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## The Influence of Project Managers' Competency on Project Performance in Private Chinese Construction Companies

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Doctor of Management

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BUSINESS  
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I declare that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university and that to the best of my knowledge it does not contain any material previously published or written by another person except where due reference is made in the text.

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## Abstract

This study aims to explore the mechanism by which the competencies of project managers in China's private construction firms affect project performance. By developing a model of project manager competencies, the research reveals the intrinsic link between these competencies and project performance, providing theoretical support and practical guidance to enhance the managerial capabilities and performance outcomes of project managers. Utilizing a combination of semi-structured interviews, survey methods, and empirical analysis, this study conducts a detailed examination of project manager competencies across three dimensions: personal traits, general leadership abilities, and project-specific management skills. The findings affirm that project manager competencies significantly and positively influence project performance. Specifically, personal traits such as responsibility, execution, proactive attitude, and communication skills directly enhance project outcomes. General leadership abilities, including team-building, organizational coordination, decision-making, and analytical skills, play a crucial role in improving team cohesion, efficiency, and project adaptability. Project-specific management skills, such as planning, risk control, and conflict resolution, are identified as direct factors ensuring projects are completed on time, within budget, and to quality standards. Moreover, the study discovers that team capability plays a significant mediating role between project manager competencies and project performance, while employee trust and team communication mechanisms serve as moderating variables that enhance the positive impact of project manager competencies on project outcomes through improved trust and communication efficiency among team members. This research not only enriches the theoretical understanding of the relationship between project manager competencies and project performance but also provides specific guidance and recommendations for project management in China's private construction sector, offering significant theoretical and practical value.

**Keywords:** Project Manager Competence, Project Performance, Team Capability, Employee Trust, Team Communication, Private Construction Enterprises

**JEL:** M17, L74

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## Resumo

Este estudo visa explorar o mecanismo pelo qual as competências dos gestores de projeto em empresas privadas de construção na China afetam o desempenho dos projetos. Desenvolvendo um modelo de competências de gestores de projeto, a pesquisa revela a ligação intrínseca entre essas competências e o desempenho dos projetos, fornecendo suporte teórico e orientação prática para melhorar as capacidades de gestão e os resultados de desempenho dos gestores de projeto. Utilizando uma combinação de entrevistas semi-estruturadas, métodos de pesquisa e análise empírica, este estudo realiza uma análise detalhada das competências dos gestores de projeto em três dimensões: traços pessoais, habilidades de liderança geral e habilidades de gestão específicas do projeto. Os resultados confirmam que as competências dos gestores de projeto têm um impacto significativo e positivo no desempenho dos projetos. Especificamente, traços pessoais como responsabilidade, execução, atitude proativa e habilidades de comunicação melhoram diretamente os resultados dos projetos. Habilidades de liderança geral, incluindo construção da equipa, coordenação organizacional, capacidade de decisão e habilidades analíticas, desempenham um papel crucial na melhoria da coesão da equipa, eficiência e adaptabilidade do projeto. Habilidades de gestão específicas do projeto, como planeamento, controlo de riscos e resolução de conflitos, são identificadas como fatores diretos para garantir que os projetos sejam completados no prazo, dentro do orçamento e com padrões de qualidade. Além disso, o estudo descobre que a capacidade da equipa desempenha um papel mediador significativo entre as competências dos gestores de projeto e o desempenho dos projetos, enquanto a confiança dos funcionários e os mecanismos de comunicação da equipa servem como variáveis moderadoras que aprimoram o impacto positivo das competências dos gestores de projeto nos resultados dos projetos através da melhoria da confiança e eficiência da comunicação entre os membros da equipa. Esta pesquisa não apenas enriquece o entendimento teórico da relação entre as competências dos gestores de projeto e o desempenho dos projetos, mas também fornece orientações específicas e recomendações para a gestão dos projetos no setor de construção privado na China, oferecendo valor teórico e prático significativo.

**Palavras-chave:** Competência de Gestores de Projeto, Desempenho do Projeto, Capacidade da

Equipa, Confiança dos Funcionários, Comunicação da Equipa, Empresas de Construção Privada

**JEL:** M17, L74

## 摘要

本研究旨在探索中国民营建筑企业项目经理胜任力对项目绩效的影响机制，通过构建项目经理胜任力的特征模型，揭示其与项目绩效之间的内在联系，为提升项目经理的业务能力和项目绩效提供理论支持和实践指导。研究采用半结构化访谈法、问卷调查法和实证分析法相结合的方法，从个人特质、通用领导能力和项目专业管理能力三个维度对项目经理的胜任力进行了详细分析。研究验证了项目经理胜任力对项目绩效具有显著的正向影响，具体表现为个人特质如责任心、执行力、积极主动态度和沟通能力对项目绩效有直接的正向促进作用；通用领导能力如团队建设、组织协调、决策能力和分析判断能力在提升团队凝聚力、效率和项目适应性方面起到了关键作用；项目专业管理能力如计划管理、风险管控和冲突解决等能力是确保项目按期、按质、按预算完成的直接因素。此外，研究还发现团队综合能力在项目经理胜任力与项目绩效之间发挥了重要的中介效应，而员工信任与团队沟通机制则作为调节变量，通过增强团队成员间的信任度和沟通效率，进一步提升了项目经理胜任力对项目绩效的正向影响。本研究不仅在理论上丰富了项目经理胜任力与项目绩效关系的研究，还在实践中为中国民营建筑企业的项目管理提供了具体的指导和建议，具有重要的理论和实际应用价值。

**关键词：**项目经理胜任力，项目绩效，团队综合能力，员工信任，团队沟通，民营建筑企业

**JEL:** M17, L74

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## **List of Acronyms**

|     |                              |
|-----|------------------------------|
| CFA | Confirmatory factor analysis |
| EFA | Explanatory factor analysis  |

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## **Chapter 1: Introduction**

This chapter provides an overview of the thesis, including the research background, research problem, research purpose, research questions, research methods, thesis structure as well as research significance and innovations.

### **1.1 Research background**

In the current context of the new industrial revolution, the construction industry is also facing an environment of industry-wide change. Driven by construction industrialization, reform of business tax into valued-added tax, and reform of assembly buildings, new technologies and new materials are being used more extensively, driving a dramatic change in the production model and organizational structure of China's construction industry. In this macroenvironment, more construction companies are implementing project management as the core management system given the fierce competitive environment and increasingly complex environmental requirements.

Construction projects are endogenously unique and extremely complex, mainly reflected in the following aspects: (1) a construction project is a complex system built by many interrelated subsystems, which interact with each other and are greatly influenced by the project environment; (2) a construction project itself has complex environmental characteristics, including political, economic, natural, social and other environments, which all influence the outcome of the project. Besides, considering that the project itself lasts a long time, susceptibility to the environment is unavoidable; (3) a construction project involves many different organizations and individuals. The teams involved are multidisciplinary teams, and each organization has different interests, leading to conflicts of interest; (4) a construction project has many goals. In addition to goals in the traditional aspects such as quality, cost and schedule, it also contains goals in other aspects such as the environment and safety, and such goals constrain each other. The complexity of the construction project itself places higher demands on the work of construction project managers. Goodwin (1993) argue that the project manager management behavior involves integrating projects and leading teams. The former requires the manager to integrate the different subsystems of the project and the organization's personnel into a whole, covering responsibilities such as planning, controlling,

coordinating and conflict management; the latter includes motivating team members to obtain high-level support from the company and cooperation with external stakeholders. Dulaimi and Langford (1999) divided the project manager's management behavior into five dimensions, which are: (1) managing project environment and resources; (2) organizing and coordinating; (3) information processing; (4) providing good growth and development opportunities for subordinates; and (5) solving motivation and conflict problems. Based on sufficient research, Hyväri (2006) further subdivided the project manager behaviors into: (1) decision making, covering planning/organization, problem solving, consulting and delegation; (2) influencing subordinates, covering motivation/mobilization, recognition and rewards; (3) relationship building, covering relationship network management, conflict management/team building, support and development of subordinates; (4) sending/searching for information, covering monitoring, information delivery and clarification. P. Chen et al. (2008) concluded from interviews that the work of our project managers, in general, guarantees success through the following behaviors: (1) planning and control; (2) relationship coordination; and (3) relationship development.

It is thus clear that the job of a construction project manager is a complex one, and a project manager with strong competencies is required to perform the above tasks well. The construction project manager is the leader and decision maker of the whole project manager and is also an important resource for project management. The degree of competency is a key factor in determining project performance. A good project manager plays a vital role in the project, and his professional management skills and rich management experience can ensure good performance to a certain extent (Wen et al., 2023).

## **1.2 Research problem and questions**

In China's current business ecology, compared with state-owned enterprises (SOEs) (including central enterprises and large local state-owned enterprises), private construction enterprises are generally relatively weak, and are more likely to be in a disadvantageous position in terms of such aspects as bidding qualifications, capital scale and financing channels. Therefore, China's private construction enterprises can only seek advantages in terms of project management and construction and compete at a more excellent individual level. This requires project managers to have a high level of competence (Luo, 2018). Meanwhile, the new industry model under the new economic conditions has changed the traditional way of working of project managers. Information-based management, diversified

models, intelligent construction, and professional training of staff have also raised higher requirements for the competency of project managers of private construction enterprises (Wen et al., 2023).

As mentioned in the research background above, Chinese private construction companies must achieve certain advantages in the management and construction of their projects to be able to win in competition with state-owned construction companies. This raises higher requirements for the competency of their project managers. However, for project managers in Chinese construction enterprises, the components of competency remain unclear, and the underlying mechanism by which competency influences project performance is still not well understood. This significantly hinders private construction enterprises in China from effectively developing project manager competencies, further limiting their ability to improve performance amidst intense market competition and economic downturn pressures.

Therefore, this study proposes the following four research questions (RQs):

RQ1: What are the components of project manager competency in Chinese construction enterprises?

RQ2: How does project manager competency influence project performance in Chinese construction enterprises?

RQ3: In the process of project manager competency influencing project performance, what roles do employee trust in the project manager and communication among team members play?

RQ4: In the process of project manager competency influencing project performance, what role does employee training play within the project team?

## **1.3 Research objectives and significance**

### **1.3.1 Research objectives**

The study adopts a semi-structured interview approach to preliminarily identify the constituent elements of competence for project managers in the current stage of Chinese construction companies. Subsequently, it employs a questionnaire survey and empirical analysis method to investigate the relationship between the competence of project managers in Chinese private construction companies and project performance. Through an in-depth examination of project manager competence, this study aims to discern and classify the core and relatively less important factors that constitute competence. Based on this classification, a

comprehensive theoretical model is constructed, which can be widely applied in various aspects such as project manager recruitment, training, and promotion. The ultimate goal is to screen and cultivate outstanding project managers, thereby enhancing the human resource and operational management capabilities of Chinese private construction companies and promoting project efficiency.

### **1.3.2 Research significance**

#### **1.3.2.1 Theoretical significance**

This study will establish and improve a theoretical model system for the competency of project managers in private construction enterprises in China, which will fill previous theoretical gaps in terms of the impact of competency on project performance and the intrinsic mechanism. It is expected to enrich the research perspective in terms of the competency of project managers in private construction enterprises in China.

Studying the competency of project managers in Chinese private construction enterprises in the economic system of the new era, analyzing the characteristic elements of its composition, constructing a characteristic model based on the characteristic elements, and exploring its intrinsic mechanism of action on performance will help facilitate the enrichment and development of the theoretical research system in this field and make up for the lack of quantitative studies on the competency of project managers in construction enterprises in China. This study combines semi-structured interviews and questionnaires to extract the characteristics of project managers' competencies in private construction enterprises in China, constructs a model of the characteristics by exploring the internal linkages among the characteristics through statistical methods, and then validates the model through structural equation modeling (SEM) and other research methods to identify the fundamental mechanism of its influence on project performance, so as to provide a theoretical basis for construction companies to introduce, select, and train high-performing project managers.

#### **1.3.2.2 Practical significance**

This study analyzes the dimensions and characteristics of the competency of project managers in Chinese private construction enterprises in the new era, constructs a model, explores the inner connection between the characteristics and the mechanism and degree of influence, explores and studies the mechanism by which competency influences project performance, verifies the far-reaching influence of project manager competency relative to Chinese private construction enterprises, and provides an important theoretical guide for each private

construction enterprise. This study is expected to provide important theoretical guidance for the selection and training of project managers in private construction enterprises.

On the one hand, an in-depth study of the characteristics of project manager competency in Chinese private construction enterprises helps to determine the qualifications for project managers according to the requirements of efficient work and guides the human resource management (HRM) of private construction enterprises. It helps to guide the competition, selection, assessment and career planning of project managers and improve the training results of project managers in the enterprises themselves. It also helps to improve the speed and quality of team building of project managers in private construction enterprises in China, strengthen the degree of person-job fit, and facilitate the professional development of project managers in private construction enterprises in China.

On the other hand, the impact between the constituent characteristics of project manager competency and performance in the context of policy form in the new era is verified and analyzed, and the link between the two is clarified to derive the inner mechanism of the role of project managers in project performance in Chinese private construction enterprises, which is conducive to the cultivation of high-performance project managers and the enhancement of core competitiveness of enterprises.

Based on the above analysis, this study will play a positive role in exploring the inner laws of the project manager team of Chinese private construction enterprises in the new era, improve the business skills and work performance of project managers, enhance the scientific nature of private construction enterprises in management, and accelerate the scientific process of human resources work in Chinese private construction enterprises. In the context of the new industrial revolution, this study bears both theoretical and practical significance for advanced management concepts as well as scientific system establishment and human resources practice. Therefore, the essence of this study is to discuss the characteristic model and influence mechanism of project manager competency in Chinese private construction enterprises in the new era.

## **1.4 Research methods**

This study employed a mixed-methods approach, utilizing semi-structured interviews, the questionnaire survey, and empirical analysis as research methods.

**Semi-Structured Interview:** The semi-structured interview method, as a research tool, allows researchers to use a pre-prepared framework of questions while also flexibly adjusting

the questioning based on the responses of the interviewees. This approach enables a deeper exploration of the interviewees' true thoughts and experiences. In this study, the choice of the semi-structured interview method was driven by its ability to provide researchers with first-hand data on the competencies of project managers in China's private construction enterprises, as well as their specific performances during project execution. Particularly when dealing with complex or sensitive topics, the open-ended nature of the conversation facilitates the uncovering of deeper, underlying information. During the implementation phase, the researchers conducted face-to-face or telephone interviews with a selected number of project managers, employing both open-ended and pre-designed questions to gather their experiences, views, and perceptions across different situations. However, this research method also has limitations, such as the typically small sample size, which may not fully represent the circumstances of all project managers. Additionally, the subjective nature of the data requires researchers to have advanced interviewing skills to effectively guide the conversation and avoid biases caused by leading or suggestive questions.

**Questionnaire Survey:** The questionnaire survey method, as a widely used quantitative research approach, was selected in this study to collect a large amount of data on the competency levels of project managers in China's private construction enterprises, as well as project performance. The reason for choosing this method lies in its ability to efficiently gather extensive data, helping researchers gain a comprehensive understanding of the overall status of the project manager population. During the implementation process, the researchers designed a questionnaire covering various competency-related elements and invited a number of project managers to complete it. The questionnaire survey provides broad sample data, facilitating statistical analysis to reveal underlying trends and patterns. However, the method has limitations, such as potential subjective bias from respondents. Moreover, the quality of the questionnaire design directly affects the validity and reliability of the data, requiring careful crafting to ensure clear and precise wording of questions, thus avoiding ambiguity.

**Empirical Analysis Method:** In this study, the empirical analysis method was employed to examine the impact of project manager competencies on project performance. By collecting and organizing data from interviews and questionnaires, and using statistical tools for data analysis, this method explores the relationship and the degree of influence between project manager competencies and project performance. The reason for choosing the empirical analysis method is its ability to provide scientific evidence, offering objective support for the research conclusions. It is particularly suitable when there is a need to identify patterns or verify hypotheses from large datasets. In practice, researchers first collected and organized the

data obtained through interviews and questionnaires, and then used statistical tools to analyze the relationship between project manager competencies and project performance. Nevertheless, this method also has limitations. Since it is based on cross-sectional data analysis, establishing causal relationships may be constrained, and more rigorous designs, such as experiments or time-series analysis, might be necessary to strengthen the argument. Additionally, the results of data analysis depend on the quality and completeness of the data; any bias in the original data could potentially affect the final research conclusions.

## **1.5 Thesis structure**

The structure of this thesis is presented in Figure 1.1 below:

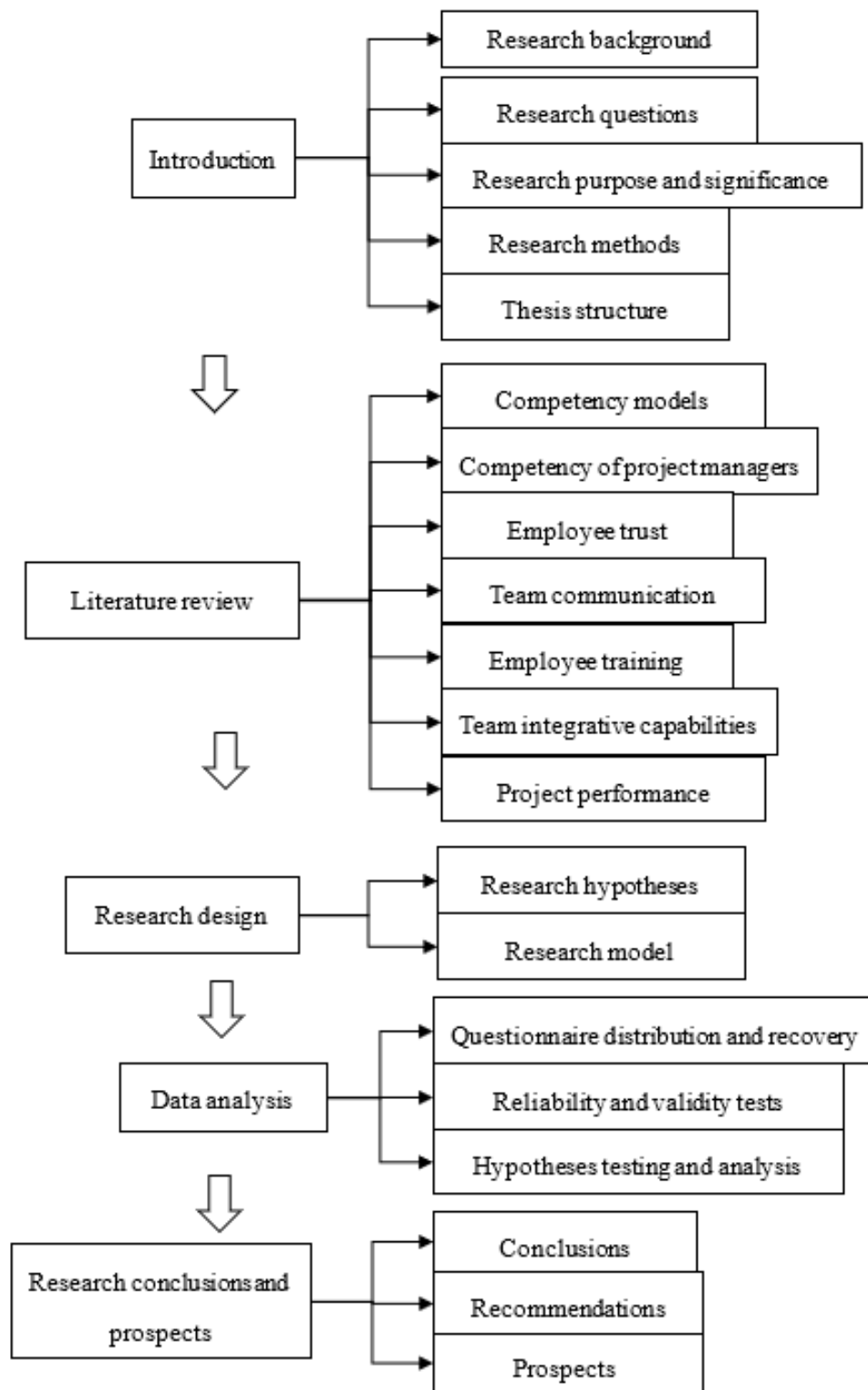


Figure 1.1 Structure of this thesis

This thesis consists of six chapters described as follows.

