

The Impact of Construction Project Flexibility on Project Management Performance

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Abstract

The complex environment of uncertainty is the main challenge that construction project managers face. Some scholars point out that flexibility is an effective method to deal with environmental change and uncertainty. The purpose of this paper is to define the connotation of flexibility of construction projects, so as to develop a scale and explore the relationship between flexibility and performance. Firstly, from the perspective of the contractor, the flexibility is regarded as a management strategy that the contractor can choose. Based on literature analysis and expert interview, the flexibility scale of construction project is developed. Then, through the questionnaire survey method we obtained 267 valid data about flexibility and performance of construction projects in China, and used confirmatory factor analysis method to scale reliability and validity analysis. Finally, AMOS21.0 software was carried out on the structure model analysis between flexibility and performance, the results show that the construction project flexibility has significant positive effect on performance. The results can provide new management ideas for contractors in the field of construction engineering to cope with the challenges of uncertainty, and project manager can improve the response ability to environmental changes through flexible strategies.

Keywords: *Construction project, flexibility strategy, scale development, performance relationship.*

I. Introduction

The fusion of different industries in the current development period brought great changes to the construction industry, such as the diversification of financing, the popularization of information technology, the application of artificial intelligence. The construction project is more and more shows the characteristics of the complexity. This kind of complex project system involves the interaction and dynamic changes of the unpredictable, that no amount of planning can't eliminate the uncertainty existing in the management, then caused the investment overspend and schedule delay out of control phenomenon. In the face of this, Acker & Mascarenhas [1] have argued that flexibility should be the most cost-effective way to cope with environmental change and uncertainty.

Flexibility is not a new concept. Since the 1970s, many scholars have carried out a lot of studies on it. The authoritative definition of Flexibility is given by Mandelbaum & Brill [2], which means the ability to respond effectively to environmental changes. Change and uncertainty exist objectively, which requires the system to have certain flexibility to adapt to environmental changes and deal with various uncertainties. The greater the uncertainty of the system, the more the value of flexibility can be highlighted. In the field of construction project management, the understanding and research on flexibility are still very weak. This paper aims to discuss the connotation of construction project flexibility, the scale development and its influence on the performance of project management.

II. Literature Review

2.1 Connotation of construction project flexibility

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The concept of flexibility was initially applied to the manufacturing industry. Gupta & Buzacott [3] mentioned in the literature on the analysis of the flexibility of manufacturing systems that flexibility is usually used to describe the ability to respond to changes or adapt to new situations. The development of flexible manufacturing systems is driven by factors such as stronger response to demand changes and the demand for customized production. With the application of the concept of flexibility in the field of management, the connotation of flexibility has gradually expanded to the concept of strategic flexibility, organizational flexibility, project flexibility, and so on.

Yang et al. [4] introduced the flexibility strategy into the operation and management field of construction companies and established an analytical framework of internal and external flexibility. The former focused on construction capacity, shortening construction period and reducing inventory, while the latter focused on solving external material supply and supporting engineering facilities, etc. Lou Lixing [5] describes the overall framework of construction project flexibility, divides it into product flexibility, process flexibility and contract flexibility, and discusses alternative flexibility strategies according to different project states.

In the field of construction project management, many scholars have made many achievements on contract flexibility. Zhu Fangwei et al. [6] expanded the connotation of contract flexibility from two dimensions of content flexibility and execution flexibility, and tested the reliability of the contract flexibility scale by using methods such as expert interview, consultation and questionnaire. Zhang Yajuan [7] classified the core elements of contract flexibility terms based on case analysis, including three dimensions of right, relationship and dispute settlement, and proposed the description index of contract flexibility state by comparing different contract models. In addition, Chai Guorong et al. [8] proposed the flexible critical chain technology for project schedule management, which is based on resource-sharing environment and highlights resource flexibility, that is, the ability of resources to respond to environmental changes quickly and effectively.

On the whole, the academic community has not fully understood the flexibility of construction projects, but has a consistent view on its core connotation: flexibility is reflected in the ability to adapt to environmental changes. This ability is not inherent in project systems. Pure rigid systems and pure flexible systems are rare. Emphasizing flexibility does not exclude rigid components [9]. Flexibility is related to management design and system choice, or it is reflected as a kind of strategy choice and system arrangement of managers. The research of Szentes & Eriksson [10] points out that it is critical for project managers to recognize the need for a balance between control and flexibility. He Weiye & Cao Yayun [11] also noted that an overemphasis on operational control, and a lack of flexible operational change management, is a key factor in the success of uncertain and complex projects. In the traditional project management field, control is a very important function. Flexible management means different management strategies, that is, improving the ability of the project to cope with environmental changes by increasing the choice space of flexible adjustment.

