed. To ensure the quality of the recovered questionnaires, reverse items are set in this questionnaire to identify the respondents' answering status, and those with an answering time of less than 3 minutes are excluded. Finally, 350 valid questionnaires are recovered, accounting for 86.2% of the recovered questionnaires.

3.3. Reliability analysis

In this study, the main factors are measured by scales. Therefore, testing the data quality of the measurement results is an important prerequisite to ensure the significance of subsequent analyses. This study uses Cronbach's α coefficient to test the internal consistency of each dimension.

The questionnaire in this study includes 8 dimensions, and reliability analysis is conducted for each dimension and the entire questionnaire, all completed based on SPSS 25. As shown in **Table 3**, the Cronbach's α coefficients of all dimensions are higher than 0.8, showing good internal consistency, indicating that the scale used in this study has high reliability and meets the requirements of subsequent analyses.

Table 3. Reliability analysis of each scale

Variable Name	Cronbach's α Coefficient
Project Characteristics	0.862
Market Environment	0.859
Decision Management	0.867
Contract Management	0.903
Construction Management	0.889
Personal System	0.882
Enterprise System	0.877
Transaction Costs	0.843

3.4. Validity analysis

Validity testing aims to evaluate the effectiveness of questionnaire results, that is, to test whether the questionnaire design can accurately reflect the essential characteristics of the research variables.

The validity test results directly determine the scientific value of the collected data. The higher the validity

3.5.2. Direct effect test

In structural equation model analysis, the sign and significance level of the path coefficient are the key indicators to judge the influence relationship between variables. The positive or negative of the path coefficient reflects the influence relationship between variables: a positive path coefficient represents a positive influence, and a negative path coefficient represents a negative influence. At the same time, a P value less than 0.05 indicates that the path coefficient is significant. From the various data values, it can be found that factors such as project characteristics ($\beta = -0.147, P = 0.024$), market environment ($\beta = -0.14, P = 0.038$), decision management ($\beta = -0.129, P = 0.035$), contract management ($\beta = -0.134, P = 0.033$), construction management ($\beta = -0.17, P = 0.013$), personal system ($\beta = -0.145, P = 0.03$), and enterprise system ($\beta = -0.148, P = 0.027$) all have a negative impact on the transaction costs of prefabricated building projects, and their standardized path coefficients all passed the 0.05 significance level test.

3.6. Discussion on hypothesis testing results

The standardized path coefficients of factors such as project characteristics, market environment, decision management, contract management, construction management, personal system, and enterprise system on the transaction costs of prefabricated building projects are -0.147, -0.14, -0.129, -0.134, -0.17, -0.145, and -0.148 respectively. Among them, the sign represents the influence relationship between variables, and the numerical size represents the degree of influence. The order from largest to smallest is: construction management, enterprise system, project characteristics, personal system, market environment, contract management, and decision management. These influencing factors have a direct impact on the transaction costs of prefabricated building projects, showing a hierarchical structure of differentiated influence intensity.

3.6.1. Construction management

It has a significant negative impact on transaction costs, that is, strengthened management can effectively control costs. Refined scheduling and modular teams reduce work idleness and resource idleness; performance appraisal drives self-supervision and reduces external supervision costs; standardized high-risk operations through special hoisting plans prevent installation errors and disputes; emergency plans and civilized construction address sudden risks and avoid community disputes, systematically reducing coordination, supervision, and dispute costs.

3.6.2. Enterprise system

Experience accumulation and high-reputation partners improve response efficiency and prediction capabilities, reducing repeated exploration and post-event correction; information sharing eliminates suspicion and games and reduces preventive supervision costs; timely feedback mechanisms stop problems at an early stage and avoid chain losses caused by amplified deviations. Collaboration among enterprises shifts from passive response to active governance, overall optimizing the transaction cost structure.