Chapter 1: Introduction. This chapter provides an overview of the whole thesis by presenting the research background, research purpose, research significance, research methods and thesis structure. It maps out the framework of the whole thesis.

Chapter 2: Literature Review. This chapter is a comprehensive review of the existing studies on the research topic and relevant theories. It lays the theoretical foundation for this thesis.

Chapter 3: Research Model and Hypotheses. This chapter proposes preliminary hypotheses based on the analysis and review of existing literature. Subsequently, a research model is established based on these hypotheses.

Chapter 4: Research Methods and Design. This chapter outlines the research methods used in this study, including the design of the questionnaire scale and the reliability and validity tests, along with necessary modifications.

Chapter 5: Research Results. This chapter presents the research findings through correlation analysis and hypothesis testing. It also integrates statistical software analysis of the survey data to validate the hypotheses proposed in Chapter 3.

Chapter 6: Discussion. This chapter compares the findings of this study with those from existing literature.

Chapter 7: Conclusion and Outlook. This chapter summarizes the key findings of the study, provides recommendations based on the conclusions and insights, and outlines potential future research directions.

## **1.6 Research innovations**

This thesis is innovative in the following three aspects.

First, this thesis constructs a model of the characteristics of project managers' competency in private construction firms. This study uses multivariate statistical analysis to study the dimensions and key characteristics of project managers of private construction enterprises regarding competency in the new ecological environment. This, to some extent, adds a new perspective to the research on the competency of project managers of private construction enterprises. In addition, the model of the competency characteristics of project managers in private construction companies is established and improved in the new situation characterized by industry change and economic new normal, thus helping these companies better adapt to the development trends of today's construction industry.

Second, this study clarifies the intrinsic relationship between the competency model and project performance of project managers in private construction companies. Based on this model, the validity of the theoretical model is tested using SEM, so is the relationship between each key characteristic of competency and project performance based on the model

of the competency characteristics of project managers in private construction companies. The systematic descriptions of the required competency characteristics of project managers in private construction companies will provide an accurate judgment of the mechanism by which the competency of project managers in private construction companies influences project performance, so that more scientific and objective conclusions can be drawn.

Third, a competency improvement approach and training strategies for project managers in private construction companies based on the competency characteristics model are put forward. The path of project manager competency enhancement is proposed regarding the characteristic elements and characteristic indicators of project manager competency in private construction enterprises, based on which the project manager competency development strategies are proposed to improve project performance.

## **Chapter 2: Literature Review**

### **2.1 Competency model**

#### **2.1.1 Definition of competency model**

##### **(1) Definition of competency**

Competency is derived from the Latin word “competere”, which means appropriate. It was first introduced by the Harvard University professor McClelland (1973) in his i entitled Testing for Competence Rather Than for “Intelligence”. According to McClelland (1973), the issue of measuring the quality elements that are key to sound performance in various aspects of life covers not only the occupational dimension but also social aspects, such as interpersonal skills and leadership. Since then, scholars of different professions have put forward their different views. Guglielmino (1979) proposed that competency is mainly composed of three dimensions: core competency, interpersonal competency and skill competency. Core competency is reflected in such aspects as the ability to make strategic decisions, innovation capacity for enterprise development and the ability to analyze economic situation reasonably. It is an important quality competency possessed by entrepreneurs; secondly, interpersonal competency encompasses aspects such as interpersonal skills, communication and negotiation skills and leadership skills; Skill competency is composed of such aspects as the ability to control and the ability to plan one's self-development. Spencer et al. (1994) considered competency an individual's potential traits that have a causal relationship with his/her performance such as qualified performance and excellent performance. Ledford Jr (1995) argued that personality traits, verifiability and the possibility of producing performance are the three major concepts of competency. Specifically, competency refers to an individual's verifiable traits, covering the knowledge, skills and behaviors that may produce performance. Parry (1996) held that competency as an important influencing factor of job performance, is an aggregate of knowledge, attitude and skills, which can be measured by setting standard values. Instead of viewing job competency as the aggregate of an individual's knowledge and skills, Sandberg (2000) saw it as the knowledge and skills used at work. C. M. Wang and Chen (2002) deemed competency the characteristics of knowledge, skills, motivation, personality, ability and values that produce high

management performance.

A synthesis of the definitions of competency in the above literature illustrates its complexity and diversity. Competency has been a topic in the scope of multidisciplinary research, and its connotations are different from different perspectives. However, a summary of the motivations of the aforementioned scholars reveals two major views: The first is that competency emphasizes individual intrinsic nature as an underlying and enduring personal “characteristic”, considering a direct causality between these characteristics and performance. It emphasizes the existence of a causal relationship between the intrinsic characteristics of individuals and effective or superior performance. The second is that competency should be considered a type of individual-related behavior, arguing that competency is “an individual’s ability to demonstrate external behaviors at work”.

Although there are differences in the definitions of competency among scholars and experts, all the variations mainly reflect characteristics in the following two aspects: First, competency has a significant impact on job performance and can be used as a basis for categorizing whether the performance of an individual is excellent or average by scientifically predicting future performance through his or her competency. Second, competency is closely related to the job. It is the ability to complete the tasks of a specific job well and is closely related to the position and usually influenced by the work environment, conditions and the characteristics of the position.

The purpose of this thesis is to uncover the competency of project managers in the construction industry in the context of industry change and the mechanism by which it contributes to project performance. For this reason, the competency defined in this thesis refers to any individual characteristic of project managers that can have a significant impact on project performance.

## (2) Definition of competency model

The “competency model” refers to the result of a competency program that selects the best people among employees, i.e., those who are high performers. Specifically, it means having the characteristics to perform a certain task or job. In other words, the competency model is composed of the knowledge, skills and personal behaviors that influence an individual to perform a given task.

Among the myriad of competency models, the most popular and most widely used ones are the Iceberg Competency Model and the Onion Competency Model.

The Iceberg Competency Model (Spencer et al., 1994), shown in Figure 2.1 below, classifies individual competencies into: skill, knowledge, social role, self-image, trait and

motive. The model suggests that individual qualities are very similar to the characteristics of an iceberg. The part of the iceberg above the water that can be observed by the naked eye corresponds to the individual's knowledge and skills; the part below the surface refers to the part that cannot be easily observed by the naked eye and needs to be identified by tools or other means, which corresponds to the individual's social role, self-image, trait and motive.

### ICEBERG MODEL OF COMPETENCIES

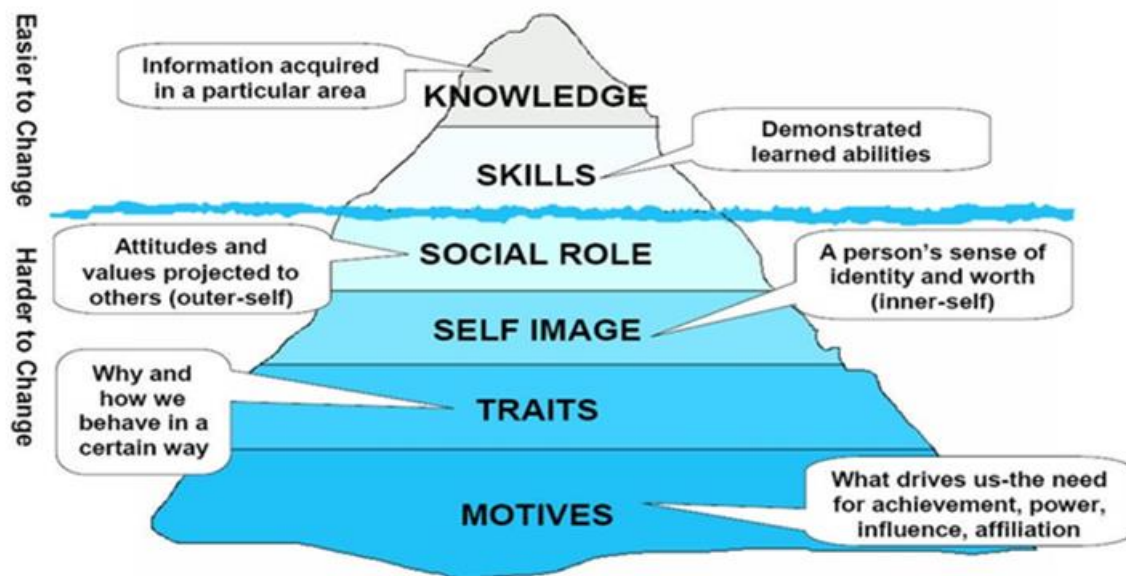


Figure 2.1 Iceberg Competency Model

Source: Spencer et al. (1994)

The Onion Competency Model (C. M. Wang & Chen, 2002) is presented in Figure 2.2 below. This model is similar to the Iceberg Competency Model in that both models characterize the revealed and hidden elements of individual qualities. Yet the Onion Competency Model is more concerned with the hierarchy of elements and the internal and external structure. According to the Onion Competency Model, the different elements of an individual's qualities are similar to an onion, divided into skin and the internal part. The skin part, which corresponds to such aspects as the individual's knowledge and skills, is easy to observe and evaluate as well as explore and develop, while the internal part, which corresponds to such aspects as self-concept & self-image, attitudes & values and personality motivation, is difficult to observe and evaluate as well as difficult to change by means of development and training.

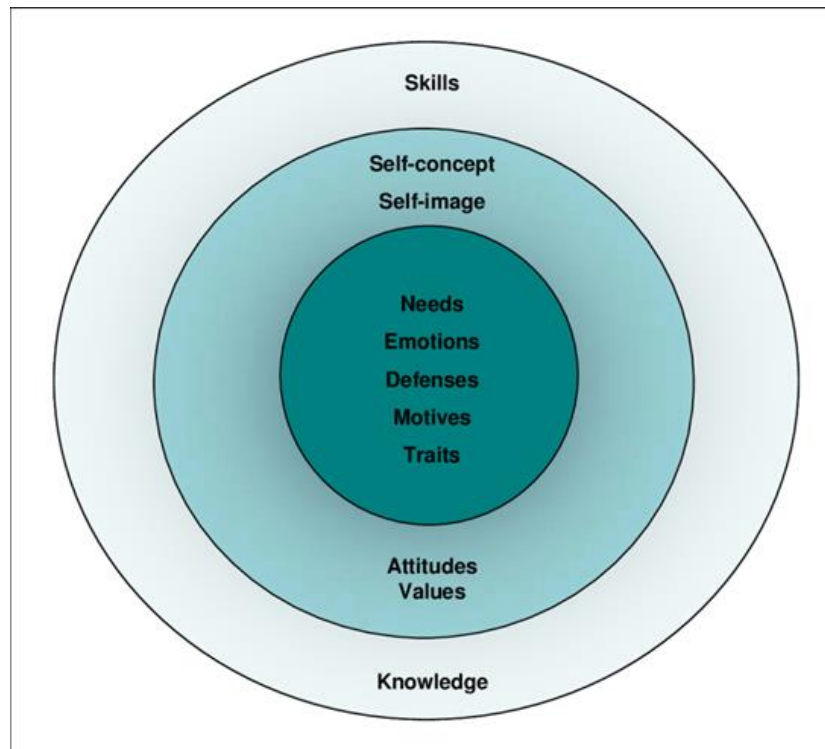


Figure 2.2 Onion Competency Model

### 2.1.2 The functions of competency models

The birth and application of competency models is one of the most important events in the history of HRM. Such models provide a guarantee for companies to raise the quality level of their employees and achieve their strategic goals. At the macro level, it links the strategic development plan with the selection and training strategy of a company; at the micro level, it provides theoretical guidance for the talent management and training plan of the company, points out the direction for the self-learning and progress of employees, and enables the effective implementation of the best use of people in the company (C. M. Wang & Chen, 2002).

Competency models can effectively tap into the quality of employees, provide help for job responsibility analysis, help companies better select talents, and improve the overall quality level of employees so that they can better adapt to their positions and create higher performance in their jobs. Guided by such models, it is possible to predict employee performance and evaluate their career development direction, providing an effective tool for companies to select and employ people. With the support of these models, enterprises can carry out more targeted training, conduct a comprehensive analysis of various aspects of employee quality and job descriptions, clarify the differences between the two according to enterprise strategic development planning, and design training content on this basis to raise the overall quality level

of employees and enhance their core competitiveness in a short period of time. The implementation of competency models helps to increase the person-job fit and ultimately facilitates the formation of a win-win situation for both employees and the company (C. M. Wang & Chen, 2002).

### 2.1.3 Competency model construction process

From different perspectives, competencies can be divided into different types (such as core content, core role and other perspectives), and the main methods for creating models include behavioral event interview (BEI), strategic deduction, questionnaire survey, job analysis, expert evaluation and performance analysis. The process and method of creating competency models with various contents are not consistent. In general, the process of creating a competency model includes the following four stages (J. F. Peng, 2014) (see Figure 2.3 below).



Figure 2.3 Competency model construction process

Source: J. F. Peng (2014)

#### (1) Preparation stage

At this stage, information about the company is obtained, and such aspects of the company as its mission, vision, strategy, organizational structure and job descriptions are understood. The competency model a company wishes to build inevitably comes from the company's strategy, especially the core competencies that can provide support for effective implementation of the strategy (J. F. Peng, 2014).

#### (2) Research and development stage

This stage includes the following steps: first, identify the position to be studied; analyze the corporate strategy and organizational structure; clarify the core business processes; and conduct interviews with relevant personnel. Second, propose the performance criteria, which means using objective and clear criteria and rules to quantify performance and lay good conditions for the subsequent competency research. Third, conduct core task analysis. Use job analysis method to break down the performance criteria of the target job into key task items and to identify the competencies that lead to high performance. Finally, apply the methods of BEI,

expert evaluation and questionnaire survey to clarify the quality elements of job competence and competence standards, thus forming the preliminary competency model (J. F. Peng, 2014).

(3) Evaluation and validation stage

Development of the competency model requires continuous tests and optimizations, in which evaluation and validation are indispensable. In the process of competency model construction, benchmark testing and SPSS software are used to analyze the reliability and validity of the data; in addition, after the framework of the competency model is built, it needs to be evaluated in management practice. On the one hand, it should be discussed and revised by the respective job holder and his/her superiors; on the other hand, the validity of the model should be tested in practical application (J. F. Peng, 2014).

(4) Model application

The significant value and role of the competency model ensures that all links of human resources (such as ability evaluation, recruitment & selection, training development and performance management) can be implemented effectively. The training system established on the basis of the job competency model ensures that the company can carry out talent training based on standards, develop progressive training contents, focus on key training needs, measure the training outcomes, continuously improve the effectiveness of training, and more effectively improve the quality of trainees (J. F. Peng, 2014).

#### **2.1.4 Competency model construction methods**

Many approaches can be used to build a competency model. Different experts and scholars have their own understanding and preferences in this regard, and companies of different natures differ significantly in their approaches to model construction (J. F. Peng, 2014). The following four methods are the most popular ones applied in reality:

(1) Derivation method

The derivation method is about using logical deduction to decompose the company's strategy and development goals as well as job characteristics and requirements step by step to deductively derive the competencies that employees should have. In some sense, the competencies identified using the derivation method are most in line with corporate goals and policies and can best reveal the development context of the company (J. F. Peng, 2014).

(2) Behavioral event interview method

The behavioral event interview method, abbreviated as the BEI method, is a widely applied and effective method for constructing competency models with high validity of the outcomes.

Its main approach is to extract competencies for a position from the interviewees' review of their past work and behaviors as well as descriptions of their experiences and cases. This form of interview effectively combines the critical incident technique (CIT) put forward by Flanagan with the thematic apperception test (TAT), in which the key step is to ask the interviewees to describe their past work successes and failures (J. F. Peng, 2014).

### (3) Questionnaire survey method

The essence of the method is to use questionnaires consisting of representative and meaningful questions/items for respondents to answer or choose. This method is easy to operate; the statistical results can accurately reflect the needs of the public; and it is currently the most widely used data collection methods. Considering that questionnaires are usually standardized, and the sample size is usually large, questionnaire surveys can be conducted quantitatively or qualitatively. Therefore, the questionnaire survey method is widely applied in the areas of psychology and educational research (J. F. Peng, 2014).

### (4) Expert panel method

The expert panel method is about engaging an expert who has in-depth research knowledge about a given position to express their views and insights on the competencies for the said position. Alternatively, a combination of internal and external experts can be engaged to gain a clear understanding of the responsibilities, requirements and behavioral role models of employees in their daily work, and to make detailed records (J. F. Peng, 2014).

## **2.1.5 Construction of competency models**

Competency models have been applied in many industries, and scholars have conducted extensive research on this topic in different industries and regarding different positions, yielding fruitful results. Yoon and Yoon (2016) used explored the core competencies and job characteristics of conference project managers in professional conference services and developed structural equation models (SEMs) for validation. The results validated the necessity to conduct research on human resources in the conference industry. X. Z. Chen and Mao (2016) pointed out in their study that the job competency model is a talent management model that can significantly improve the core competitiveness of organizations and is affirmed by many managers of enterprises and institutions. They applied the competency theory to the training and curriculum reform of computer network professional talents, identified the elements of competency, established a typical model of computer network professional competence, and pointed out the direction for the training of typical job talents of computer network

professionals. L. Li (2017) explored job competency evaluation model, built a senior-level competency evaluation index system for career management students by combining the questionnaire survey and analytic hierarchy process (AHP), and created a job competency evaluation model by using AHP to assign appropriate weights to each index.

Winter (2018) studied the professional competency model of nursing staff, covering numerous dimensions such as learning, competence and performance, and clarified the competencies that practicing professional nurses should have. Cao (2018) studied the national productive service industry and talent training policies and established a talent competency model for intelligent manufacturing system operation and maintenance based on the framework of DevOps and CMMI models. Proceeding from the breadth, depth and size, the information coding process and system architecture were analyzed, and certain results were achieved. D. Chen et al. (2018) used the questionnaire survey method to collect primary data and information and comprehensively employed factor analysis and correlation analysis to clarify the elements of the grass-roots commanders' competency model. They pointed out in their study that the grassroots commanders' competency model should be composed of four dimensions, namely, professional quality, leadership traits, basic abilities and personality traits. Ismail et al. (2018) used Indonesian construction workers as the sample and explored how to build a workforce competency model. Based on the model they developed, it is clear that the most important competency criteria of construction workers include skills, interpersonal, communication and attitude. Based on the findings, Ismail et al. (2018) pointed out that the Indonesian workforce is basically competent in interpersonal, communication and attitude for their jobs, but is not competent in skills and that further training is needed to improve their skills in the future. Fernández-Ronquillo et al. (2018) developed a competency model for micro-entrepreneurs to identify the competencies that this group should possess for their jobs and to provide direction for adjusting their management behavior and improving business performance. Their model covers 27 competencies, and only micro-entrepreneurs with these competencies are able to lead their companies out of difficulties. Fu (2018) combed through the ideas of establishing the human resources model and the application methods and argued that the competency model can provide help for employee training and selection in enterprises. Guo et al. (2018) established an ethical competence model for corporate executives by comprehensively using BEI and questionnaire survey to provide guidelines for practical operations. Abdullah et al. (2018) argued that many of the very common problems in the Malaysian construction industry are rooted in construction managers not possessing sufficient competencies. They stressed that a good construction manager should have 16 technical

competencies, mainly in management, such as management of employees, materials, labor, plants, subcontractors, safety and contracts. Jabar et al. (2018) studied the competencies of project managers for IBS construction projects in the Malaysian construction industry. The results showed that project managers for such projects undertake a wider range of responsibilities than for ordinary construction projects. Kozhevnikov et al. (2018) conducted a study on the competency model of science and technology (S&T) personnel in the steel industry and pointed out that a highly qualified S&T person should not only have a wealth of expertise, be able to work efficiently and collaborate well with others, but also have excellent engineering skills, management skills and a good performance in innovation. M. Y. Li (2018) employed a combination of literature research, BEI and questionnaire survey methods to empirically explore and study the competencies of HR managers in technology-based SMEs, determined the weights of competency elements through AHP, and finally constructed a competency model for human resources management (HRM) in SMEs. Luo (2018) chose talents in the tourism industry as sample and established a competency model based on the competency theory and the iceberg model. The results show that the “part above the iceberg” consists of eight “visible” competencies and the “part below the iceberg” consists of eight “invisible” competencies. Prikshat et al. (2018) made a comparative analysis of the Indian HR competency model and the Western model based on data collected from a sample of 100 Indian organizations. The results showed that of the three Indian HR competency models presented, the HR Compass model and the Western model were the most convergent. Stačinskaitė and Petrauskienė (2018) conducted a study on the Lithuanian civil service competency model and practice and used semi-structured expert interviews and a qualitative social survey to identify the challenges in the application of the competency model. Welch and Hodge (2018) conducted a study on the regional leadership competency model, which provides a strong basis for hiring and training people for regional leadership positions. X. Y. Chen and Jiang (2017) explored the competencies that marketing students should possess under the guidance of competency theory and put forward feasible suggestions to enhance their competencies, starting with training arrangements as well as hardware and software configurations. P. Xu and Zhang (2018) explored the HRM model of enterprises from the perspective of competency. D. X. Yang (2018) used the research results on knowledge workers' comprehensive competency model to create a competency model for knowledge workers in high-tech enterprises, which provides a powerful tool for the training and selection of talents. Yao (2018) carried out research and analysis of the competency of cross-border e-commerce talents by applying BEI and questionnaires, compiling and analyzing raw data, clarifying the types of competency characteristics, and

establishing the competency model of cross-border e-commerce professionals. Y. H. Zheng and Chen (2018) carried out an empirical study of a student evaluation and selection method based on competency theory and found that the application of this method is able to identify outstanding students more accurately and to form teams for student innovation and training projects.