To sum up, scholars emphasize the ability to respond to environmental changes as the connotation of flexibility. Both enterprises and projects need some level of flexibility to adapt to various changes and uncertainties, and they need to dynamically adjust their management behaviors according to environmental changes and business progress. Of course, different corporate cultures, different teams, different management styles and different institutional arrangements will affect the flexibility of the project. From this perspective, here construction flexibility means a management strategy that enhances the organization's ability to respond to changes in the environment by improving flexibility.

2.2 The Relationship between Flexibility and Performance

Different scholars have analyzed the relationship between flexibility and performance from the perspectives of supply chain flexibility, team flexibility and contract flexibility. Lummus et al. [12] put forward the concept of supply chain flexibility and pointed out that if the whole supply chain is composed of flexible components, the

performance of the whole supply chain can be improved. Later, the team also introduced the concept of flexible management, Sara et al [13] analyzes the relationship between the flexible and team performance, study confirms that flexible team personnel of high quality will improve team to bring positive impact on team performance, the complexity of the environment in the face of uncertainty, the flexible as a strategy that can improve team cohesion and team efficiency. However, when faced with diverse and complex environment, flexible strategy reduces team performance and cohesion.

In terms of contract flexibility, Harris et al. [14] pointed out that, as an important mechanism to deal with risks and uncertainties, contract flexibility can guide the contracting parties to adjust their behaviors according to the dynamic changes of the external environment, and contract flexibility can also improve the service level and satisfaction. Later, Nysten-Haarala et al. [15] specifically analyzed how flexibility is integrated into the contract management process and clearly pointed out that contract flexibility has a positive effect on the improvement of project management performance, also can help enterprises improve contract management capabilities and cope with external environment changes.

Li Li et al. [16] found that trust, as a key factor, drives the formation of contract flexibility, and PPP contract flexibility plays a significant role in improving project management performance. Lou Lixing [17] used structural equation model to carry out empirical research and found that contract execution flexibility has a significant positive impact on project management performance, while contract clause flexibility has no significant positive impact on project management performance. Zhao Yanchao et al [18] found divergent results in his research on PPP projects, Contract clause flexibility and contract execution flexibility have significant positive correlation with project performance respectively.

Of course, some results have been achieved on the relationship between project flexibility and project success or performance. Zaman et al [19] point out that Project flexibility as a risk mitigation strategy to protect the project from the impact of an uncertain environment, thereby reducing project failure. Tiwari & Suresha [20] examines the linkage between the management of project risks and project flexibility for information technology projects in Financial Services. They found that incorporating project flexibility is important for greater success of projects. Project flexibility is proved to enrich the performance of a project.

To sum up, there have been many studies on the relationship between flexibility and performance, but no unified understanding has been reached, which also indicates that in different environments, the composition and elements of flexibility are different, and there are great differences in the impact on performance. Therefore, defining the connotation and measurement indicators of the flexibility of construction projects is still the first task to be solved. Although the overall impact of flexibility on performance shows a positive trend theoretically, the role of flexibility needs to be verified.

III. Conceptual Definition and Research Hypothesis

In order to better measure the flexibility and performance of construction projects, it is necessary to define the connotation and boundary of the concept of flexibility and performance of construction projects.

3.1 Construction project flexibility

As mentioned above, flexibility usually refers to the ability to effectively respond to environmental changes, which is not only related to the quality of the project team, but also related to the design of the organizational structure, the design of the management system and the selection of management methods of the project team. Compared with rigid management, flexible management means one kind of different management strategies. Flexible management brings greater flexibility and choice space to the project organization, and can avoid chaos in project management when facing external changes and disturbances.

From the perspective of the contractor management team, this paper considers how to use flexible strategies to improve the ability of the project to cope with environmental changes. Therefore, the connotation of flexibility focuses on answering which management measures can improve the flexibility of the project. Based on this research purpose, construction project flexibility refers to the ability of the contractor to improve the project response to change and uncertainty through the implementation of flexible strategies, in order to better achieve the project management performance objectives.