3.6.3. Project characteristics

Component standardization unifies technical parameters and price benchmarks, reducing negotiations and rework of non-standard components; BIM+RFID realizes full-process visualization and accurate traceability, reducing errors and omissions from the source and reducing manual supervision; the collaborative management system smooths the interface between design, production, and construction; although environmental uncertainty will push up costs, standardization and digitization can offset this risk, resulting in a significant net cost reduction effect.

3.6.4. Personal system

Skilled workers accurately perform key processes such as hoisting and grouting, reducing operational errors and quality disputes; tacit collaboration among trades eliminates handover waiting and conflict rework; managers create an efficient collaborative atmosphere through goal setting and conflict resolution. Human capital directly reduces coordination and time costs by reducing behavioral uncertainty and supervision dependence.

3.6.5. Market environment

A transparent bidding and tendering and credit system shortens the search and review cycle; industry standards provide technical consensus and responsibility benchmarks, reducing repeated negotiations and quality disputes; a complete industrial chain and large-scale production promote standard unification; policy incentives (such as subsidies/floor area ratio) enhance cooperation willingness. An institutionalized market environment converts uncertainty into predictable rules, systematically reducing costs.

3.6.6. Contract management

Forward-looking contracts clarify rights, responsibilities, and risk sharing, avoiding repeated games during performance; incentive-punishment mechanisms mobilize the enthusiasm for self-optimization; guarantee agreements convert disputes into standardized claims; change clauses and milestone payment binding link performance progress; provisional valuations ensure rapid response to unexpected matters. Contract design is the core institutional tool for cost governance.

3.6.7. Decision management

Feasibility studies avoid large-scale changes caused by incorrect technical route selection; detailed surveys pre-control site adaptation issues; market and policy research support accurate quotation and compliant design; capital flow plans ensure payment reliability. High-quality early decisions lay a stable execution foundation, inhibiting later coordination, correction, and default costs from the source.

4. Conclusion

This research aims to reduce the transaction costs of prefabricated buildings as its core objective, based on the WSR system methodology framework, this study systematically reveals the influence mechanism of multi-dimensional factors on the transaction costs of prefabricated building projects through empirical tests of questionnaire analysis and structural equation models (SEM). The main research conclusions are as follows:

- (1) Optimize the “Physics” environment and consolidate the technical and market foundation: Governments and industry associations should accelerate the improvement of the standard system for prefabricated buildings, promote the standardization and modularization of component design, and reduce the coordination and rework costs caused by non-standard customization from the source. At the same time, they should further improve the market credit evaluation system and bidding and tendering mechanisms, supplemented by appropriate policy incentives (such as floor area ratio rewards and tax reductions), and guide the construction of a complete regional industrial chain to reduce the information search and negotiation costs in the early stage of the project;
- (2) Refine the “Matter” process and improve contract and decision boundaries: In the early stage of the project, strengthen feasibility studies and on-site surveys to ensure high-quality and forward-looking decisions

and avoid large-scale design changes later. In the transaction contracting phase, focus on the completeness of contract design, establish clear incentive-punishment mechanisms and risk sharing clauses, bind key milestone payment rules, and supplement with improved change and guarantee procedures. In construction and daily management, fully implement refined scheduling and performance appraisal, formulate special construction emergency plans and standardized hoisting plans, and convert uncertain risks into standardized processes, thereby reducing daily communication and correction prevention costs;

- (3) Deepen “People” collaboration and build a digital trust and cooperation system: All participating entities should strive to establish long-term strategic partnerships, give priority to selecting partners with complementary resources and high reputation, and reduce excessive dependence on external institutionalized supervision. At the same time, vigorously introduce and apply digital information sharing platforms such as BIM and RFID to eliminate information silos and asymmetry. In addition, attention should be paid to the cultivation of the leadership of core managers and the professional skill training of front-line workers. Through tacit trade cooperation and an efficient team collaboration atmosphere, directly reduce time and internal friction costs at the human capital level.

Disclosure statement

The author declares no conflict of interest.

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