Ao (2019) analyzed the HRM competency characteristics of Chinese universities and designed a special model to provide an effective tool for the recruitment, training and assessment of efficient young teachers in the context of China's reality. K. Y. Chen (2019) summarized the competencies that HR managers should possess through an exploration of the HR professional manager competencies and introduced their application in practice. T. Chen (2019) explored the competency characteristics of the group of hotel middle managers and established a competency model from the dimensions of professional knowledge and using a man according to his ability. According to the model, the competency characteristics that hotel middle managers should possess include customer focus, learning facilitation, personal charm, control ability and insight. Y. L. Chen (2019) established a TCM competency model to provide guidance for TCM hospital staff management. The results of their study indicated that a qualified TCM practitioner should possess professional ethics, self-improvement, professional foundation, TCM knowledge/skills and modern medical knowledge/skills. He (2019) collected data on the competency of track and field coaches and comprehensively applied item analysis, exploratory factor analysis (EFA) and reliability analysis to design a specialized competency evaluation scale, which consists of five subscales involving a total of 22 items. Specifically, the track and field management ability subscale consists of seven items; the sports science knowledge subscale consists of five items; the injury prevention management subscale is composed of three items; and the biological science knowledge subscale is formed by three items; and the track and field training ability subscale consists of four items. Hu et al. (2019) analyzed the competencies of software engineers and provided solutions for the better management of this group of employees, which helped solve many problems in the training, selection and performance assessment of software personnel and achieve higher management efficiency. J. L. Zhong (2019) created a competency model for accounting professional education and validated the model with real cases, showing the way to enhance the quality of accounting professional education. Negara et al. (2019) studied and analyzed the competencies of civil servants and client-side project managers commissioned to the public construction sector and identified the competencies that should be possessed by clients or client project managers in Indonesian construction projects and tested the current construction project

manager competency standards. By collecting primary data and conducting research through BEI method, L. Shi et al. (2019) concluded that public health physicians should have knowledge, skills and performance characteristics of public health events. The competency model they created is composed of seven dimensions: basic medical knowledge, specialized skills, public health knowledge, research and development, health management and health promotion, professionalism and comprehensive abilities.

Based on the existing model, Horváthová et al. (2019) established a competency model for sales managers of manufacturing companies. After specifying the indicators, the AHP method and Saaty method were comprehensively used to assign appropriate weights to each indicator. After fully understanding the appointment as well as the assessment of the chief quality officer of BYD, W. Wei (2019) used the AHP method with post leadership, knowledge and skills as the first-level indicators together with ten second-level indicators to establish a chief quality officer competency model. H. Zhao (2019) pointed out that the establishment of the enterprise leader competency model is directly related to the future development of the enterprise. He defined the business leader competency model, analyzed the meaning and path of establishing the business leader competency model in an all-round way, and elaborated the modeling strategy.

Mohd Ali et al. (2020) analyzed the competencies that Shariah auditors should have in the context of Islamic banking industry, based on which the SAR competency model was created. The main competencies identified include knowledge as well as personal and core skills. Campion et al. (2020) pointed out that the most central value of the competency model is to implement organizational strategies into employee behavior in the past. However, no scholar has studied this from a theoretical perspective. Their study built a conceptual framework to characterize the above process. Michibayashi et al. (2020) conducted a study to examine the competencies of public health nurses in local tobacco control in Japan. Applying a combination of semi-structured interview method, the iceberg model and qualitative descriptive methods, they found that public health nurses' competencies are related to three motivations: improving tobacco control effectiveness, breaking free from tobacco control constraints, and strongly promoting tobacco control efforts. Hu et al. (2019) integrated a variety of research methods, such as literature research, workflow analysis and expert interviews under the guidance of bimodal IT theory and job competency model theory, such as were synthesized and applied to propose the traditional and new models of IT talent job competency quality models. J. T. Li et al. (2020) designed a data-driven competency model construction method to extract valuable talent evaluation information from raw data. The proposed nine methods clarified the characteristics that can objectively reflect personnel profiles and competencies, on which basis

the competency model is built and proven to be effective. McCartney et al. (2021) created an experience-driven competency model based on a profile of the knowledge, skills and abilities that HR analysts should possess (KSAO). Prajugjit and Kaewkuekool (2020) developed the DSD trainer competency model and assessed through a task-oriented approach. The model consists of seven dimensions, namely training course design, career expertise, training measurement and evaluation, investigation and diagnosis of problems and needs, productivity improvement, training techniques and training procedure design. X. Zheng et al. (2020) analyzed the factors related to CMA competencies and identified 20 CMA competency items into three dimensions: (1) personal characteristics; (2) competencies; and (3) thinking.

S. Wang (2021) pointed out in their study that the most core competencies of international e-commerce talents lie in three aspects: foreign language proficiency, international e-commerce competence and international e-commerce talent quality, and established a specialized competency model based on the findings. Suifan et al. (2021) adopted a scientific survey method to explore how the competencies of project managers affect the efficiency of project execution. They quantified the competencies of project managers leading construction projects of various sizes, using project managers and engineers from Jordanian project management consulting firms registered with the Amman Chamber of Commerce as sample. The results of their study showed a positive association between the two. In addition, project manager competency is a key determinant of execution efficiency, with affective competency and efficiency having the strongest association, while the management dimension having the relatively least effect on efficiency. Therefore, to effectively improve project execution efficiency, the key is to enhance the affective component of project manager competency.

In 2022, C. C. Chen et al. (2022) built a predictive model using advanced artificial intelligence (AI) technology, which includes a quantitative mathematical model through which the level of personnel competency and improved performance can be quantified. This model shows that there are discrete and continuous relationships between the competency dimensions and their synergistic effects. Four AI algorithms were used to train a dataset containing 362 data elements, covering two optimized combinations of the dimension values in Step 1, and 360 data elements derived from the dimensional relationships that generate synergies. The model created predicts the competencies of job applicants and then compares them to their values to improve job performance, providing an informative tool for selection. J. Y. Wu and Song (2022) made an effort to provide a robust explanation for the competencies of the best Chinese researchers. Therefore, the model was developed by coding the biographies of 17 Chinese scientists layer by layer under the guidance of the grounded theory to build a competency model for outstanding

Chinese researchers. The results found that the competency model for excellent Chinese researchers is composed of five dimensions: research knowledge base, research quality, internal research motivation, innovation awareness and thinking ability, as well as research skills and self-development, and these five dimensions further encompass 32 specific competency characteristics, such as research interests and research results.

## **2.2 Project manager competency**

### **2.2.1 Definition of project manager competency**

The project manager is one of the most important members of the entire project organization, playing the dual role of decision maker and manager at the same time. In addition, because a construction project itself is a one-time project, involving many factors and the phenomenon of “authority gap”, the responsibilities of project managers and general managers are different. As a result, the competency requirements of the two are also inconsistent. To improve the management and leadership effectiveness of project managers, construction companies must adjust the competency requirements for this position in a timely manner. In this context, more scholars have started to get involved in the research field of project manager competency and have yielded more fruitful results. Goodwin (1993) argued that the management behaviors of project managers include two types, namely integrating the project and leading teams. The former requires the project manager to bring together all the subsystems and people involved in the project to form a whole and involves such responsibilities as planning, control, coordination, communication and conflict management; the latter involves motivating members, obtaining high-level support, and cooperation with external subjects. Walsh (1988) conducted a questionnaire survey to distill the competent characteristics of good project managers, which include adequate delegation, proven skills and effective communication. Pettersen (1991) summarized the competency characteristics of project managers based on a review of the existing literature and identified three dimensions of skills, abilities and personality traits. Specifically, the characteristics of the skills dimension include project management, interpersonal skills and communication skills; the competency dimension involves team management, system analysis and stress resistance; and the personality traits dimension encompasses integrity and sense of responsibility. Gushgari et al. (1997) conducted a questionnaire survey to rank the 20 competency characteristics of project managers in descending order of importance, with the most important ones being communication, listening,

project management, decision-making, leadership and motivation. Edum-Fotwe and McCaffer (2000) found through their survey-based study that project managers need to have not only leadership, communication and negotiation skills but also knowledge beyond the traditional nine areas of project management, such as finance, accounting, sales and marketing. Using the BEI method, Cheng et al. (2005) identified 12 competency characteristics of engineering project managers, including self-control, teamwork and information search ability. L. Shi et al. (2014) comprehensively employed expert interviews and the questionnaire survey method with Chinese construction project management consultants as participants and categorized the main competencies as personnel quality, field practice and continuous learning ability.

It can be seen from international literature that the research on project manager competency has gone far beyond the scope of project management. Many project management associations have created a variety of project manager competency systems to improve the overall quality of the project manager team. The International Project Management Association (IPMA) has established 46 competencies for project managers in its official document, which can be categorized into three dimensions, namely situational, technical and behavioral competencies. In this study, the full name of “project managers” is “project managers of construction enterprises”. Based on the purpose of this study and the literature analysis, the core task of this study is to employ empirical research methods to build a model of project manager competency characteristics that can meet the needs of construction enterprises.

### **2.2.2 Project manager competency dimensions and measurement**

As for the dimensions and measurement of project manager competency, existing studies have identified different dimensions to construct project manager competency. Walsh (1988) conducted a questionnaire survey to summarize 18 characteristics of good project managers, such as delegation, providing technical support and effective communication. Pettersen (1991) summarized the competency characteristics of project managers to involve three dimensions of skills, competencies and personality traits. Specifically, the skills dimension consists of such characteristics as project management, interpersonal and communication skills; the competency dimension is composed of such characteristics as team management, system analysis and stress resistance; and the personality traits dimension consists of such characteristics as sense of responsibility and integrity. Goodwin (1993) noted that the behaviors of project managers include two types, namely leading teams and integrating projects. The former's scope of responsibility includes planning, control, coordination, communication and

conflict management. The project manager should effectively integrate the subsystems and all personnel involved in the project; the latter includes motivating members, obtaining high-level support and cooperation with external subjects. Donnelly and Kezsbom (1994) believed that the most important competencies of a project manager should be in the area of management, reflected in the ability to analyze and judge accurately in all situations, being open to the opinions of subordinates, and valuing the goals and needs of the organization. Gushgari et al. (1997) carried out a questionnaire survey and ranked the 20 competencies of project managers in descending order of importance, with the most important ones being communication skills, listening skills, project management skills, decision-making ability, leadership skills and motivation. The study by Edum-Fotwe and McCaffer (2000) revealed that project managers need to have not only negotiation, communication and leadership skills but also knowledge beyond the traditional nine areas of project management, such as sales and marketing as well as finance and accounting. Cheng et al. (2005) carried out a study using the BEI and identified 12 competency characteristics of engineering project managers, including teamwork, information search ability and self-control. L. G. Shi et al. (2014) comprehensively employed the questionnaire survey method and expert interview method in light of China's reality and summarized three important competencies, i.e., continuous learning ability, field practical performance and moral quality. Using the questionnaire survey method, X. Q. Wang et al. (2014) carried out dimensional and project-level statistical analysis and variance analysis of different level groups at the dimensional level with project managers in construction enterprises as participants and created a model of project manager competency characteristics, which includes six dimensions in order of cognitive skills, social skills, resource management skills, achievement orientation, stress resistance orientation and responsibility orientation. S. B. Zhang et al. (2013) measured the competency characteristics of construction project managers and validated the construction project manager competency characteristics model consisting of emotional intelligence, charisma, project management and cognition. Dong (2016) used structural equation modeling to investigate the factors related to the competency of construction project managers and identified the most important factors as general management ability, personality traits and expertise.

### **2.2.3 Project manager competency**

The research results on project manager competency in the construction sector are also abundant. In fact, many scholars have established project manager competency models. Below

is a review of the existing research results in this regard. Based on fuzzy mathematical ideas, Mana'an et al. (2014) designed a new assessment method to provide a new tool for the performance appraisal of project managers in the construction phase of major housing building projects. The study was conducted with a Ghanaian real estate developer as the case and used structured interviews to explore measures of key competency factors that reflect the performance of project managers during the construction phase. Panas et al. (2014) noted that project managers' responsibilities range from stakeholders, scope, time, cost and risk, and that knowledge and experience are key to building the project manager management capacity. However, most colleges and universities that offer construction courses are basically using the traditional classroom approach. It is time to use simulation modeling as a tool for construction project manager capacity development. Fore (2011) pointed out that as projects become increasingly complex and uncertain, and as industry competition turns white-hot, leadership competency models designed based on past projects are gradually revealing more flaws and failing to adapt to the current era. Project success is not only the achievement of objectives with limited resources and budget, but also, and very importantly, the enhancement of organizational competitiveness. Fore (2011) explored the competencies that leaders of strategic projects should have. He randomly selected 35 individuals from government and private companies as respondents for a questionnaire survey. The results showed that the respondents' position and years of experience were important factors in determining the core competencies required for strategic projects. Liikamaa (2015) proposed a new self-evaluation method to collect and analyze the information and data of a project manager's competencies at work. The results revealed a collective view of the most important competencies in the work of project managers, providing a reference for companies to recruit and develop project managers.

In 2016, Brahmantariguna et al. (2016) stated in their study that the role of the project manager is the key to ultimate success. The assessment of their competencies should be conducted in terms of knowledge, skills and attitudes. They also explored how project manager competency (as measured by the three independent variables of knowledge, skills and attitudes) affects ultimate success. Mohammad et al. (2016) argued that the key to improving the performance of construction projects is to enhance project management, construction management and site management. Although they differ from each other, however, construction management, which involves both off-site and on-site activities, is a key determinant of the succession of a project. Therefore, it is important to have a qualified construction manager in place at a given stage to ensure that construction activities are carried out consistently and that the proposed development is ready to be completed based on a

combination of objectives. The results of this study also indicate that education and training can help raise the management performance of project managers. Hanna et al. (2016) conducted a study in the construction industry and designed a common mathematical formula to assess project manager competencies. The mathematical model was designed to reveal the importance of various project manager competencies to industry practitioners, distinguishing between exceptional project managers and average project managers. The results of this study revealed that having business and financial acumen, disciplinary understanding of all phases of a construction project and their interrelationships, continuous monitoring of similar construction projects, and consistent knowledge of available information technology were the most significant competencies between outstanding and exceptional project managers. Based on their study, Jaafar et al. (2016) created a model that is able to quantify the level of competency of female project managers and used the model to make quantifiable measurements.

Lee et al. (2016) explored the relationship between project managers' leadership and participants' individual competencies and project performance, and the results showed that (1) project managers' leadership competencies are conducive to improving project participants' individual competencies. (2) Project manager's leadership skills and project management performance are positively associated with each other. (3) There is no significant association between project manager's leadership skills and project completion performance. (4) The personal competencies of project participants can contribute to the improvement of project management performance. (5) There is no significant association between the personal competencies of project participants and project completion performance. (6) Project management performance is significantly related to project completion performance. (7) The relationship between project manager leadership and project completion performance is dependent on project completion performance. (8) The relationship between project participants' individual competencies and project completion performance is dependent on project management performance. Sadatrasool et al. (2016) stated in their study that project managers should maintain an optimistic attitude in the process of managing costs and resources. The model was created by applying a combination of multi-criteria decision making and principal component analysis (PCA) methods to project managers in the oil industry. This method takes into account several criteria and invites many experts with extensive experience to assign appropriate weights to each indicator. The model's functionality was demonstrated on the basis of specific cases, and the model was confirmed to be fully feasible using the VI-KOR method.

In 2017, Omran and Suleiman (2017) studied the project managers of small and

medium-sized enterprises (SMEs) in the Palestinian construction industry and ranked on each of their competence dimensions. They were considered to cover four dimensions, namely, knowledge competence, personal/behavioral competence, functional competence, and value/ethical competence. Specifically, the knowledge dimension focuses on technical, managerial, general, computer, communication, legal and financial knowledge. The personal competence dimension covers two aspects, intraprofessional and socio-vocational. The functional competence dimension covers seven aspects, such as developing project plans, facilitating project initiations, and managing human resource functions. The values/ethical competence dimension includes personal values as well as professional values. Dziekoński (2017) conducted a study on Polish construction project managers to create a model of their competencies. The model involves numerous factors that are associated with the project manager's attributes and provides a reference for the design of a new approach to construction project management in Poland. Mohammad et al. (2016) pointed out that an important factor for the construction project to achieve the desired goals is the technical competence of the construction manager. However, it often exceeds the terms of reference in reality. Hanna et al. (2018) argued that a qualified project manager plays an important role in the project, and continuous empowerment of the project manager is crucial. The automated model created is able to derive project manager competency weights by simply entering actual data.

Mainga (2017) investigated the relationship between project management competence dimensions and project efficiency. The results indicated that certain "higher-level" project management competencies, such as "dynamic capabilities," had a relatively significant impact on predicting project efficiency. Enhancing project efficiency requires strengthening multiple specific factors.

Huda (2017) developed a dynamic model to simulate the relationship between project management competence, resources, capabilities, and performance among small and medium-sized contractors in Indonesia. The study found that project management competence had a positive and significant influence on performance concerning company resources or capabilities. Additionally, the emotional sensitivity and communication skills of project managers may explain the variations in project performance.

In 2018, Sang et al. (2018) analyzed the green building competencies of project managers. They combed through existing research findings and held focus groups to clarify the critical success factors of green construction and project manager competencies. Their findings show that green construction performance is largely determined by project manager competencies, especially their leadership and organization, goal management and emotional intelligence.

They emphasized that the competence of project managers is a crucial factor determining project success. Their study assessed project manager competence in green buildings and identified key success factors for both green building projects and project manager competence. The research findings indicated that leadership and organizational abilities of Chinese project managers in green buildings, goal management skills, and emotional intelligence were significant factors influencing green building performance. Ha and Tran (2018) explored the literature on project manager leadership abilities and project success, highlighting the need to enhance project management capabilities in the construction field.

Hwang et al. (2019) discovered that the technical requirements and incentives for collaboration, the project manager's professional knowledge and awareness, and stakeholder needs and support in green building projects had a significant impact on project manager job satisfaction. Rezk et al. (2019) affirmed the important role of the project manager for construction projects. Their study mentions that project manager competencies have long been widely valued by the academia. But most scholars have focused their main attention on hard skills (e.g., technical knowledge) and soft skills (e.g., personality traits). Besides, few scholars had studied transportation project managers working for state highway agencies (SHAs). This comprehensive competency assessment model, designed specifically for SHA project managers, consists of 55 basic project manager competencies in five dimensions: leadership, project management knowledge and experience, industry knowledge and experience, SHA operational knowledge and experience, and cognitive/personal effectiveness.