Different scholars have given different suggestions on how to improve organizational flexibility. He Cheng et al. [21] mentioned that flexible organizations generally take measures such as appropriate decentralization of power and encouragement of learning and innovation activities, so that enterprises can quickly adapt to environmental changes and achieve sustainable development. This proposal is also supported by Rehak et al. [22] Golden & Powell [23] pointed out that IT technology can enhance organizational flexibility, but outdated IT technology may have the opposite effect. Yang et al. [4] put forward some suggestions to improve flexibility, including communication, participation, providing support and building a learning organization. Zhu & Mostafavi [24] suggest that project manager should proactively design project systems that meet the needs of complex environments by using BIM technique, information sharing and cooperation, and so on. Zhang Yongwu [25] also agree that contractors should improve the flexibility of project schedule management by application of BIM technique.

In the field of construction project management, research on project flexibility framework is still immature. Based on the literature on flexibility, this paper intends to expand the scope of literature around the connotation of "ability to adapt to change and uncertainty", supplemented and improved by expert interview method, and construct the project flexibility scale.

3.2 Construction project management performance

The mainstream view of the current definition of project Performance holds that Performance is the unity of the result and its generation process, and the effect of the project in the future is considered [26]. Some scholars point out that project performance is different from project management performance, which is usually measured in terms of time, cost and quality. Project performance is a broader concept that relates to the goals of all stakeholders throughout the project lifecycle [27]. Time, cost, and quality are the three classic KPI indicators. Although these indicators are influential during the project execution phase, they lose their importance when the project is completed and the product is delivered to the customer, and the satisfaction of the stakeholders becomes the KPI indicators. Therefore, project performance is the combination of project management performance and product success. Later, considering the social effects and commercial benefits of future projects, people put forward "project success", a broader concept different from project performance, and pay more attention to customer satisfaction, profitability, environmental sustainability, health and safety, and even aesthetics, education and other aspects after the project is put into use [28].

This paper studies the relationship between flexibility and performance of construction projects from the perspective of contractors. Therefore, performance is defined as project management performance. It focuses on the performance of process performance of construction projects, that is, the goal to be achieved by the contractor's project management activities, and does not consider other goals such as stakeholder satisfaction, product success and so on. According to the actual situation of construction projects in China, safety and environmental protection are also very important and common goals, which should be taken into consideration. Therefore, in this research, the project management performance is expressed by multi-dimensional objective system with five indexes, such as quality, time, cost, safety and environmental protection.

3.3 Research hypothesis

Generally speaking, flexibility is considered to be a good strategy to cope with environmental change and uncertainty [1], that is, improving organizational or system flexibility can achieve the purpose of adapting to environmental change, absorbing or mitigating the impact of external interference events, and better help managers achieve strategic or project goals. Therefore, in a general sense, flexibility can have a positive impact on performance [19] [20]. However, in some cases, this relationship is not always valid. For example, team flexibility can improve team performance in the face of uncertainty, but it cannot in the face of diversity [13]. Project contract execution flexibility plays a positive role in improving performance, but clause flexibility has no significant positive effect on performance [17].

To sum up, we need to further verify the impact of construction project flexibility on project management performance, and put forward the following research hypotheses:

H: Construction project flexibility has a positive impact on project management performance.

IV. Development of Flexible Scale for Construction Projects

4.1 Flexibility index of construction project

4.1.1 Literature Analysis

Based on relevant literature on project flexibility and from the perspective of contractors in the construction implementation stage, this paper sorts out and summarizes the management measures that contractors can take to improve project flexibility, so as to determine the flexibility index of construction projects. The results are shown in Table 1.

Table1 A list of flexible indicators of construction projects.

Flexible Indicators	Literature Resources
Flexible contract	Harris et al.,1998; Nystén - Haarala et al.,2010; Zhang Yajuan,2015; Lou Lixing,2015; Li Li et al., 2017; Zhu Fangwei et al.,2018.
Application of BIM technology	Golden & Powell,2000; Zhang Yongwu,2005; Zhu &Ali Mostafavi, 2017.
Communication	Yang et al, 2006.
Information sharing	Zhu & Ali Mostafavi, 2017.
Cooperation	Zhu&Ali Mostafavi, 2017.
Flat management	Zhang Yongwu,2005; Yang et al, 2006.
Management innovation	He Cheng et al,2009; Rehak et al., 2018.
Emergency resource	Chai Guorong et al., 2008;Rehak et al.,2018
Team learning	Yang et al., 2006; Zhang Yongwu, 2005; Sara et al., 2007.