In 2020, Moradi et al. (2020) used a human behavior approach to analyze and study the competencies of project managers in Finnish collaborative construction projects. They started by collecting a large amount of data and analyzing the behavior of project managers to clarify their competencies, from which they eventually distilled ten core competencies, such as language proficiency, group capabilities and leveraging diversity. Moradi et al. (2020) analyzed the competency requirements of project managers for collaborative construction projects. The results show that the four groups of competencies in the matrix model are structured based on their contribution to the project manager's successful performance in collaborative construction projects and the extent to which they can develop these competencies.

Moradi et al. (2020) assessed project manager competence using human behavior methods in collaborative construction projects in Finland. The analysis of project manager behavior led to the identification of specific abilities. The study proposed ten core competencies for project managers in collaborative construction projects, such as team capabilities, language proficiency, and diversity utilization.

El-Sawalhi and Lafy (2021) investigated the relationship between project manager competence and employee performance in the context of construction companies in the Gaza Strip. The research found that the three most influential factors affecting employee performance based on project manager competence were productivity, adherence to work instructions, and working after normal working hours. The three most critical competencies that project managers needed to influence employee performance were communication skills, team management, and problem-solving.

Montenegro et al. (2021) revealed that emotional intelligence significantly influenced project success among construction project managers, with internal and external stakeholder relationships playing a vital mediating role. Some components of emotional intelligence had more significant effects on stakeholder relationships and project success, while internal and external relationships impacted project success components to varying degrees.

Favoretto and Carvalho (2021) explored the relationship between knowledge management and project performance, finding a significant correlation between the two.

Agindano (2021) demonstrated that management commitment, project regulations and procedures, employee communication, employee capabilities, work environment, and employee involvement had a positive and significant impact on the West Coast Headquarters Building project's performance. These factors collectively had a simultaneous positive and significant effect on the project's performance.

Sarpin et al. (2021) identified key competencies required for project managers to successfully manage sustainable construction projects, including professional competency, emotional resilience, stress management, and negotiation skills.

Dlamini and Cumberlege (2021) highlighted the crucial role of project managers as key contributors to project success, with their roles, responsibilities, and competencies directly affecting timely completion of construction projects.

Lin (2021) examined the relationship between project management competencies, work motivation, and performance among individuals involved in e-commerce. The study indicated that project management competencies positively influenced work performance for those participating in e-commerce.

Elmezain et al. (2021) studied the relationship between project success and project manager factors. The research showed that project managers maintained competitive levels in technical, conceptual, political, and interpersonal skills and emphasized specific aspects of project success, including cost, schedule, and quality.

Sultana-Muchindu and Kabwe (2022) found a close relationship between emotional

intelligence of project managers and project success in the construction industry. The study investigated the impact of emotional intelligence of project management professionals on the success of the L400 road project in the Lusaka region and confirmed the influence.

Sonelma and Sucita (2022) emphasized the significant role of project managers in project implementation. Project manager competence was measured through three aspects, namely the PMI Talent Triangle, which includes technical project management, leadership skills, and strategic and business management. The research indicated that the regression coefficient values for technical project management, leadership skills, and strategic and business management were 0.423, 0.097, and 0.437, respectively, with project manager competence contributing to 44% of the impact on the success of construction projects.

Khalfan et al. (2022) demonstrated that leadership had a significant influence on quality management practices and operational performance in construction projects. Quality culture significantly impacted quality management practices but had no influence on operational performance. Quality management practices significantly influenced operational performance.

## **2.3 Employee trust**

### **2.3.1 Definition of employee trust**

Trust has been one of the most popular concepts in the field of organizational behavior in the past few years, and has been studied by scholars from different fields, accumulating relatively fruitful results. American organizational behavior scholar Deutsch (1958) was the first to study trust, defining it as an individual's belief in the intentions and talents of the partner in question, and a belief that the partner will behave as he or she wants to. Although this definition does not begin with organizational interpersonal relationships, it accurately captures the characteristics of trust: expectations, context and irrational behavior (Deutsch, 1958). Mayer et al. (1995) mentioned in their study that whether trust is under conditions that can be monitored or constrained, one voluntarily presents himself/herself in situations where losses could easily be caused by the other party when estimating that the other party's future behavior will have a significant impact on oneself. Trust is a psychological state that individuals have in social interactions. It involves having confidence in the words, actions, and decisions of others and being willing to take actions based on this confidence (McAllister, 1995). Under such a mindset, even when individuals cannot control the entire situation, they are willing to take on potential risks, believing that others will act on their behalf (Rousseau et al., 1998). Trust is

closely associated with leadership effectiveness. When employees trust their leaders sufficiently, they are more likely to follow their leaders, believe in their decisions, and expect benefits and gains from them (Mayer et al., 1995). Additionally, once leaders have gained the trust of their subordinates, they can better stimulate their subordinates' potential (Hosmer, 1995). Scholars in various fields have elaborated on the concept of trust from different perspectives, among which the representative ones are listed in Table 2.1 below.

Table 2.1 Related concepts of trust

| Fields                  | Definition                                                                                                                                                                                                    | Commonality of definitions                                                                                  |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|
| Psychology              | With mutual trust, neither partner will exploit the other's weaknesses for profit (Sabel, 1993).                                                                                                              | The essence of trust is confidence, belief or expectation. It is a state of mind, not a behavior or choice. |
| Organizational behavior | Trust is a belief in the predictable and relevant ability, high moral character, and good intentions of another person and an unwillingness to monitor them (Aryee et al., 2002).                             |                                                                                                             |
| Economics               | Trust is an expectation that stems from a community where behavior is regulated and honest and cooperative. It is related to the rules people share and the quality of group members (Rousseau et al., 1998). |                                                                                                             |

### 2.3.2 Dimensions and measurement of employee trust

For the understanding of trust dimensions, the basis of dimensional classification adopted by scholars in various fields is different due to their research backgrounds and differences, and inconsistencies in research focus. Most of the scholars consider the basis, scope, level and content of trust when classifying its dimensions. Initially, scholars treated it as a single dimensional concept when they conducted research on it and designed special scales. However, trust is formed by a combination of institutions and relationships, and many scholars later pointed out that one-dimensional studies were not sufficient to explain trust and that the internal consistency of the early scales was generally less than ideal. In this context, scholars began to explore trust from different dimensions.

Rousseau et al. (1998) pointed out in his study that there are four types of trust: obstructive, institutional, relational and calculative. Martins (2002) explored trust from the organizational level in light of actual management experience and went beyond the individual perspective of previous scholars. Kramer (1999) divided trust into work-oriented and credit-oriented trust based on the content of trust. Proceeding from the basis of trust, W. M. Li and Liang (2002) divided trust into special trust of private relationships and universal trust of shared beliefs. Based on the level of trust, S. Q. Peng (1999) points out that trust includes trust based on

hypocrisy, perceptions and genuine feelings. In addition, Bao and Xu (2006) argued that trust can be divided from the trustor, the trusted and the mutual relationship. According to the concept of trust, from the perspective of the trustor, trust includes affect-based trust, which comes from the affective interaction and input between employees and superiors, and cognition-based trust, the key to which lies in the judgments made by individuals on various factors excluding affect (McAllister, 1995).

This study deals with the level of trust that individual employees have in their leaders, where subordinates have trust in organizational leaders based on their own perceptions, independent of other organizational factors (e.g., the leader's ability to do the job). This means that subordinates are more inclined to have trust in the leader, and the stronger such subjective feelings are, the more positive factors will be produced, and vice versa. Therefore, this study proceeds from the trustor position. According to the concept of trust, trust is composed of affect-based trust and cognition-based trust (McAllister, 1995). This way of division is more consistent with China's reality. On the one hand, the leader is the core of an organization and usually decides how to allocate organizational resources and determine organizational goals, performance appraisal indicators and other aspects within his/her authority. Most employees do not have the authority to make decisions in these aspects. Therefore, considering that the future is always uncertain and based on the principle of reciprocity, employees will carefully judge the level of trust in their leaders and therefore display rational cognitive characteristics. On the other hand, compared to Western cultures, Eastern cultures place a heavier emphasis on interpersonal relationships and the trust between individuals. Therefore, trust in the Chinese context contains both an emotional trust component under collectivism and a rational cognitive component (B. Zheng, 1999). Based on the two-dimensional theory of trust, McAllister (1995) designed a scale to measure employee trust. As more and more studies on trust keep being conducted, various new scales and measurement methods have emerged, such as the new scale improved by S. Y. Wang (2003) based on a revision of previous scales. Her trust scale can measure affect-based trust and cognition-based trust through four items. The scale was optimized several times based on empirical analysis, and problems were repeatedly identified and solved to ensure that the revised scale had sufficient reliability.

### **2.3.3 Existing studies on employee trust**

Scholars have two main focuses in their exploration of the variables related to employee trust.

### **2.3.3.1 Antecedents of employee trust**

A review of existing research findings reveals the following main factors related to the level of employee trust in their leaders.

Individual employee characteristics: examples include individual employees' upbringing, education level, psychology. The formation of trust is conditional on the interaction between two parties, so the personality characteristics of both parties largely determine the strength of trust. Jarvenpaa et al. (1998) noted that the differences in individual characteristics determine the propensity to trust as well as the degree of trust. Subordinates' propensity to trust the leader affects their degree of trust in the leader. Specifically, there is a positive association between the two reflected in that the higher the propensity to trust, the stronger the trust; and the lower the propensity to trust, the weaker the trust. In the process of frequent interaction, this influence will continue to weaken. For example, Podsakoff et al. (1996) pointed out in their research that employees' personal ability, experience and literacy level are factors that determine their level of trust in leaders. Some scholars go beyond the level of personality characteristics and trust relationship to fully consider the position of the trustor and explore the role of personality characteristics of the trusted one. The results of a series of empirical studies show that personal factors of leaders also determine the degree of employee trust in them. Such personal factors can be the leader's own competence, goodwill and integrity. B. Zheng (1999) argued that the factors of employee trust in their leaders are not consistent with the factors of leaders' trust in their employees, and that the relationship between the two parties as well as leaders' goodwill and integrity are the factors that determine employees' trust in their leaders.

The relationship between the two parties of trust: the similarity and interaction between the two parties of trust are different between subordinates and individual leaders. This is one of the factors that determine the degree of trust. Farh et al. (1998) studied a sample of Chinese companies and found that if employees make it clear that their personal and superior qualifications are relatively similar, their level of trust in each other is enhanced. The relationship between employees and their superiors is a key factor in determining the degree of trust between the former and the latter, and the affective communication between superiors and subordinates helps enhance trust and create a stronger sense of belonging within the subordinates (Wong et al., 2003).

Intra-organizational factors: As members are part of an organization, so the organization is the basic condition for the generation of organizational trust. There is a close relationship between intra-organizational factors and employees' behavioral attitudes. So, organizational

factors are factors that determine employee trust, especially the organizational climate, nature, and characteristics, which have received extensive attention from the academia. Y. Wang (2003) explored the relationship between organizational nature and trust and compared managers from the public as well as the private sector in various regions. The results showed that private sector managers trust their subordinates more. The root cause of this may lie in hiring autonomy. Specifically, private sector managers have more autonomy in hiring compared to the public sector. Tan and Tan (2000) pointed out in their study that procedural justice and distributional justice are the key factors that determine employees' organizational trust. Jia et al. (2006) used the faculty of universities as the sample and identified a strong connection between transformational leadership style and employees' organizational trust. Intra-organizational trust and external environment are directly related, and it is important to note that the cultures among nations and countries are a very important environmental factor in determining trust. C. C. Chen et al. (1998) believed that there is a strong association between individualism and cognition-based trust, while collectivism mainly affects affect-based trust. Doney et al. (1998) conducted an exhaustive study to divide the process of trust generation into five links: calculation, prediction, intention, competence and transfer. They also pointed out that social factors such as collective/individualistic culture and power distance can influence the process of trust generation of subordinates in the leadership.

### **2.3.3.2 Outcomes of employee trust**

The degree of subordinates' trust in their superiors is a key determinant of subordinates' work attitudes and behaviors, which in turn determine their job performance. Below is a review of the research results on the relationship between trust and employee attitudes.

(1) Individual behavior: employees' behavioral intentions and trust are directly related. Tan and Tan (2000) stated that leadership trust is a key determinant of employees' turnover intention. Ferres et al. (2004) found that trust in colleagues helps reduce the turnover rate of employees. Chowdhury (2005) argued that affect-based trust and cognition-based trust both affect knowledge sharing within organizations, although the effect of cognition-based trust on complex knowledge sharing is relatively more significant.

(2) Individual attitudes: According to existing research findings, employee attitudes consist of affective and cognitive components, and the higher the level of trust, the more positive behaviors employees will exhibit in the organization. The research carried out by Ferres et al. (2004) suggests that trust in colleagues leads to stronger perceived organizational support by employees. Tan and Tan (2000) identified a strong association between organizational trust and

organizational commitment, and organizational commitment involves both cognitive and affective aspects.

(3) Job performance: Some scholars have explored the association between performance and trust and found that trust is one of the factors determining performance and that there is a strong association between the two. N. Y. Li et al. (2006) explored the relationship between job performance and inter-organizational trust by collecting primary data and information through questionnaires and using empirical research methods. The results found that employees' trust in their colleagues enhances job performance. However, some scholars have questioned that trust is not a direct influence on performance. For example, H. M. Wei and Long (2009) developed a model of the relationship between trust and performance, and the findings showed that employees' cognition-based trust in their superiors can facilitate task performance, but the relationship between the two is dependent on emotional commitment, which mediates the said relationship. Le and Nguyen (2023) investigated the mediating role of affective trust and cognitive trust in the relationship between ethical leadership and employee knowledge sharing behavior based on social exchange theory. The study demonstrated that employee trust in leadership positively mediated the relationship between ethical leadership and knowledge sharing behavior. Distributive justice significantly facilitated the impact of ethical leadership on implicit and explicit knowledge sharing behaviors.

It can be seen from the empirical studies of employee trust that trust facilitates employee cooperation, stimulates organizational learning and improves organizational climate. Organizations in which members trust each other have lower employee turnover rates and a more stable workforce. Enhancing employee trust enables employees to adopt more beneficial behaviors for the organization and makes them feel more satisfied with the organization.

## **2.4 Team communication**

### **2.4.1 Definition of team communication**

Team communication is the process of members transmitting and receiving meaning to and from each other (Johnson et al., 2023). The functions of communication are reflected in four aspects: control, motivation, emotional expression, and information transmission (Robbins et al., 2014). Research results indicate that effective team communication contributes to enhancing innovation capabilities (Keller, 2001; Ancona & Caldwell, 1992), improving project performance (Ancona & Caldwell, 1992; Keller, 2001), as well as boosting

employees' organizational commitment and individual performance (Meyer & Allen, 2001). Researchers have not reached a consensus on the elaboration of the concept and connotation of communication. From the perspective of its nature and research focus, there are three mainstream views: sharing, transmission and influence, as follows in Table 2.2.

Table 2.2 Definition of communication

| Perspectives | Definition                                                                                                                                                                                                                                                      |
|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Sharing      | The process by which an individual shares his/her attitudes, ideas to exert influence on other individuals (Shannon, 1949)<br>Any process by which two parties to a message share information, ideas and emotions to reach commonality (McGregor & Peake, 2000) |
| Transmission | A process where members of the organization inform other members of their decisions (Simon, 1947)<br>Communication and understanding of meaning (Robbins et al., 2014)                                                                                          |
| Influence    | The act of transmitting and exchanging information or ideas to influence the thoughts or behavior of others (H. Zhao, 2019)                                                                                                                                     |

Communication is a prerequisite for all forms of organizations. Barnard (1968) pointed out that communication is the most important element of an organization and one of the basic conditions for its birth and development. Project communication is a special kind of organizational communication, and the former is a subset of the latter. Therefore, the author firstly reviews and presents the research results on organizational communication.

Organizational communication has long received extensive attention from the academia, and scholars have studied it from different perspectives and accumulated fruitful results. However, very few of these results are related to project team communication. Most scholars, when conducting research in this area, refer to the theories of their predecessors and stay only at the surface, without making breakthrough innovations. Or they simply innovate in terms of application for specific industries or companies. Very few scholars have used empirical research methods to explore the relationship between project team communication and various variables. Overall, research on communication in project teams is relatively scarce. Turner and Müller (2004) proceeded from the ways of communication and put forward suggestions for project teams and owners, focusing on the frequency, content and medium of communication to point out the way to improving project performance.

Project communication is a type of organizational communication that is consistent in some respects. For example, its purpose is to achieve set goals and perform decomposed tasks. The difference between the two is that projects exhibit one-time and specific characteristics, and project teams are temporary organizations formed to perform specific tasks. Compared with traditional organizations, project teams are more flexible and generally less stable. A project team is an organization that is temporarily aggregated to achieve project goals with limited resources. The temporary nature of project teams determines that there is no common

working basis among members and it is difficult to form a good tacit understanding, which poses certain obstacles to communication and exchange.

#### **2.4.2 Dimensions and measurements of team communication**

Communication is not a stable variable and is difficult to measure. A review of the existing literature reveals that there are not many ways to classify and measure the dimensions of project communication. Roberts and O'Reilly III (1979) were the first scholars to propose an organizational communication measurement scale. They designed a comprehensive communication questionnaire consisting of 16 dimensions such as communication frequency, communication direction and communication outcome. Downs and Hazen (1977) summarized eight communication satisfaction factors (including but not limited to personal feedback, work information, parallel and informal communication, and communication with superiors) and formed a communication satisfaction questionnaire.

A review of the existing research findings shows that very few scholars have proceeded from communication content to design questions to achieve communication measurement. However, Muchinsky (1977) mentioned that the study of communication content has a significant practical role and value, and the content of communication is the most important element of communication. Penley and Hawkins (1985) creatively started from communication content and prepared a scale able to measure communication content. The scale is composed of five dimensions (task communication, performance communication, career development communication, communication response, and personal communication) measured by 18 items. Kirmeyer and Lin (1987) considered that the content of communication includes both work communication and non-work communication. J. T. Shi (2012) drew on the previous research results and focused on the content of communication while exploring the relationship between communication and knowledge sharing. He divided communication into work communication and interpersonal communication.

#### **2.4.3 Existing studies on team communication**

With regard to team communication, existing research has focused on exploring the ways in which teams communicate. Y. Yang et al. (2020) explored how to effectively build trust through the way project managers communicate with their subordinates to keep them engaged and committed to their work. Their research developed a model that helps to understand and trust the mediating role from a relational perspective. The study examined the impact of a

leader's communication style and its four dimensions, namely support, assertiveness, verbal aggressiveness and clarity, on subordinates' turnover intention and work engagement. The study showed that support, clarity and assertiveness had a significant positive effect on trust, while verbal aggressiveness had a negative effect. Trust was positively associated with subordinates' work engagement which was negatively related to turnover intention. The study concluded that leaders' communication styles have an impact on subordinates' project outcomes by means of trust. Cook et al. (2021) uncovered an impact of the structural patterns and motivations of leaders on the perceived patterns of interpersonal communication and personal perceptions of centralized team leadership structures. Galli (2021) proposed that communication is one of the most critical factors for project success, as without a scientifically effective communication plan and management strategy, projects are likely to go downhill quickly. The focus of this study is on the communication processes and models that influence the project environment and will recommend sound and effective strategies to assist in achieving internal and managerial communication within the project team to help the project succeed. Johnson et al. (2023) independently developed two human-autonomy team training methods for communication and trust calibration to enable team effectiveness in degraded conditions. Their study revealed that (1) teams trained in coordination had relatively higher communication anticipation ratios; and (2) team training, including autonomous agents that simulated effective information exchange, had the potential to positively impact team communication and coordination. Abbink et al. (2022) proposed that communication is one of the most effective means of promoting teamwork. However, asymmetric communication can easily breed collusion and undermine team effectiveness. This study shows that the exclusion of any one member when conducting team communication can be detrimental to teamwork; collusion among communication partners to divide the profits due to the excluded member can directly undermine the latter's motivation to work hard. Samuel and Matthew (2021) studied team communication and mutual support as factors that drive team members' performance in the organization. The study found that team communication was a positive predictor of task performance and situational performance, and a negative predictor of counterproductive behaviors at work. The study also recommended that management should encourage employees to work together and educate them on these key behaviors (communication and mutual support) to help improve employee performance in the organization. Manata et al. (2022) studied the impact of project manager communication behaviors on integrated project delivery (IPD) and took into account the impact of team-level information sharing on team-level outcomes (i.e., project quality, quality of decision making,

consistency of direction and process commitment). Their study shows that sharing team information is beneficial, but the effects of project manager communication behaviors are inconsistent.

Based on the Chinese context, existing literature supports that team communication plays a mediating role in the relationship between leadership/management and team effectiveness and performance. Several studies have demonstrated the mediating effect of team communication. L. Z. Wu et al. (2013) explored the impact of abusive management on team performance and found that team communication and collective efficacy mediate this relationship, acting as a complete mediator. Y. Wang and Chen (2013) used multiple linear regression to establish the relationship between project manager characteristics and project team capabilities, proving the influence of project managers on project team capabilities, with team communication acting as a mediating factor. J. G. Zhou et al. (2012) studied the impact of transformational leadership behavior on the performance of research teams and identified the mediating role of team communication.

Y. L. Wang et al. (2009) pointed out that in the relationship between transformational leadership, team communication, and team performance, empowering leadership behaviors such as vertical participation in goal setting, vertical encouragement of autonomous behavior, shared encouragement of team cooperation, and shared participation in goal setting have positive effects on team performance. Shared empowering leadership behavior better predicts team performance than vertical empowering leadership behavior, with team communication mediating the relationship between empowering leadership behaviors and team performance, particularly in goal setting participation.

Hao and Yin (2018) found that team communication positively influences team performance. M. Liu (2014) showed that entrepreneurial team interaction behaviors mediate the effect of entrepreneurial leadership styles on team efficacy. J. S. Li and Qiao (2020) demonstrated that in high-tech enterprise research and development, team communication behavior influences autonomous innovation performance through the mediating variable of knowledge absorption capacity. Hyeon and Bum (2020) revealed that ethical leadership has a direct impact on team communication, and team communication mediates the effect of ethical leadership on team effectiveness. Y. C. Li and Ma (2009) found that team communication mediates the effect of shared mental models on team efficacy.

These findings suggest that in the context of leadership and management affecting team effectiveness and performance, team communication plays a crucial mediating role. In Chinese construction project management, project managers act as leaders, influencing team

communication through management, which in turn reduces communication costs, promotes internal knowledge sharing within the team, enhances overall team cohesion, and ultimately impacts project performance.

## **2.5 Employee training**

### **2.5.1 Definition of employee training**

The concept of training was first put forward in *The Principles of Scientific Management* by Taylor (1919), who developed a set of training methods that could improve the efficiency of workers by observing and organizing the experiments of workers handling pig iron. The publication of the aforementioned book also enabled Taylor (1919) to become the pioneer and founder of employee training theory. With the rapid development of the market economy in recent years, the corporate sector has paid more and more attention to the training of employees, and enterprises of all sizes in all fields have started to train their employees, hoping that this will improve the advantages of corporate talents, so that the economic strength and competitiveness of enterprises can be greatly improved. In this context, theorists have also conducted extensive research on the topic of employee training. Noe and Wilk (1993) believed that employee training is a series of organized and orderly activities aimed at promoting employees to master the necessary knowledge and skills for their work and to be able to apply them to the actual work. Qin et al. (2007) argued that employee training is the provision of a learning work environment for employees to acquire the professional skills necessary for their work and thus be used by the company. Baldwin and Ford (1988) proposed that employee training is the planned and purposeful training of employees in various forms of existence to improve the efficiency of employees, so that the organization can run efficiently and ultimately achieve corporate goals.

Although scholars have given different definitions to employee training, the underlying meaning is similar: employee training is an important way to invest in human capital, and its goal is to facilitate the progress of employees, change their work attitudes, improve their job skills, update their knowledge structure, and thus improve their own capabilities for the purpose of achieving the collective goals of the organization and ultimately gaining competitive advantages for the company.

### **2.5.2 Dimensions and measurement of employee training**

Existing studies on the dimensions and measurement of employee training are relatively well developed. Noe and Wilk (1993) put forward two measurement methods for employee training. One is based on the actual training content as the starting point, mainly including aspects such as the number of training courses, the annual training time count, as well as the plan and intention to attend training next year. The other is based on employee perceptions and measures the evaluation of employees about the training system of the company, mainly in terms of willingness, opportunities and benefits of training as well as the support from superiors. On this basis, they developed a related Likert scale. Tharenou et al. (1994) also used the Likert scale approach to measure the training content engaged in by employees, and its main indicators included the training opportunities provided by the company the number of training sessions attended by each employee, the degree of utilization of training results, and the support of colleagues. Based on a further analysis and critique of the training content of previous relevant employees, Tharenou et al. (2007) proposed more general personnel training evaluation indicators: absolute indicators (e.g., the total amount of employee training), proportional indicators (e.g., the proportion of the number of employees participating in training to the total number of employees), content measures (e.g., the types of training employees participate in), and importance measures (e.g., the degree of employee awareness of the importance of training), dividing training into different dimensions. Some measures are calculated based on a single item, while others are calculated based on an integrated consideration of the scores of multiple dimensions to ensure the fairness and validity of the measurement to a certain extent.

### **2.5.3 Existing studies on employee training**

In terms of antecedent variables, the influencing factors of employee training are divided into the following three main aspects.

The first refers to the organizational factors. Since the 1980s, researchers have gradually begun to focus on the influence of organizational factors on employee training effectiveness. Based on the actual evidence, Rouiller and Goldstein (1993) found that the organizational training transfer climate perceived by the employees themselves is a strong explanatory variable for the effect of employee training. In other words, the organizational training transfer climate is likely to have an indirect effect on the effect of employee participation in training while affecting individual employee behavior. Baldwin and Ford (1988) argued that

the management support provided to employees by the organization and the opportunities employees have to apply what they have learned in training have a significant impact on the effectiveness of employee training to some extent. Tracey et al. (1995) conducted a study on the impact of two factors, transfer of training climate and continuous-learning culture, on supervisors' new learning skills. The results of the study showed that both factors are important for supervisors' new learning skills (or behaviors), which in turn proved that: transfer of training climate has a direct impact on employees' post-training behaviors. Noe (1986) argued that establishing a learning organization, creating a learning climate and shaping a continuous learning culture can help employees put what they have learned to practice. Based on empirical research, C. Y. Li and Liu (2011) demonstrated that environmental suitability indirectly affects the behavioral standards of employee training and elaborated on the ways in which environmental suitability in the actual work atmosphere impacts training effectiveness.

The second has to do with individual factors, such as employees' own sense of efficacy, motivation to participate, personal needs and competencies. Medina (2017) held that employees' motivation to participate in training plays a key role in ensuring that the training achieves the desired effect and plays a key role. Quinones and Ehrenstein (1997) argued that internal characteristics such as employees' own perceived self-efficacy and sense of fairness prior to training can have a significant impact on the final training effect. Based on human capital theory, Yan and Zhao (2014) studied informally employed workers and found that the high level of personal competence of employees who participate in training has a high explanatory power for the training effect. Ma (2008) revealed a comprehensive relationship between the three factors of employees' own learning ability, experience and cognitive ability and training effectiveness and built a two-factor model consisting of individual and environmental factors that can influence the training effectiveness of employees.

The third involves the training system factors, which mainly include the design and method of the training system. Ford et al. (1992) believed that various types of training content design will contribute to the effectiveness of employee training, such as rich materials, various formats, and personalized courses, all of which will contribute in different ways to achieve the expected performance of training. J. Wang and Wang (2010) conducted experiential research and exploration of the influencing factors of employee training. The results have proved that the training methods, teachers and program design all have a positive effect on the training effect and are a major factor that affects the training effect.

Regarding the outcome variables related to training, the relevant research findings are as

follows:

Hassen (2022) found that training design, training needs assessment, training delivery methods, and training evaluation have significant positive effects on employee performance. Nor (2023) studied the relationship between training and development, employee performance, and public service delivery. The research revealed a significant positive relationship between training and development and employee performance. Judeh and Khader (2023) demonstrated a positive and significant relationship between green training and development, green employee behavior, and employee retention.

Giday (2023) examined the impact of training predicted by training needs assessment, availability of training resources, and employee perceptions of training on employee performance. The results indicated that training needs assessment and the availability of training resources have a significant impact on employee performance.

## **2.6 Team integrative capabilities**

Because the project manager's own capabilities have a direct impact on the team integrative capabilities, the indicators of team integrative capabilities are considered as the dependent variable to establish its relationship with the project manager's capabilities. This section will address the definition, dimensions, measurement and existing studies on team integrative capabilities.

### **2.6.1 Definition of team integrative capabilities**

From the perspective of research time, researchers at different stages have proposed different definitions of the term "team". Esch et al. (1992) proposed that a group of two or more differentiated individuals is called a team, in which each individual has a unique position and task, and the different individuals are interlinked and interdependent, working towards the common value. Kozlowski and Bell (2013) described the definition of a team in this way, where the members of a collective are organized and disciplined to accomplish related tasks, pursue consistent goals, and influence each other, while also showing interdependence of tasks, maintaining and managing boundaries, and in addition, embedding an organizational context where boundaries and constraints exist and have an impact on the mutual exchange between units.

It can be concluded that a team is different from a work group in the usual sense. A team must not only have the common characteristics of a general work group, but also have factors

such as information sharing among members, participation in decision making and role orientation. More importantly, the main characteristics of a team - complementing the skill deficiencies among individuals and pursuing common performance goals. Therefore, a team is not the result of superficially adding individuals together but exists both in the organization and beyond the individual and the organization for its own specific reasons.

Team integrative capabilities refer to the ability of project team members to secondarily integrate the resources under their organization's control, create a specific environment, and effectively and securely achieve or exceed the initially specified goals (X. P. Zhao et al., 2008). The personal qualities and abilities of each team member can be considered as resources under the control of the organization, and the team integrative capabilities refer to the ability to create an environment to achieve the team's goals based on the organizational resources. Therefore, team integrative capabilities can also be seen as the ability to create a team working environment that helps achieve project goals.

### **2.6.2 Dimensions and measurement of team integrative capabilities**

Regarding the dimensions and measurement of team integrative capabilities, existing studies have classified team integrative capabilities into different dimensions for measurement. L. R. Yang et al. (2011) considered team integrative capabilities based on three dimensions: project manager's leadership style, overall team competencies and project success. McDonough (2000) categorized the factors influencing team competency into four indicators: member cooperation, goal commitment, member initiative and mutual respect. Chan et al. (2001) divided team competencies into eight dimensions: functional and technical performance of the requirements shared by all project participants, the degree of understanding of new roles and responsibilities by all project participants, the degree of acceptance of changes in roles and responsibilities, the sharing of common project goals, adequate cooperation, the communication methods chosen between individuals, the high level of trust among members and the speed of conflict resolution. Chow et al. (2005) summarized the five influencing factors of team capability that are generally agreed upon: clarity of team goals, inter-dependency, team cohesiveness, level of trust among members and enthusiasm of all participants. Dionne et al. (2004) focused on the impact between transformational leadership and team performance. It is argued that transformational leaders rely on team work processes to influence team performance, which leads to three indicators for evaluating team work processes, namely team cohesiveness, communication skills and conflict management skills.

Aronson et al. (2006) measured team capabilities from seven perspectives: the ability of individuals to recognize and resolve conflicts, the encouragement of different perspectives and views by team members, the degree of knowledge and information sharing and mutual assistance among individuals, the recognition of contributions made by others, the initiative of individuals in activities, working hard toward established common goals, and the free information sharing among members. Baiden and Price (2011) measured team competencies in six dimensions: ownership of team participants, shared goals and visions, autonomy and inclusiveness in communicating with each other, cooperation and participation among members, acceptance of disagreements at various stages of problem solving and frequency of assessing individual contributions and roles.

### **2.6.3 Existing studies on team integrative capabilities**

Research related to team integrative capabilities has focused on how to measure team integrative capabilities and the impact of team integrative capabilities on performance. L. R. Yang et al. (2011) used questionnaires and interviews to study the intrinsic associations among project managers' leadership style, team integrative capabilities and project success. In terms of measuring team integrative capabilities, their study showed that team cohesiveness, communication skills and writing skills all have a critical impact on project success. Therefore, team integrative capabilities were measured from these three perspectives. McDonough (2000) studied the factors affecting successful cross-functional teams from three perspectives: initial phase factors, competency person factors including team leaders and managers, and team behavior factors. The study concluded that the team behavior factor has four indicators: cooperation among members, goal commitment, members' initiative and mutual respect. In addition, a questionnaire survey was conducted, which proved that the team behavior factor has a profound and far-reaching impact on the success of cross-functional teams. Using the DB project as a reference, Chan et al. (2001) investigated the impact of team integrative capabilities on the overall project performance. In the study, the authors measured the team integrative capabilities based on eight indicators, which were the sharing of required functional and technical performance by all project participants, the level of understanding of new roles and responsibilities by all project participants, the acceptance of changes in roles and responsibilities, the sharing of common project goals, adequate cooperation, the communication style chosen between individuals, the high level of trust between members, and the speed of conflict resolution. Based on a review and analysis of existing literature,

Chow et al. (2005) summarized the five factors that were generally agreed upon as influencing factors of team capabilities: clarity of team goals, dependence among individuals, cohesiveness of the team, level of trust among members and work ethics of all participants. In addition, a Singaporean construction team was selected for a case study, and a questionnaire and multivariate statistical methods were used to draw the final conclusion that team goal clarity, team cohesiveness and trust among members are the three indicators that have a higher degree of influence on team effectiveness among the five factors. Dionne et al. (2004) focused on the influence between transformational leadership and team performance and concluded that transformational leadership relies on the teamwork process to influence team performance, leading to three indicators to evaluate the team work process, team cohesiveness, communication ability and conflict management ability. Aronson et al. (2006) explored the impact between team leader personality and team performance using a New Product Development (NPD) project as the case. The authors developed a hypothesis that team capabilities are intermediate variables that exist in the process where team leader personality affects team performance. Aronson et al. (2006) measured team competency from seven perspectives: individuals' ability to perceive and resolve conflicts, the degree of knowledge and information sharing and mutual assistance among individuals, team members' encouragement of different viewpoints and perspectives, individual initiative in activities, recognition of the contributions made by others, working hard toward established common goals and free information sharing among members. Baiden and Price (2011) examined the relationship between project team integration and the effectiveness of teamwork using the six key elements of effective teamwork as described in the book entitled *Teamworking* published by Construction Excellence. The six key elements are a sense of ownership by team participants, autonomy and inclusiveness in communicating with each other, a shared goal and vision, acceptance of disagreements at all stages of problem solving, cooperation and participation among members, and frequency of assessing individual contributions and roles. These six elements are used as important references to evaluate the efficiency of teamwork, the need for a cooperative atmosphere and environment for efficient teamwork, and the ability of the group to create more than one environment.

Existing research has covered different aspects of team capability and explored the relationship between team capability and organizational performance from various perspectives. Tang et al. (2020) investigated the influence of transformational leadership on team innovation and revealed that transformational leadership had a positive impact on team innovation, with leadership power distance and leader's perception of team capability

mediating this relationship. Prokopenko and Obodovskyi (2020) examined project teams in the information technology field, studying the influence of team members' capabilities on project efficiency. The research results showed that the abilities of project team members significantly influenced project efficiency.

Tu et al. (2020) explored the effects of differences among team members and interdependence of goals on team members' affective and informational states. The study found that differences in team members' abilities and goal interdependence affected team members' emotional and informational states.

Wolfson et al. (2022) proposed a theoretical framework for dynamic team composition and explored how changes in team potential and dynamic capabilities impacted team capability. McLaney et al. (2022) developed a framework for hospital team collaboration, emphasizing the importance of team capability and behavior in hospital settings.

Bosongo et al. (2023) focused on health management teams in the Democratic Republic of the Congo and studied the practice and influencing factors of team capacity building within the context of provincial health administrative reforms. Tikas (2023) concentrated on developing and validating a scale for team innovation capability. J. Yoon et al. (2023) confirmed the relationship between shared leadership, dynamic capability, and team performance in Korean companies.

Taking all the above research into consideration, team integrative capability has a significant impact on organizational performance. The different research methods and study subjects provide valuable perspectives for a deeper understanding of the relationship between team capability and organizational performance. These research findings have practical implications for organizational managers and team leaders, helping them optimize team capabilities and enhance organizational performance. However, it is essential to note that while these studies offer valuable insights, in practical applications, a flexible approach tailored to specific organizational and team contexts is necessary for comprehensive analysis and decision-making.

## **2.7 Project performance**

### **2.7.1 Definition of project performance**

The definition of project performance has not been unified. Drucker (1966) believed that any organization should be proactive in understanding what performance is and what it entails. To

date, however, researchers have been inconsistent in its conceptualization of performance. In general terms, performance refers to the extent to which an individual or organization achieves organizational goals in a given situation. However, the concept involves different dimensions, and the results of research on it are, to some extent, determined by the perspective one chooses to study. Most scholars, when conducting their research on it, have started from two points: the degree of achievement of task goals and work output. Bates and Holton III (1995) mentioned in their study that performance involves different dimensions, that its measurement results are mainly determined by the factors that people consider, and that the final results are different when they are measured based on different factors. Before carrying out performance measurement and management work, it is necessary to clarify its definition and connotation, and only by accurately grasping its definition can we measure it in a more objective and comprehensive way. In the field of management, performance is the desired outcome, the effective output of an organization in all aspects to achieve its goals (Fang, 2003). There is no consensus on the conceptualization of performance, mainly because scholars understand it as a result or a behavior (L. F. Zhong & Shi, 2002). For a long time, the performance theory system that has received the most attention and recognition is the outcome view of performance, which is defined by scholars as the output results or outcomes of work (Long, 1986). The behavioral view of performance has evolved over time. As time goes by, the behavioral view of performance is gaining more recognition, and those who share this view point out that performance is not a consequence or a result of an action, but an action or behavior that is linked to organizational goals (Ilgen & Schneider, 1991). Certainly, there are also some scholars who believe that performance is not just a result or a behavior, but a combination of both, and define the concept of performance from a comprehensive perspective (Brumbrach, 1988). According to their research, the core of performance management is the content, process and results of behavior.

Project performance reveals the degree of project completion and helps to reflect how good or bad the project is. Construction enterprise projects have long construction time, complex site environment and involve many subjects, so project performance research is very challenging. From the field of management, performance is the effective output of the organization in all aspects to reach the goal, which is an expected result that appears, and it consists of two parts: individual performance and organizational performance. To achieve good organizational performance, the key is individual performance, but the achievement of individual performance does not mean the inevitable achievement of organizational performance. Therefore, the difficult problem of project performance evaluation has caused

some trouble to scholars. Yet at the same time, it has also received more attention. With the rapid development of the construction industry, more and more scholars have started to devote themselves to this field of construction project performance research and have made outstanding contributions to enrich the research results in this area.

### **2.7.2 Dimensions and measurement of project performance**

The framework for project performance evaluation theory is well established, with the most influential being “The Iron Triangle” theory put forward by Atkinson (1999), which has been widely recognized for establishing technical criteria based on a good balance of cost, schedule and quality objectives. Later, many scholars have borrowed or even directly quoted this theory when conducting research in this area. In the past, people usually considered only one dimension when measuring the achievement of project performance goals, while the “The Iron Triangle” theory (Gardiner & Stewart, 2000) involves three dimensions: time, cost and quality.