4.1.2 Expert interview

The second stage is to select and interview experts in the field of construction project management practice to collect the supplement opinions of the initial index set from literature analysis. Nine experts from the front line of construction project management were selected to participate in this survey. After sorting out, the opinions of experts were mostly reflected in several indexes of literature retrieval, and the flexibility index of the project was only fine-tuned as follows: "communication" and "information sharing" overlap in a certain sense, and are merged into "information sharing".

The third stage is to seek opinions on the initial scale formed through interviews with academic experts. This stage was completed with the help of 4 professors majoring in engineering management, most of whom are senior teachers and scholars in the research field. After thorough discussion with them on the index selection, question

presentation, questionnaire design and other issues of the initial scale, the revision of the scale and questionnaire was completed. The adjusted variable Settings and descriptions are shown in Table 2.

Table 2 Variable setting and scale description.

Constructs	Variable	Variable description
Flexible Indicators	Flexible contract	The project used an adjustable contract (price, time, scope, etc.)(PF ₁)
	Application of BIM technology	The project uses BIM technology(PF ₂)
	Information sharing	There is sufficient communication of information between the parties involved in the project(PF ₃)
	Cooperation	The cooperation of relevant parties in this project is in good condition(PF ₄)
	Flat management	The project has a high level of organization flattening(PF ₅)
	Management innovation	The team management of the project has a good atmosphere of innovation(PF ₆)
	Emergency resource	The project has adequate emergency resources(PF ₇)
	Team learning	The project team has strong continuous learning ability(PF ₈)
Performance Indicators	Time	Achievement of the project duration target(PP ₁)
	Cost	Achievement of the project cost target(PP ₂)
	Quality	Product quality or process quality of the project is qualified(PP ₃)
	Safety	The safety objectives of the project have been well achieved(PP ₄)
	Environmental protection	The environmental objectives of the project have been achieved well(PP ₅)

4.2 Implementation of questionnaire survey

The research object of this paper is construction projects. Any construction projects under construction or completed within the territory of China can be included in the scope of investigation. The respondents were limited to "managers of construction project contractors with certain work experience". In order to excavate the characteristics of the projects under construction or completed projects as much as possible, the following points are concerned during the survey implementation : (1) The respondents are required to have participated in or are implementing large and medium-sized construction projects; (2) Avoid personnel without project management practice experience to participate in the survey; (3) To avoid the newly recruited interns from participating in the survey; (4) Avoid issuing too many questionnaires for the same project.

In order to meet the needs of confirmatory factor analysis and structural equation model analysis, a total of 300 questionnaires were sent out and 273 were recovered with a recovery rate of 91%. The returned questionnaires were numbered, and 6 questionnaires with missing options were eliminated: No.93, No.98, No.101, No.170, No.176, and No.201, and 267 valid questionnaires were obtained. The ratio of the number of valid questionnaires and scale questions was more than 9:1, which met the needs of subsequent statistical analysis.

V. Empirical Analysis

5.1 Feasibility of confirmatory factor analysis

In this study, SPSS20.0 software was used to conduct reliability analysis on the collected data, and the analysis results are shown in Table 3.

Table 3 Cronbach's α coefficient and reliability grade statistics.

Scale	Measure terms	Standard Cronbach's α	Reliability grade
Project management performance	PP ₁ -PP ₅	0.879	high

Project flexibility	PF ₁ -PF ₈	0.891	high
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It can be seen from Table 3 that the Cronbach's α coefficient of the project flexibility and performance scale is greater than 0.8, indicating that all variables have passed the reliability test and can be analyzed in the next stage.

Barlett test and KMO measure are carried out using SPSS20.0 software, and the test results are shown in Table 4.

Table 4 KMO test and Barlett test.

		Performance scale	Flexibility scale
Barlett test	KMO test	0.818	0.890
	approximate chi-square value	762.678	1059.962
	degree of freedom	10	28
	significance	0.000	0.000

As can be seen from the above table 4, the KMO values of the project management performance and project flexibility scales are all greater than 0.8, meeting the requirement of good grade and meeting the research needs. The Barlett sphere test of each scale reached a significant level, indicating that both scales were suitable for confirmatory factor analysis.

5.2 Confirmatory factor analysis

The software AMOS21.0 is used to conduct confirmatory factor analysis. The project flexibility measurement model has a total of 8 measurement indicators. In this paper, a first-order project flexibility model is constructed to conduct confirmatory factor analysis. The modified model is shown in Fig.1.