Such an evaluation approach involves few elements, which is easier to assess and consider, and simpler to operate. However, goal theory also has its limitations reflected in the following aspects. First, in reality, most projects have many goals. For example, construction projects often have goals for such aspects as cost, schedule, quality and safety, and they are related to each other in a certain way, which can cause constraints on each other. For example, if a construction project has a quality problem, it may lead to a safety incident. Eliminating safety hazards requires additional costs and wastes some time, which in turn affects the achievement of cost and schedule goals. Second, under such a performance evaluation system, project managers are likely to adopt short-sighted behaviors to achieve better performance evaluation results, ignoring long-term benefits and making it difficult to optimize the project. Third, the difference in the objectives of each project will make the horizontal comparison of projects more difficult. When evaluating projects, it is important to take The Iron Triangle into account, as well as the needs of project team members, commissioners and other relevant subjects for the project (Weston & Gibson Jr, 1993). A system of indicators was set up that not only includes the indicators of The Iron Triangle, but also the performance related to the project team. The measurement items not only combine the dimensions of quality, cost, schedule and safety but also add the satisfaction of users and related subjects, so that it can reflect the project performance more comprehensively and objectively.

From a systems perspective, it is not reasonable to treat performance purely as an

outcome (Y. L. Wu & Cao, 2005). So, scholars have proposed the behavioral performance perspective (Sinkula et al., 1997). The scale designed by Belassi and Tukel (1996) consists of 12 items, which are time, cost, performance, satisfaction and effectiveness. Feng and Chen (2005) pointed out that the financial indicators alone cannot reflect the level of project performance in an all-round way and built a project performance evaluation index system with such aspects as “production capacity, project management level and civilized construction level” as the first-level indicators. Meng (2007) incorporated the indicators of production efficiency and safety in “The Iron triangle” and built a new evaluation system on this basis. Xu and Ren (2010) introduced the Balanced Scorecard into the project performance evaluation, providing a new tool for the evaluation of project performance. Xu and Ren (2010) started from long-term performance aspects and selected the indicators in terms of internal processes, quality, stakeholders as well as innovation and learning to explore the impact of the quality of project relationships on project performance. Yu and Wang (2010) evaluated project performance from a single dimension while dissecting the impact of knowledge sharing on project performance. With reference to the Park et al. (2004), the designed scale is used to design items in terms of project technical goal achievement, business purpose accomplishment and strategic value.

The purpose of this study is to reveal the relationship between project manager competency and project performance and the way it works. In the course of the study, the overall project performance, which is also known as organizational performance, is targeted. A review of the existing literature shows that when evaluating the performance of engineering projects, the four dimensions of quality, cost, schedule and safety should be taken into account. From the objective of this study, various methods such as questionnaire survey are used to obtain scientific and accurate research conclusions.

### **2.7.3 Existing studies on project performance**

Currently, scholars' perception of competency and its extensions is rather vague, but most scholars agree on two points. First, there is a strong association between competency and job performance, and that the former can be used to predict the latter. In the past, some scholars pointed out that there is a relationship between the level of intelligence of an individual and his or her high or low performance. However, as more relevant research results come out, it was realized that the strength of the relationship between intelligence and performance is relatively weak. Neisser et al. (1996) mentioned that it is not reasonable to predict job

performance exclusively by the results of intelligence tests, otherwise the results might be wrong. Based on the existing research results, it is known that when assessing performance, it is necessary to take the competencies of the evaluated subjects into account in addition to their intelligence. Many scholars also consider performance an outcome variable of competency. Later, scholars also explored the influence of competency characteristics on performance and argued that the elements of competency characteristics are important factors that influence job performance and that they can be used to make predictions about job performance (Moore et al., 2002; Kolibáčová, 2014).

Most domestic scholars, when exploring the relationship between competency and performance, usually start from the perspective of the impact of individual and team competencies on performance. The aim of this study is to reveal the ways in which project managers' competencies affect project performance. Therefore, in the preliminary study, the focus was on compiling literature involving the relationship between individual competencies and performance. C. M. Wang and Chen (2002) pointed out in their research that job performance helps measure the level of competency, and the performance evaluation system was established starting from the job performance, organizational performance and functional performance dimensions. Then they used methods such as SEM to validate that the management qualities and management skills contained in competency are important factors affecting job performance. Combined with contextual evaluation, Jin et al. (2004) explored the influence of managerial competency characteristics on job performance and found that the association between various managerial competency characteristics and job performance are inconsistent. D. F. Wang et al. (2007) conducted an empirical study, and the results showed that differences in job performance can derive differences in the constituent characteristics of competencies, thus demonstrating that competency characteristics and job performance are strongly related. Du (2008) conducted an EFA to examine the performance of the competency characteristics of business operators in various management functions and the impact on performance. S. D. Zhang (2015) conducted a questionnaire survey to create a competency model of project managers in real estate companies. The results of regression analysis and SEM indicated that there is a dual relationship between project manager competency and job performance, both directly and indirectly.

Aravindh et al. (2023) employed SEM analysis to study the synergistic effects of construction industry alliance contracts and lean methods on project performance indicators. Dabirian et al. (2023) used system dynamics analysis to examine the impact of fiscal policies on construction project performance. Onubi et al. (2023) studied the role of economic

performance and analyzed how to bridge the gap between health and safety performance and owner satisfaction in construction projects adopting environmentally friendly practices.

Aramali et al. (2023) investigated a novel earned value management system maturity framework and its relationship with project performance. Acheampong et al. (2023) focused on Ghana and researched the influence of emotional intelligence on project performance in developing countries.

Majeed et al. (2023) explored the impact of team mindfulness on project team performance. LaPatin et al. (2023) examined controversies in wind energy construction projects and explored how social systems influence project performance. Van Tam et al. (2023) studied the influence of BIM-related factors on construction project performance. Chang et al. (2023) explored the relationship between multiculturalism and performance from a multilevel perspective, based on a comprehensive conceptual framework for multicultural virtual teams.

Tarawneh et al. (2023) researched the impact of cash flow changes on project performance from the contractor's perspective. Pérez Rave et al. (2023) investigated the relationship between dynamic capabilities and project performance based on empirical evidence in the project domain.

L. Luo et al. (2023) used fuzzy cognitive mapping to explore the dynamic impact of large-scale project governance on performance. Irfan et al. (2023) studied the influence of work-life balance, organizational support, and job burnout on project performance. Abal-Seqan et al. (2023) conducted a study in Qatar to examine critical success factors and their impact on construction project performance.

Based on the above research, it is evident that project management and project governance have significant impacts on project performance. As this study focuses on project managers, their capabilities and proficiency directly affect project management, which, in turn, can have a direct impact on project outcomes and performance. Therefore, studying the abilities, proficiency, and qualities of project managers can be better described using the more specialized term “project manager competence.”

## **2.8 Theoretical analysis**

### **2.8.1 Social exchange theory**

Social Exchange Theory emerged in the 1950s, founded by Homans (1958) from Harvard

University. According to this theory, the essence of social interactions is exchange behavior, where the exchange behaviors of different individuals ensure a well-functioning social order. Scholars of this theory can be categorized into four schools: Exchange Social Behaviorism (Homans, 1958), Outcome Matrix (Thibaut, 1959), Exchange Network Theory (Emerson, 1962), and Exchange Structuralism (Blau, 1964).

Homans (1958) put forth the theory of Exchange Social Behaviorism. This theory encompasses six primary propositions: a) Success Proposition, b) Stimulus Proposition; c) Value Proposition, d) Deprivation-Satisfaction Proposition, e) Aggression-Approval Proposition, and f) Rationality Proposition.

Based on outcome matrices, Thibaut (1959) explored the exchange relationships among different individuals and quantifies interpersonal interactions by describing them using outcome matrices. Scholars of this school generally evaluate the outcome matrices by comparing with past expected experiences and with alternative options.

Grounded in network and exchange perspectives, Emerson (1962) introduced several new concepts such as actor, dependence, and equilibrium. He combined social exchange theory and network theory to investigate inequalities and power dynamics in social networks. His findings suggest that participants in an exchange determine their relative power based on their relative dependencies.

While sharing the emphasis on individual behavior and interaction with Homans (1958), Blau (1964) presented a distinct viewpoint. From a micro perspective, Blau (1964) accepted Homans' (1958) viewpoint, asserting that behavior is enhanced by rewards. Blau (1964) argued that social exchange can create win-win situations, improving social exchanges and leading to positive emotions such as responsibility and trust towards others. Thus, he identifies trust as a pivotal factor in social exchange. Blau (1964) posited that exchange continues to evolve over time, with individuals making commitments, thereby enhancing mutual trustworthiness.

In China, the study of Social Exchange Theory is intertwined with the concepts of *guanxi* and *mianzi*. Huang and Hu (2005) from Taiwan combined social exchange theory with features of Chinese society to create the *guanxi* and *mianzi* theoretical model, integrating these terms to explain social exchange behaviors in Chinese society. In this model, the interactive parties are defined as requesters and resource allocators. When a requester seeks advantageous distribution of resources controlled by the resource allocator, the latter promptly assesses their relationship through an inner judgment: What is our relationship like?

While explaining the *guanxi* and *mianzi* model, Huang (2009) classified interpersonal

relationships into three types based on the proportion of two components: instrumental, emotional, and mixed relationships. a) Emotional relationships are relatively stable over time and prioritize emotional and psychological fulfillment over material resources. b) Instrumental relationships are aimed at acquiring material resources and are governed by the principle of fairness during transactions. c) Mixed relationships combine elements of both emotional and instrumental aspects, sustained through reciprocal interactions and mutual support.

For this study, the mixed relationship described in the *guanxi* and *mianzi* model aptly characterizes the relationship between project managers and their team members. It encompasses both utilitarian instrumental aspects and non-utilitarian emotional components. As per social exchange theory, both parties experience gratitude, develop mutual trust in social exchanges through fulfilling obligations when they make commitments. In this way, they continually enhance trustworthiness in the evolving exchange relationship. Hence, trust stands as one of the paramount elements within the realm of social exchange.

In the context of this study, trust pertains specifically to interpersonal trust. Moorman et al. (1992) defined trust as the willingness to rely on a dependable exchange partner, generating a sense of reliability and benevolence in one party towards the other. Therefore, trust is formed between both parties during the exchange process. Doney and Cannon (1997) emphasized the importance of believing in the partner's capability and willingness to act in their own interest. Cook and Wall (1980) indicated that two main factors are associated with trust: trustworthiness intent and individual competence, reliability, or professional ability. The former encompasses virtues like kindness and honesty, while the latter is broadly categorized into implicit moral intent and explicit professional capability by the scholar. Morgan (1994) elaborated on competence-based trust, wherein cooperative members hold sufficient trust in each other's knowledge and abilities, forming a prerequisite for successful exchanges. Schaubroeck et al. (2011) highlighted two categories of interpersonal trust in their research: affect-based trust and cognition-based trust. The former involves emotional connections and is based on genuine care and concern, while the latter is grounded in performance-related cognitive trust, including but not limited to ability and responsibility.

Y. W. Wang et al. (2006) conducted research on interpersonal trust among Chinese individuals, identifying five prototypes of trust strategies stemming from Confucianism: kinship trust, nurture trust, customary trust, professional trust, and institutional trust. Professional trust is rooted in the acknowledgment of each other's professional knowledge and skills. It arises when an individual can leverage the knowledge of another trusted individual to

solve complex professional issues. In professional trust, the trusted party's sense of obligation is typically not as strong, making them replaceable by others with similar knowledge.

From the analysis above, it is evident that Schaubroeck et al. (2011) cognition-based trust aligns with the essence of professional trust studied by Y. W. Wang et al. (2006), as both emphasize the trusted party's competence and reliability. Similarly, the essence of affect-based trust and nurture trust are quite similar, both focusing on the intimate relationship between transaction parties. Therefore, in the subsequent model establishment, this thesis adopts both cognition-based trust and affect-based trust to represent the project team members' attitudes of trust towards the project manager. According to the Social Exchange Theory (Schaubroeck et al., 2011), cognition-based trust is crucial in economic exchange relationships, while affect-based trust holds prominence in social exchange relationships. Similarly, aligning with the guanxi and mianzi model for analyzing transactional relationships, cognition-based trust corresponds to the utilitarian component, while affect-based trust corresponds to the emotional component.

### **2.8.2 Team effectiveness theory**

Amidst the ever-evolving business landscape, many organizations form small groups such as work teams to enhance task efficiency. Work teams, which are highly flexible, comprise specific individuals assembled temporarily to accomplish specific tasks. Empirical evidence underscores the effectiveness of such teams. Prompted by this realization, scholars have pointed out that in modern society, work teams offer a certain degree of assurance for organizational success (Cohen & Bailey, 1997).

Consequently, more scholars have ventured into the research domain of teams and team effectiveness, offering robust theoretical guidance for the utilization of teams within organizations. Swezey and Salas (1992) pointed out that a team refers to an organization formed by two or more individuals who have their own expertise and team roles, play specific roles, interact and collaborate to achieve common goals, and have interdependence and adaptability to each other. Susskind and Borchgrevink (1999) indicated that a team is a gathering of at least two individuals who come together to achieve a common purpose, collaboratively engage in temporary activities (past, present, or future), and interact under certain independent premises. Katzenbach and Smith (1992) stated that a team is a combination of several members, each possessing distinct skills, with shared goals, performance standards, and work methods; they trust each other relatively more, thus

collaborating effectively to achieve work objectives. Salas et al. (1999) defined a team as a collection of two or more distinguishable individuals, with dynamic, interdependent, and adaptable interactions, sharing common goals, assigned specific roles and functions, and limited time spent within the team.

In summary, while there is broad divergence among scholars regarding the concept of a team, consensus has been reached on its characteristics, including shared purpose, mutual interdependence, clear roles, satisfaction derived from collaboration, simultaneous individual and team responsibility, and possession of complementary skills (Higgs et al., 2005). During the team formation process, it is imperative to consider both the nature of the tasks the team will undertake and the type of team to be created. In other words, prior to forming a team, its purpose and tasks should be defined. According to Cohen and Bailey (1997), teams can be categorized into four types: work teams, parallel teams, project teams, and management teams.

When studying teams, many scholars have focused on the factors associated with team effectiveness and attempted to identify characteristics of high-quality teams. This effort aims to provide guidance for the creation of excellent teams and the enhancement of team effectiveness, leading to the emergence of diverse team effectiveness models.

Mcgrath (1964) introduced the Input-Process-Output (I-P-O) model of team effectiveness. According to this model, team effectiveness consists of three components: input-process-output. Input signifies resource-related elements; P represents process, encompassing the processes and methods by which resources are transformed into performance; O signifies output, representing the team's outcome. He mentioned that input elements influence team processes, ultimately leading to changes in team performance. Thus, team processes act as mediators in the relationship between input and output.

Subsequently, numerous scholars have appropriately refined the I-P-O model. Among these, notable and influential contributions include that of Jewell and Reitz (1979). They further dissected the ultimate team outcome in the I-P-O model, differentiating it into intrinsic and extrinsic components (see Figure 2.4). The term “intrinsic” refers to the enhancement of internal cohesion and member satisfaction within the team, while “extrinsic” pertains to the optimization of external relationships and customer satisfaction.

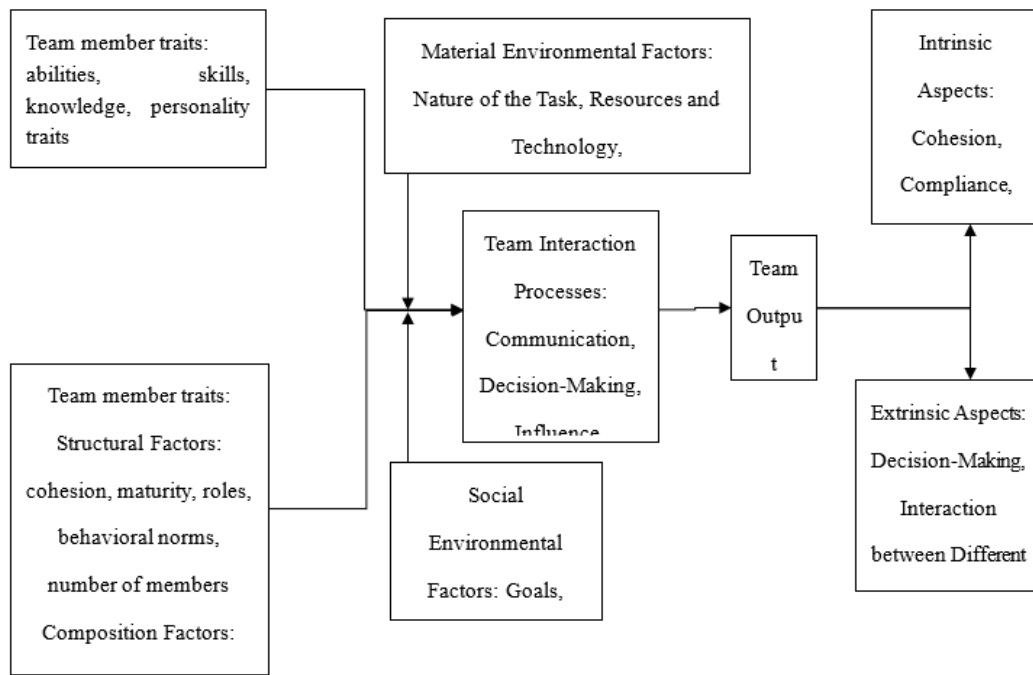


Figure 2.4 Team effectiveness model 1

Source: Jewell and Reitz (1979)

In Reitz and Jewell's (1979) model, input elements encompass member attributes and team characteristics. The competence of team members correlates directly with structural features of the team, such as team size and internal cohesion. They extend the I-P-O model (McGrath, 1964) and introduce a notable innovation by shifting environmental factors from input variables to moderating variables, further classifying them into material and social environmental elements.

Building upon the I-P-O model, Hackman (1983) developed the Team Effectiveness Model, illustrated in Figure 2.5. This model's input variables encompass team design and organizational context, while team processes influence team performance, and environmental resources are directly relevant. He emphasized that the reward system within teams, along with the effectiveness of employee training and information systems, constitute crucial factors determining the effectiveness of work teams. Moreover, the availability of useful environmental resources significantly impacts team performance. Concerning the interaction within work teams, he highlighted that members' efforts and the performance strategies implemented by the team are of paramount importance in their research.

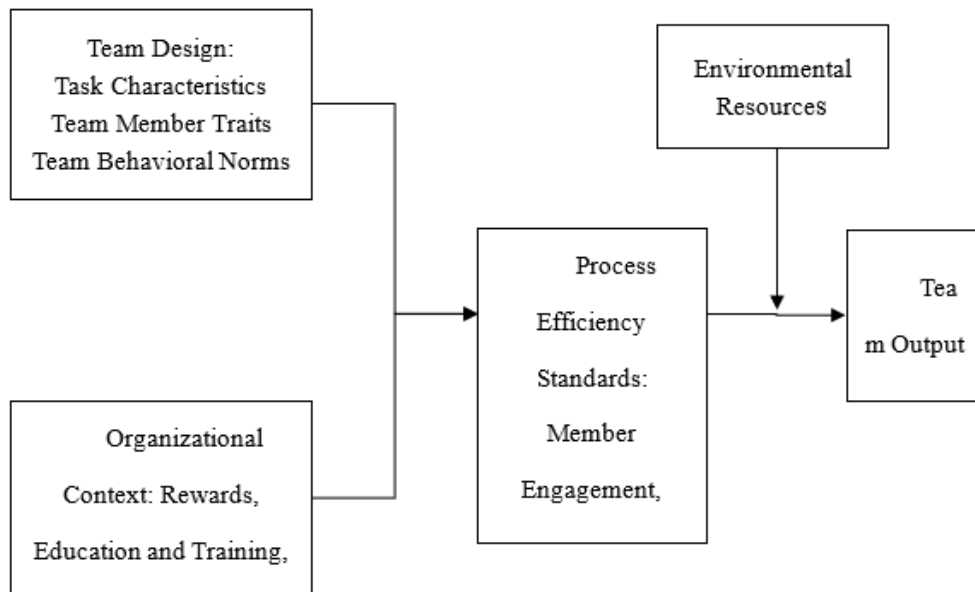


Figure 2.5 Team effectiveness model 2

Source: Hackman (1983)

Building upon the I-P-O model, Gladstein (1984) devised a novel explanatory model, as depicted in Figure 2.6. The Team Effectiveness Model proposed by Gladstein (1984) synthesizes input variables at both the organizational and team levels, with team interactions mediating the influence on team performance. The key distinction from the models mentioned earlier lies in the consideration of task characteristics as moderating variables rather than input variables. In their research, he indicated that the complexity of team tasks, uncertainty in the external work environment, and the interdependence of task processes determine the impact of team interactions on team performance. In essence, when facing intricate team tasks, achieving comparable output requires heightened input variables and optimized team interactions.