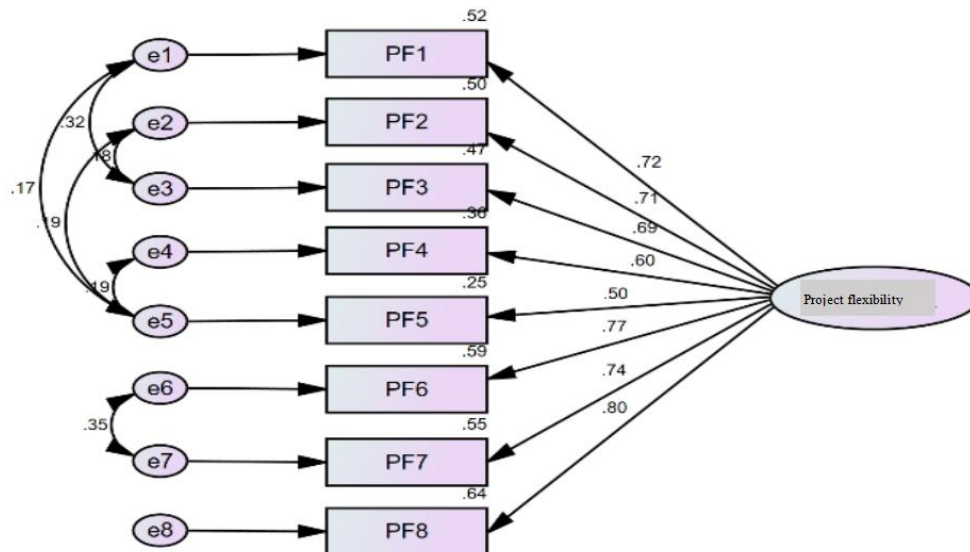


Fig. 1 Fitting result of project flexibility measurement model.

Project management performance includes five measurement indicators, and a project management performance measurement model is built. Through confirmatory factor analysis, the fitting results of the modified model are shown in Fig. 2.

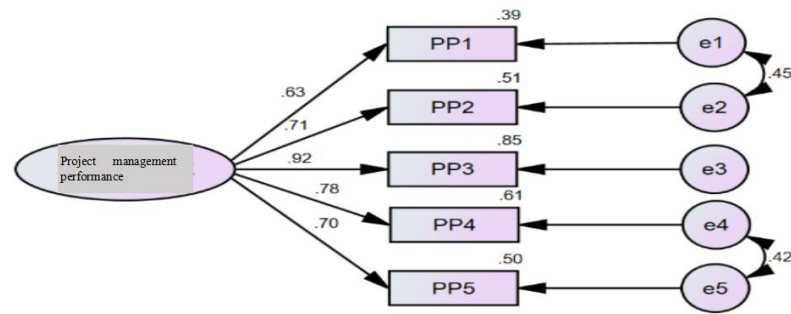


Fig. 2 Fitting results of project management performance measurement model.

According to Table 5, the χ^2/df of the two measurement models was less than 3, the equivalent values of GFI, AGFI, NFI, IFI and CFI were all greater than 0.9, and the value of RMSEA is less than 0.08. After the modification, the indicators of the flexible measurement model met the requirements, indicating that the model fitted well and the measurement model was effective.

Table 5 Fitting index of project flexibility and performance measurement model.(n=267)

Index	χ^2/df	RMSEA	GFI	AGFI	CFI	NFI	IFI
Flexibility model	2.660	0.079	0.965	0.910	0.978	0.965	0.978
Performance model	2.024	0.062	0.991	0.955	0.996	0.992	0.996

Parameter estimation results of project flexibility and performance measurement models are shown in Table 6.

Table 6 Parameter estimation table of project flexibility and performance measurement model.

Latent variable	Items	Standardized Coefficients(R)	T-value	R ²	CR	AVE
Project flexibility	PF ₁	0.724	-	0.525	0.881	0.485
	PF ₂	0.710	10.683***	0.504		
	PF ₃	0.687	12.556***	0.472		
	PF ₄	0.596	9.022***	0.355		
	PF ₅	0.503	8.1065***	0.253		
	PF ₆	0.769	11.421***	0.591		
	PF ₇	0.738	10.969***	0.545		
	PF ₈	0.799	11.919***	0.638		
Project management performance	PP ₁	0.625	-	0.391	0.867	0.570
	PP ₂	0.713	12.867***	0.508		
	PP ₃	0.921	10.531***	0.848		
	PP ₄	0.779	10.182***	0.607		
	PP ₅	0.704	9.434***	0.496		

According to the results in Table 6, the standardized load of each measurement item in project flexibility and performance measurement model is above 0.5, and all the standardized coefficients reach a significant level. Therefore, each item in the table can be used as the measurement index of the potential variables of flexibility and performance. The combined reliability of all indicators of performance and flexibility is more than 0.6, the AVE of all indicators of performance is greater than 0.5, and the AVE of all indicators of flexibility is close to 0.5, indicating that the measurement of all latent variables shows good internal consistency, and the reliability index is acceptable.