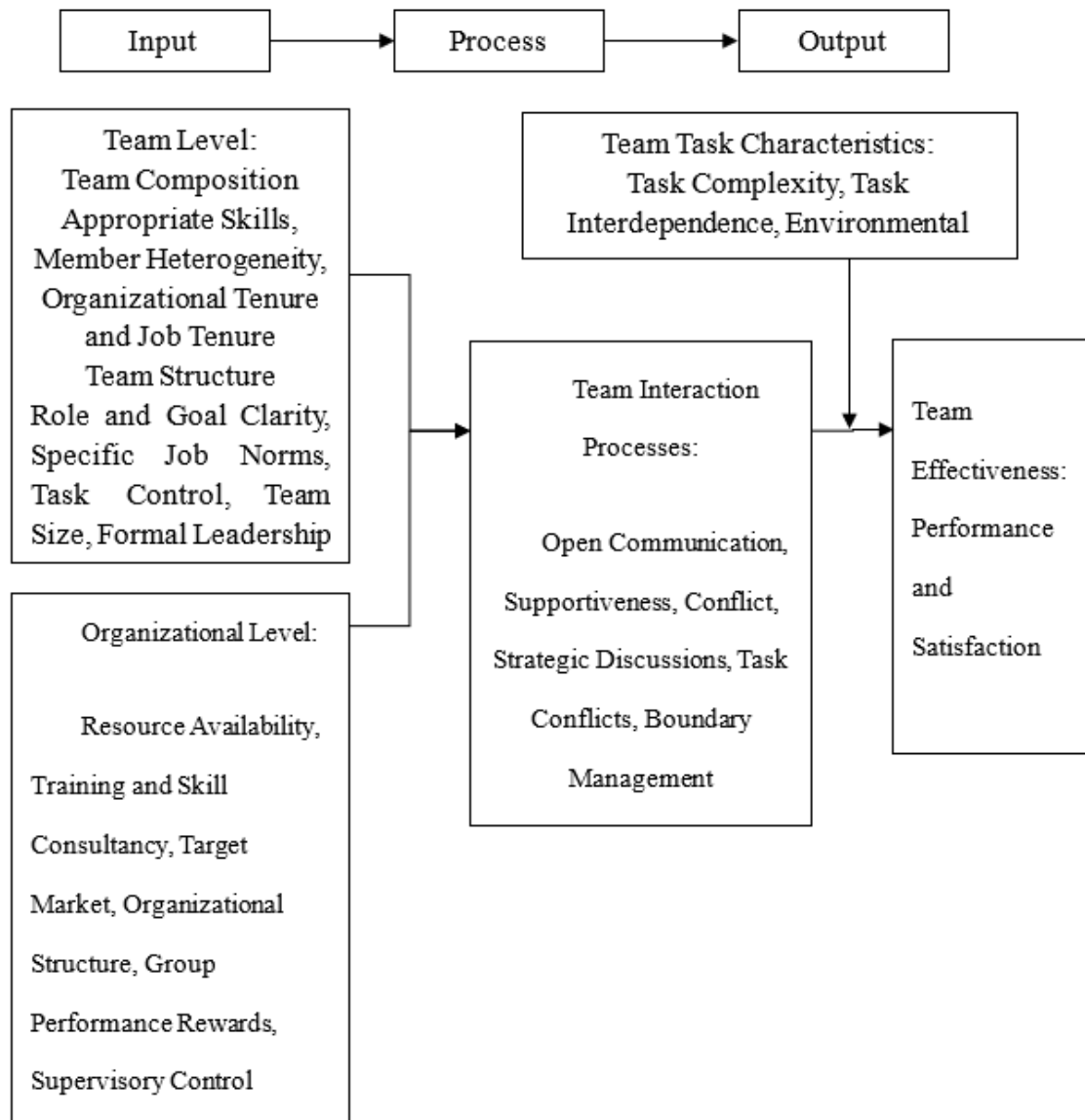


Figure 2.6 Team effectiveness model 3

Source: Gladstein (1984)

For a considerable period of time, scholars conducting related research have utilized or drawn upon the I-P-O model, often incorporating empirical findings to adjust or refine the model. This has led to the emergence of a series of new models. Most scholars have placed this model within broader contexts or have unearthed aspects that were previously overlooked. For instance, Cohen and Bailey (1997) characterized environmental factors as driving forces behind other composite inputs within teams, thereby eliminating the interference of contextual issues (see Figure 2.7). This approach respects the multi-level nature of teams. Each individual is embedded in a team, the team is embedded in an organization, and the organization is embedded in an environment, which align perfectly with multi-level models. Furthermore, Gladstein (1984) highlighted in their research that team interaction processes

encompass both internal (external) processes and team psychological characteristics, which deepened our understanding of team operations and made it more accurate and detailed.

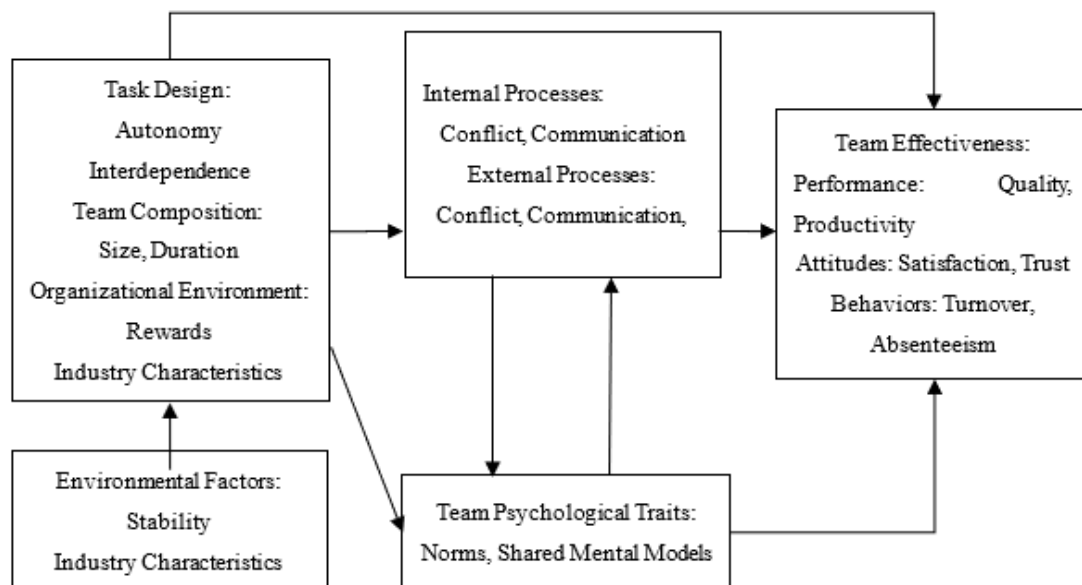


Figure 2.7 Team effectiveness model 4

Source: Cohen and Bailey (1997)

In their research, Ilgen et al. (2005) pointed out certain limitations within the I-P-O model for team effectiveness. Specifically: firstly, the transmission of the effects of input elements to various outcome elements as intermediary factors is not truly a process but rather cognitive or emotional states that exist within individuals; secondly, studying team effectiveness within the I-P-O model confines the research to a linear path from input to output, excluding feedback paths, which makes it difficult to achieve breakthrough progress in team research; finally, the I-P-O model treats all main effects as progressively enhancing processes, following a path from input to process to output, but in reality, the main effects of input and process might influence each other, interact between different process factors, and even interact with emergent states.

Based on this analysis, Ilgen et al. (2005) introduced an alternative model for team effectiveness: the Input-Mediator-Output-Input (IMOI) model (illustrated in Figure 2.8). This model replaces process variables with mediators, providing a broader perspective and a more accurate explanation of team performance and the related mediating factors' variability. By incorporating an input element at the end of the model, it better captures the cyclical feedback nature of team effectiveness. The removal of connecting lines between letters signifies that the associations between input, intermediary, and output variables are not necessarily linear or additive; they can be nonlinear and contingent at times.

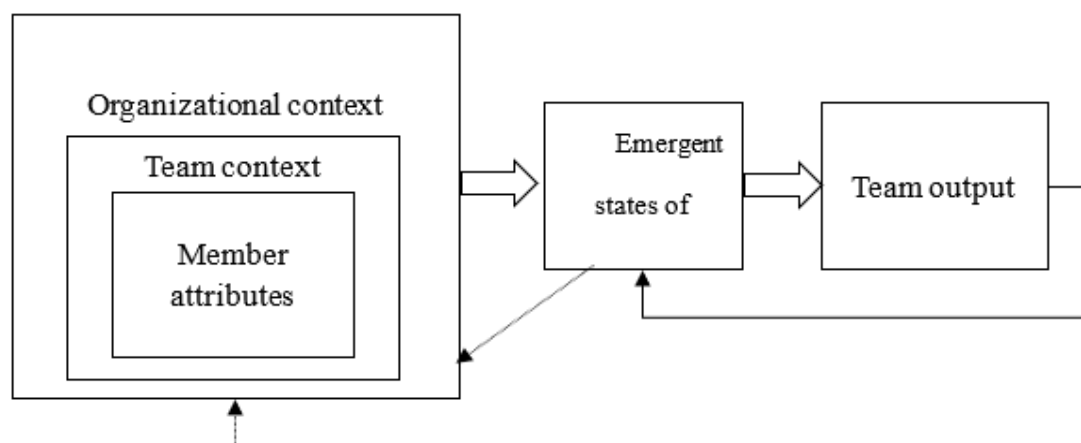


Figure 2.8 IMO team effectiveness framework

Source: Ilgen et al. (2005)

Analyzing this figure enables the determination that the design of embedded team outputs implies an influence from environmental and organizational contextual factors on team-level features such as team leadership and task design. Therefore, team context and requirements necessitate specific attributes (competence) among team members, influencing internal allocation within the team. Typically, external factors impact internal ones, and from a long-term perspective, this effect is also reversed.

The IMO framework of team effectiveness describes intrinsic feedback loops in team development. The solid arrows from team output to team intermediary variables indicate that current team output significantly affects subsequent team intermediary variables. During the team development process, the emergent state of the team continuously changes, and the team optimizes its operations based on prior output results. However, the dashed lines from team output and intermediary variables to team input suggest a relatively weak impact on the next stage's team input. Team results, processes, and states exert an influence on subsequent team factors such as composition, structure, or organizational context, but this effect is indirect and requires a longer time to manifest (Ilgen et al., 2005).

Regarding the segmentation of process elements, overlooked by the I-P-O framework, it is notable that processes, which were previously not considered as such and are not inherent to team members' actions, such as cognitive processes and motivational states, are collectively termed as a new type of intermediary variable — emergent state (e.g., team effectiveness, cohesion) (Ilgen et al., 2005). Hence, based on the IMO model, team effectiveness features two intermediary variables: the team's operational processes and emergent state.

Despite the diverse array of team effectiveness models, they all encompass team processes (Mathieu et al., 2008). A series of research outcomes underscore that various team

process variables exert varying degrees of influence on team performance (LePine et al., 2008).

For instance, Tesluk and Mathieu (1999) highlighted the importance of team coordination as a relevant factor in team management. Hirst et al. (2004) verified the connection between team communication and team performance. Y. L. Wang et al. (2009) explored the impact of empowering leadership on team performance, revealing a link between team communication and this operational process, indicating that team communication moderately influences the relationship between goal-setting participation and team performance.

Furthermore, scholars have delved into the associations between diverse process variables and team performance, such as the crucial role of team participation (De Dreu & West, 2001), the connection between information sharing and team decision quality (Johnson et al., 2006), the comprehensive analysis of the relationships between task and interpersonal conflicts and team performance (De Dreu & West, 2001), the enhancement of team performance through interpersonal team processes (Mathieu et al., 2006), and the examination of the relationship between paternalistic leadership behavior and team performance which underscores the positive impact of benevolence and moral behavior of team leaders on conflict management and, subsequently, team performance improvement (X. A. Zhang et al., 2009).

Team emergent states encompass cognitive, motivational, and emotional states that are subject to constant change, interrelated with team context, inputs, processes, and outcomes (Marks et al., 2001). Consequently, scholars have placed significant emphasis on team emergent states, including team effectiveness, psychological empowerment, team atmosphere, and team cohesion.

For instance, Lester et al. (2002) demonstrated the contributory role of team effectiveness in enhancing team performance levels. Mathieu et al. (2006) highlighted how psychological empowerment influences team performance and customer satisfaction as mediated by team processes. Katz-Navon et al. (2005) investigated the impact of team safety climate on team performance.

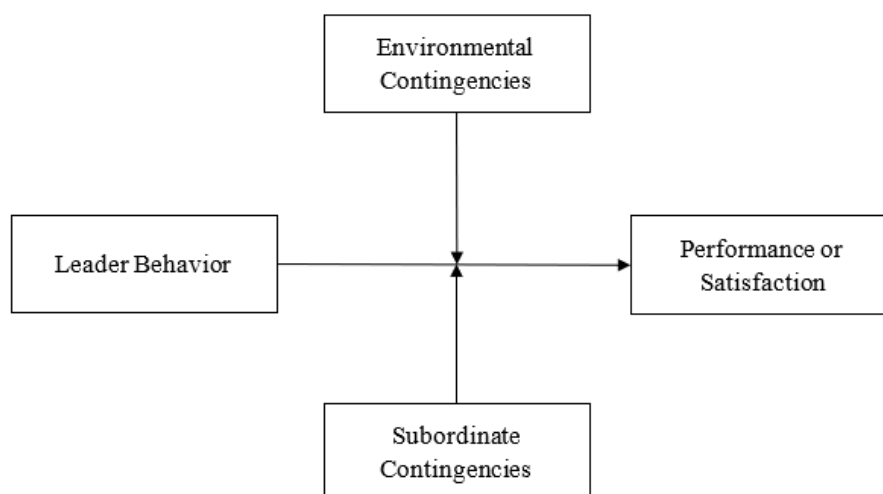
Notably, team cohesion has garnered more attention compared to other emergent state variables (Kozlowski & Bell, 2013). Beal et al. (2003) conducted a meta-analysis, revealing an average correlation of 0.30 and 0.17 between team cohesion and team performance behavior and outcomes, respectively. L. R. Yang et al. (2011) employed team communication and team cohesion as representatives of team process variables and team emergent state variables, analyzing their mediating roles in the relationship between team leadership and team performance.

This study selected these variables because the research subjects were engineering project teams comprising members from diverse professional backgrounds (financial, technical, contractual). They form temporary teams where effective communication and sufficient cohesion are pivotal to the entire engineering project team.

### 2.8.3 Leader path-goal theory

This study is grounded in the leader path-goal theory, which falls within the realm of leadership contingency theories. According to this theory, the central task of leaders is to assist subordinates in achieving their work goals, thus contributing to the realization of organizational objectives. To achieve this, leaders provide guidance and support to subordinates, aligning their goals with those of the organization.

Furthermore, the path-goal theory introduces two contingency variables to better elucidate the relationship between leadership behavior and outcomes. Firstly, there are controllable environmental factors for subordinates, such as task structure and formal power systems. Secondly, there are subordinate contingency factors, including locus of control and past experiences, as depicted in Figure 2.9 (Robbins et al., 2014). Subsequent scholars have built upon this theory and conducted research under specific hypothetical conditions. While not all studies may yield supportive results, the majority of research findings confirm the logical foundation of this theory. In essence, if leaders are able to compensate for deficiencies in subordinates or the work environment, it is likely to enhance subordinate job performance and satisfaction (Cheng et al., 2005).




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Figure 2.9 Leader path-goal theory diagram

Source: Robbins et al. (2014)

Based on the leader path-goal theory and taking into full consideration the characteristics

of engineering projects, the role and capabilities of a project manager, who serves as the primary leader of the project team, play a pivotal role in determining the team's work performance. The relationship between these factors is also intertwined with the environment and subordinate contingency factors. When engaging in project management activities, these contingent factors primarily encompass team training and the comprehensive capabilities of the project team. Considering the variations in task structure and power systems across different project contracting approaches, the comprehensive capabilities of the project team reflect the collective proficiency in project management within the workforce.

Grounded in the path-goal theory, this thesis investigates how the capabilities of a project manager influence the comprehensive capabilities of the project team and project performance.

## **2.9 Chapter summary**

This chapter provides a literature review, focusing on the connotation, dimensions and measurement of competency models, project manager competency and project performance, and compares the existing research results to lay a solid foundation for the subsequent research.

Chinese private construction enterprises have flourished in recent years, with project managers playing a pivotal role in project management. Their competencies directly influence project success and performance. Recent literature highlights the close relationship between project manager competencies and project performance, especially within the specific context of Chinese private construction enterprises. Due to the rapidly changing market environment, intensified competition, and increasing project management demands, the causal link and mechanism between project manager competencies and project performance remain inadequately clarified.

On one hand, existing studies show that hard skills, such as technical project management abilities, strategic decision-making, and business management capabilities, are fundamental for ensuring the smooth progress of projects (Sonelma & Sucita, 2022). The professional competencies of project managers in budget control, schedule planning, and quality management directly impact the operational efficiency of projects. However, for Chinese private construction enterprises, improving project manager competencies extends beyond these areas. It also requires consideration of unique business characteristics and market demands, such as the ability to adapt flexibly to market changes, manage complex

interpersonal networks, and handle uncertainties.

On the other hand, emotional competencies and leadership also play a significant role in the work of project managers (Sultana-Muchindu & Kabwe, 2022). In the project practices of Chinese private construction enterprises, the emotional intelligence and interpersonal skills of project managers often profoundly influence team cohesion, execution, and ultimately project performance. Additionally, the leadership style of project managers, particularly moral leadership and effective team communication, has been proven to be a crucial factor affecting project performance (Khalfan et al., 2022).

Despite this, the specific mechanisms by which project manager competencies affect project performance in Chinese private construction enterprises remain to be deeply explored. Within the current academic research framework, although the core role of project manager competencies in enhancing project performance and team capabilities in Chinese private construction enterprises is widely recognized, the deeper mechanisms underlying this core relationship—especially the roles of specific mediating and moderating variables—remain underexplored.

When examining the direct relationship between project manager competencies and project performance, the literature suggests a positive impact. However, the detailed theoretical explanation and rigorous empirical testing of how this impact is transmitted and enhanced through a series of potential mediating factors are still lacking. For instance, it remains a pressing research challenge to determine whether and how the personal traits, leadership abilities, and professional management skills of project managers translate into team efficiency and project performance through mediating variables such as increased trust among team members and optimized communication mechanisms.

Similarly, while reviewing the interactive relationship between project manager competencies and team capabilities, research has pointed to several potential mediating variables such as employee trust and team communication. However, empirical data and theoretical support are insufficient regarding the exact mediating roles of these variables and how their effects vary under different conditions.

Furthermore, in studying the dynamic adjustments between project manager competencies and other key variables, employee training as a potential moderating variable remains an insufficiently explored area. The academic community has yet to adequately investigate how employee training intervenes and influences the interaction between project manager competencies and the outcomes of team trust and communication. Specifically, there is a need to understand how training alters the behavior, mindset, or professional knowledge

structure of project managers and consequently enhances the operational efficiency and project outcomes of the entire team.

In conclusion, the existing research on the impact mechanism of project manager competencies on project performance and team capabilities in Chinese private construction enterprises, particularly in terms of identifying and exploring the roles of mediating and moderating variables, shows significant theoretical and empirical gaps. There is an urgent need for further in-depth research to fill these gaps, thereby providing more precise and robust theoretical support and practical guidance for improving project management levels and performance in Chinese private construction enterprises.