5.3 Project flexibility-performance structure model fitting

The structural model of the impact of construction project flexibility on project management performance is built, and the software AMOS21.0 is used for fitting analysis of the data and the hypothesis model. The model analysis results are shown in Fig. 3, and the statistical indicators of the fitting results are shown in Table 7.

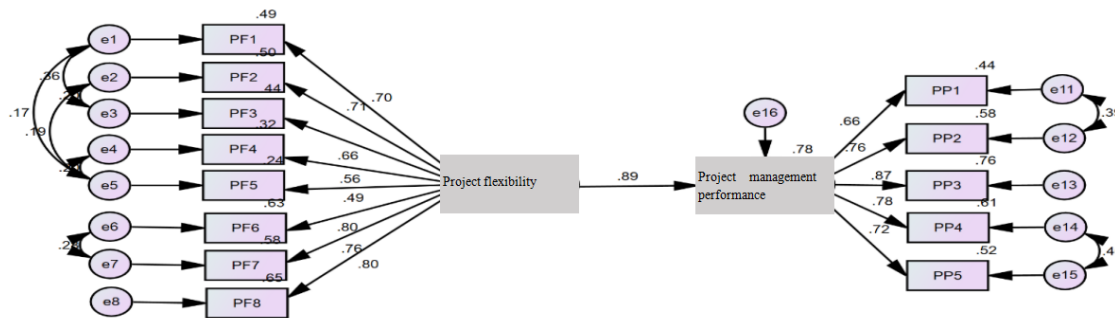


Fig. 3 Fitting results of project flexibility-performance structure model.

Table 7 The statistical values of the fitting results.

Variable relation	The non-normalized path coefficient	Standard error	Critical ratio	Standardized regression weights	P
Project flexibility and performance	1.034	0.111	9.298	0.886	***
Fitting index	$\chi^2/df=2.233$, RMSEA=0.068, GFI=0.925, AGFI=0.878, CFI=0.967, NFI=0.942, IFI=0.967				

* means $p < 0.1$, ** means $p < 0.05$, *** means $p < 0.01$

According to the analysis results in Table 7, the path Regression Weights of project flexibility on project management performance is 0.886, reaching a significant level of 0.01. The adaptation index of the model showed that $\chi^2/df = 2.233$, less than 3. GFI, NFI, IFI, CFI all reached the standard of 0.9. AGFI > 0.85 was acceptable, RMSEA=0.068, less than 0.08. Since there is no mature scale for the construction project flexibility, this study is a pioneering study. Most of the measurement scales used are self-designed based on interview results and theories. Therefore, according to the above situation, it can be considered that the fitting indexes of the theoretical model meet the requirements as a whole.

Through the analysis of structural equation model, the standardized Regression Weights between project flexibility and project management performance is 0.886, $P < 0.01$, indicating a high significance level to confirm the theoretical hypothesis, and the hypothesis that project flexibility has a significant positive effect on performance is supported.

IV. Conclusion

From the perspective of contractors, this paper regards flexibility as a management strategy that contractors can choose to improve the project's ability to respond to change and uncertainty through flexible strategy, aiming to better improve the project management performance. The following conclusions were obtained: (1) Based on literature analysis and expert interview method, eight measurement indicators of construction project flexibility were obtained, including flexible contract, BIM technology application, information sharing, cooperation, flat management, management innovation, emergency resources, team learning, etc. (2) By obtaining valid 267 data of flexibility and project management performance of construction projects in China through questionnaire survey, the structural equation model of flexibility and performance of construction projects is constructed. The software AMOS21.0 is used for fitting analysis of the model. The results show that construction project flexibility has a

significant positive effect on performance. (3) The results provide new management ideas for contractors to cope with the challenges of uncertainty, and expand the theoretical method of project management. The mechanism of project flexibility and specific application scenarios should be further analyzed in the future.

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