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## **Chapter 3: Conceptual Model and Hypotheses**

### **3.1 Research hypotheses**

#### **3.1.1 Main effects hypotheses**

##### **3.1.1.1 Competence of project managers and project performance**

Levenson et al. (2006) explored the impact of managerial competence on organizational performance, establishing a positive correlation between managerial competence and organizational performance. E. Wang et al. (2005) examined ERP project teams in enterprises and found that charismatic leadership contributes to improved execution performance of ERP projects. Thite (2000) conducted research on information technology project personnel and arrived at similar conclusions. Mainga (2017) highlighted the relatively greater influence of certain higher-order project management capabilities, like dynamic capabilities, on predicting project efficiency. Huda (2017) discovered a positive and significant influence of project management capabilities on company resources or capabilities in terms of performance. Sang et al. (Sang et al., 2018) indicated that the performance of green construction projects is predominantly determined by project manager capabilities, particularly in leadership, organizational and goal management, and emotional intelligence.

Rezk et al. (2019) affirmed the pivotal role of project managers in construction projects. El-Sawalhi and Lafy (2021) found that the most influential factors on construction employee performance, based on the impact of project manager competence, were productivity, compliance with work instructions, and working after regular hours. Montenegro et al. (2021) demonstrated a significant influence of emotional intelligence of construction project managers on project success. Agindano (2021) demonstrated that top management significantly and positively affects construction project performance.

Sarpin et al. (2021) identified key abilities required for successful management of sustainable construction projects, including professional competence, emotional resilience, stress coping abilities, and negotiation skills. Dlamini and Cumberlege (2021) emphasized the pivotal role of project managers as contributors to project success, directly impacting whether construction projects are completed on time. Lin (2021) found that the project management capabilities of individuals involved in e-commerce have a positive influence on their work

performance. Elmezain et al. (2021) indicated that project managers impact project success through technical, conceptual, political, and interpersonal skills.

Sultana-Muchindu and Kabwe (2022) found a close correlation between emotional intelligence of project managers and project success in the construction industry. Sonelma and Sucita (2022) emphasized the significant role of project managers in project implementation, with project manager competence accounting for 44% of the impact on construction project success. Khalfan et al. (2022) revealed a significant influence of leadership on quality management practices and operational performance in construction projects.

S. Q. Zheng et al. (2016) empirically analyzed the impact of construction enterprise project manager competence on performance, with a path coefficient value of 0.65, indicating a significant positive correlation between the two; the competence of project managers considerably determines the ultimate success or failure of projects.

Q. Q. Du (2022) constructed a theoretical model involving project manager competence, leadership trust, and project performance, revealing that project manager competence serves as a promotive factor for member leadership trust. J. N. Guo (2022) confirmed the existence of the following pathway: project manager competence → psychological safety → team learning → team performance. Q. Zhang et al. (2022) emphasized that project manager competence is a promotive factor for project performance in construction projects.

Based on the analysis above, the following hypothesis is formulated in this study:

Hypothesis 1 (H1): In Chinese private construction firms, the competence of project managers has a positive impact on project performance.

M. I. Cheng et al. (2005) employed the behavioral event interview method to identify 12 competence elements of engineering project managers, including abilities related to self-control, teamwork, as well as conceptual, analytical, and flexibility skills. L. G. Shi et al. (2014) asserted that the most crucial competencies of project managers lie in personal qualities, on-site practical skills, and the ability for continuous professional learning. X. Q. Wang et al. (2014) established an engineering project manager competence model with six dimensions: cognitive skills, social skills, resource management skills, achievement orientation, stress resistance orientation, and responsibility orientation.

S. B. Zhang et al. (2013) measured engineering project manager competence traits, concluding that the competence model consisting of emotional intelligence, personality charm, project management, and cognitive dimensions is statistically valid. L. Q. Dong (2016) ranked influencing factors of engineering project manager competence in order of impact, identifying

comprehensive management ability, personal traits, and professional knowledge as relevant factors. S. Q. Zheng et al. (2016) revealed that the competence of project managers in construction enterprises is mainly influenced by four key factors: comprehensive management ability, leadership ability, professional knowledge background, and personal traits; project manager competence has a significant positive impact on performance.

Sang et al. (2018) found that project manager capabilities predominantly determine the performance of green construction projects, particularly in leadership, organizational and goal management, and emotional intelligence. Sang et al. (2018) indicated that leadership and organizational capabilities, goal management abilities, and emotional intelligence of project managers in Chinese green construction projects are important factors influencing green construction performance.

Rezk et al. (2019) affirmed the importance of project managers in construction projects and identified two focus areas for project manager capabilities: hard skills such as technical knowledge, and soft skills such as personal traits. Moradi et al. (2020) distilled ten core competencies for Finnish collaborative construction project managers, including team abilities, language skills, and utilizing diversity. El-sawalhi and Lafy (2021) found that, based on the impact of project manager capabilities, the three most influential factors on construction employee performance are productivity, compliance with work instructions, and working after regular hours.

Sarpin et al. (2021) revealed that key abilities required for successfully managing sustainable construction projects include professional competence, emotional resilience, stress coping abilities, and negotiation skills. Dlamini and Cumberlege (2021) emphasized that project managers are key contributors to project success, with the roles, responsibilities, and abilities of project managers directly impacting whether construction projects are completed on time.

J. N. Guo (2022) found that competence in four dimensions—personality traits, leadership charm, project management, and communication and coordination—all positively influence team performance. L. Zhang et al. (2022) demonstrated that project manager competence significantly and positively affects project performance; personality traits variables of conscientiousness, agreeableness, and extraversion positively predict project performance; neuroticism personality variables have strong inverse predictive effects; the predictive effects of personality traits on project performance change after introducing competence; conscientiousness and agreeableness have substitution effects on personality traits, while neuroticism and openness have complementary effects.

Q. Q. Du (2022) revealed that the four dimensions of project manager competence: professional knowledge, personal traits, management abilities, self-improvement. Each have a positive influence on team members' leadership trust and project performance. Team members' leadership trust positively promotes project performance. Project manager competence indirectly affects project performance through leadership trust.

Sonelma and Sucita (2022) pointed out that project managers play a crucial role in project implementation, with project manager competence measurable through three aspects: technical project management, leadership skills, and strategy and business management.

Considering the existing research findings, it is evident that project manager competence encompasses several dimensions. Thus, this study formulates sub-hypotheses based on the constructed dimensions of project manager competence. In Section 4.1 of the thesis, project manager competence is divided into three dimensions: personal traits, general leadership abilities, and project-specific management abilities. Based on this foundation, the following sub-hypotheses are formulated:

Hypothesis 1a (H1a): In Chinese private construction firms, the dimension of personal traits within project manager competence positively influences project performance.

Hypothesis 1b (H1b): In Chinese private construction firms, the dimension of general leadership abilities within project manager competence positively influences project performance.

Hypothesis 1c (H1c): In Chinese private construction firms, the dimension of project-specific management abilities within project manager competence positively influences project performance.

### **3.1.1.2 Project manager competence and team comprehensive capability**

Thamhain (2004) highlighted the role of project managers as leaders in promoting team capabilities. Turner and Muller (2004) described leadership forms based on intelligence and emotions and hypothesized that the leadership style of project managers affects project success, with this association influenced by project attributes. Their findings demonstrated that the leadership style of project managers impacts the team's capabilities and performance. Dionne et al. (2004) emphasized the inclusion of team collaboration processes in the leadership/team performance influence model and constructed a leadership/team performance framework with team cooperation as an intermediary variable.

L. R. Yang et al. (2011) evaluated leadership using execution and reform styles, measured team capabilities through team communication, cohesion, and collaboration, and assessed

project performance using project cost, schedule, and quality. They postulated relationships between leadership and team capabilities, between team capabilities and project performance, and the influence of project attributes on the relationship between team capabilities and project performance. Their study, combining survey methods and multiple regression analysis, confirmed the effectiveness of the conceptual framework model proposed by Dionne et al. (2004).

Tang et al. (2020) demonstrated the positive impact of incentive-based leadership on team innovation. J. Yoon et al. (2023) affirmed the relationships among shared leadership, dynamic capabilities, and team performance in Korean companies, with leadership having a positive impact on team dynamic capabilities.

Additionally, considering the path-goal theory, we can infer that project managers have an impact on the project team. Based on this, the study proposes the following hypothesis:

Hypothesis 2 (H2): In Chinese private construction firms, project manager competence positively influences team's comprehensive capabilities.

Building on the relevant content in Section 4.1 later in the thesis, project manager competence is divided into three dimensions: personal traits, general leadership abilities, and project-specific management abilities. This leads to the formulation of the following sub-hypotheses:

Hypothesis 2a (H2a): In Chinese private construction firms, the dimension of personal traits within project manager competence positively influences team's comprehensive capabilities.

Hypothesis 2b (H2b): In Chinese private construction firms, the dimension of general leadership abilities within project manager competence positively influences team's comprehensive capabilities.

Hypothesis 2c (H2c): In Chinese private construction firms, the dimension of project-specific management abilities within project manager competence positively influences team's comprehensive capabilities.

### **3.1.1.3 Team comprehensive capability and project performance**

The significance of communication, coordination, and teamwork within the team interaction process, impacting team performance (Esch et al., 1992). Research by L. R. Yang et al. (2011) has illuminated that project team capability stands as a pivotal determinant of project performance. McDonough (2000) conducted a study on factors influencing successful cross-functional teams, which encompassed three dimensions: initial stage factors,

competency factors encompassing team leadership and management, and team behavioral factors. This study substantiated the profound impact of team behavioral factors on the success of cross-functional teams.

Chan et al. (2001) validated the influence of team comprehensive capability on the overall performance of projects. Dionne et al. (2004) presented research demonstrating that transformational leadership relies on team capability to influence team performance, thereby introducing three evaluative metrics for team capability: cohesion, communication, and conflict management.

Aronson et al. (2006) found that team capability functions as a mediator in the process of team leadership influencing team performance. Prokopenko and Obodovsky (2020) ascertained that the capability of project team members significantly impacts project efficiency. J. Yoon et al. (2023) validated the relationship between team dynamic capability and team performance.

Through a comprehensive analysis of the aforementioned studies, it is posited that team comprehensive capability plays a pivotal role in organizational performance. Given this perspective, the present study establishes the following hypothesis:

Hypothesis 3 (H3): In Chinese private construction firms, team comprehensive capability positively influences project performance.

### **3.1.2 Mediating effect hypotheses**

#### **3.1.2.1 Employee trust as the mediator**

Employee trust is a crucial predictor of leadership effectiveness (Dirks, 2000). Many scholars have indicated its role as a mediator in the social exchange process between leaders and subordinates (Aryee et al., 2002; J. Yang & Mossholder, 2010).

Concerning interpersonal trust, McAllister (1995) proposed two types: cognitive-based trust (referred to as cognitive trust below) and affect-based trust (referred to as affective trust below). Cognitive trust is based on cognitive foundations related to performance, including abilities, responsibilities, and reliability. Affective trust refers to emotional bonds among individuals, grounded in genuine care and emotional concern; it relies on empathy, friendliness, and harmony beyond utilitarian interests. In terms of specific relational components, cognitive trust is primarily instrumental, treating the interaction partner as a means to achieve one's objectives, whereas affective trust is primarily emotional, often considering the interests of the other party to sustain the relationship.

In the context of engineering projects, a qualified project manager not only needs to possess sufficient professional competence to assure project members that they can lead the project to successful completion, but also instill confidence in the team to overcome challenges and utilize their talents, thereby enhancing project performance. Additionally, project managers can foster emotional connections with team members through social means and personal charisma, cultivating spontaneous support and cooperation. This support leads team members to trust the manager's decisions and put forth their maximum effort, even engaging in proactive behaviors beyond their job duties, which is beneficial for project success. Especially within the socio-cultural context of China (Huang, 2009), mutual trust between project managers and team members contributes to elevated project performance because trust is a crucial component of personal relationships.

Meta-analysis conducted by Dirks and Ferrin (2002) indicated that transformational leadership enhances subordinates' cognitive and affective trust in leaders. Dirks (2000) studied a basketball team and found that trust and affective trust in leadership enhance overall team performance.

Schaubroeck et al. (2011) demonstrated that transformational leadership strengthens members' cognitive trust in leadership, subsequently enhancing team performance, whereas service-oriented leadership strengthens affective trust, leading to elevated team performance. Lee et al. (2016) found that knowledge-based leadership enhances subordinates' interpersonal trust in leadership's competence and goodwill orientation, thereby promoting team performance.

Burke et al. (2007) established an integrated framework for employee trust, revealing that leader attributes like competence and benevolence enhance subordinates' trust, fostering followership consistency and citizenship behavior, and subsequently enhancing work performance. Research by J. Yang and Mossholder (2010) indicated positive correlations between subordinates' cognitive trust in leadership and their role performance and job satisfaction, while affective trust encourages internal and external role behaviors, intensifying job satisfaction.

Studies by H. M. Wei and Long (2009) on knowledge work teams revealed that member trust in leadership positively affects task performance and organizational citizenship behavior, elevating team performance. W. M. Zhang and Xia (2011) proposed that subordinate cognitive and affective trust in team leadership mediate the relationship between charismatic leadership and team innovation performance.

Hafeez et al. (2022) found that employee trust in leadership mediates the impact of

high-performance HR practices on project team performance. Similarly, Q. Q. Du (2022) developed and confirmed a theoretical model of project manager competence, leadership trust, and project performance. Le and Nguyen (2023) established that employee trust in leadership plays a positive mediating role between ethical leadership and knowledge-sharing behavior.

Based on these findings, this study proposes the following hypothesis:

Hypothesis 4 (H4): In Chinese private construction firms, employee trust mediates the impact of project manager competence on team comprehensive capability.

### **3.1.2.2 Team communication as the mediator**

Team communication is fundamentally the circulation of information within a team (Cook et al., 2021). Effective internal communication mechanisms reduce misunderstandings and barriers, enhancing the efficiency and accuracy of information flow (Dougherty, 1992), thereby aiding efficient team operation.

Many scholars have highlighted team communication as a critical variable in team processes, essential for team existence and growth. Effective team communication aligns members' goals toward a common direction (Van Ginkel & Van Knippenberg, 2008), accelerating the efficient transmission of information, which is beneficial for task completion. Moreover, effective team communication can help to integrate members' knowledge and skills, directly impacting overall team performance.

The importance of team communication is undeniable, recognized by academia and practitioners alike. However, achieving effective communication in practice can be challenging. Srivastava et al. (2006) noted that effective team communication is not naturally formed; it requires effort from every team member, especially leaders. Authoritarian leadership can inhibit team communication to some extent (L. Z. Wu et al., 2013), whereas empowering leadership enhances communication efficiency (Y. L. Wang et al., 2009). Research by Zhou et al. (2012) found that transformational leadership behaviors enhance team communication and overall performance. Y. L. Wu and Cao (2005) conducted a case study, indicating that team leadership, based on variables like team communication, promotes improved team performance in high-level management teams in the public sector.

Effective team communication is a prerequisite for efficient team operation and achieving good performance. Research shows that the root causes of team failure often stem from communication and coordination among members, rather than members lacking sufficient competence (Kahai et al., 1997).

Particularly when teams display evident heterogeneity, the effectiveness of team

communication significantly influences performance. Empirical studies suggest that team communication improves the performance of R&D projects (Keller, 2001). Hirst et al. (2004) studied R&D project teams, establishing a leadership-project performance model, empirically confirming team communication as a mediating factor. Huang and Hu (2005) found that team communication is a contributing factor to R&D performance. Sarker et al. (2011) analyzed social networks of global virtual teams, confirming the impact of team communication on team performance. Lievens and Moenaert (2000) investigated financial service teams, revealing that team communication enhances innovation performance.

Specifically, the mechanisms through which team communication affects team comprehensive capability and performance are as follows: a) Enhancing team knowledge sharing and learning, improving decision quality. Several studies suggest that team communication influences team learning and knowledge sharing, raising overall information levels. This helps teams understand various solutions better, enhancing decision quality (Stasser & Titus, 1985).

b) Alleviating or even suppressing internal conflicts, enhancing team coordination. Cohesion and effective communication promote shared mental models, enhancing team members' alignment with overall goals. This reduces interpersonal and task conflicts, providing robust support for goal achievement (Okhuysen & Eisenhardt, 2002). Effective team communication promotes efficient information dissemination, aligning members' understanding of team matters, enhancing collaboration effectiveness, and ultimately improving team performance.

From the perspective of engineering project teams, leaders with high competence levels foster better communication atmospheres, establishing effective communication mechanisms, enabling successful communication between different team members, and ultimately enhancing team performance. Hyeon and Bum (2020) demonstrated that ethical leadership directly impacts team communication, with team communication mediating ethical leadership's effect on team effectiveness. Samuel and Matthew (2021) studied team communication and mutual support as drivers of organizational work performance. Manata et al. (2022) researched the impact of project manager communication behavior on integrated project delivery, considering the mediating role of team-level information sharing on team-level outcomes (consistency of direction, decision quality, process commitment, and project quality).

Considering the Chinese context, existing literature supports the role of team communication as a mediator between leadership and team effectiveness and performance.

Research also supports the mediating effect of team communication. L. Z. Wu et al. (2013) explored the influence of abusive supervision on team performance, confirming the complete mediating role of team communication and collective effectiveness. Y. Wang and Chen (2013) established a relationship between project manager characteristics and project team capabilities using multiple linear regression, and confirmed the mediating role of team communication.

Research by Zhou et al. (2012) demonstrated the mediating effect of team communication on the relationship between transformational leadership behavior and research team performance. Y. L. Wang et al. (2009) highlighted the positive influence of shared empowering leadership behaviors on team performance, with shared empowering leadership more significantly predicting team performance than vertical empowering leadership. Team communication mediated the relationship between shared empowering leadership and participation in goal setting and team performance.

Hao and Yin (2018) found that team communication positively influences team performance. M. Liu (2014) found that entrepreneurial team interaction mediates the influence of entrepreneurial leadership style on team effectiveness. J. S. Li and Qiao (2020) showed that team communication, mediated by knowledge absorption capabilities, impacts autonomous innovation performance in high-tech R&D. Y. C. Li and Ma (2009) demonstrated that team communication mediates the effect of shared mental models on team effectiveness.

Given these findings, this study proposes the following hypothesis:

Hypothesis 5 (H5): In Chinese private construction firms, team communication mediates the impact of project manager competence on team comprehensive capability.

### **3.1.2.3 Team comprehensive capability as the mediator**

Research conducted by L. R. Yang et al. (2011) validated the impact of project manager leadership style on project performance. The overall team capability influences the manifestation of leadership style during project execution, thereby mediating the effect of project manager's leadership style on project performance. Nauman et al. (2022) noted that enhancing transformational leadership and team building for project success requires a positive empowering environment. Team comprehensive capability is often closely related to such an environment; it influences team members' initiative and work enthusiasm, thereby affecting project performance.

Fareed et al. (2021) emphasized the influence of emotional intelligence, intellectual intelligence, and transformational leadership on project success. Team comprehensive

capability affects team members' emotional management and cooperation skills, thereby influencing project performance. Siddiquei et al. (2022) explored the impact of time leadership on project team task performance, with team comprehensive capability often affecting team performance in time management and consequently project performance. Hashim et al. (2022) highlighted the strong correlation between project managers' personal traits and project sustainability and performance. Project managers' personal traits often impact team members' collaborative efficiency and team cohesion, thereby influencing project performance. Q. Zhang et al. (2022) explored the impact of goal orientation of construction project managers on project performance. The overall team capability directly influences the establishment of project manager's goals and team execution capabilities, thereby affecting project performance.

Team comprehensive capability plays a crucial role in project management, partially moderating the influence of project manager competence on project performance, providing valuable guidance for successful project realization. Given these observations, this study proposes the following hypothesis:

Hypothesis 6 (H6): In Chinese private construction firms, team comprehensive capability mediates the impact of project manager competence on project performance.

### **3.1.3 Moderating effect hypotheses**

Based on Social Exchange Theory, a trust relationship develops between leaders and employees, and this trust relationship may be influenced by employee training (Le & Nguyen, 2023). After training, employees may strengthen their endorsement of the organization, subsequently leading to a greater endorsement of leadership. Therefore, in Chinese private construction firms, we believe that employee training moderates the relationship between project manager competence and employee trust (N. Y. Li, 2006). In other words, employee training can enhance the positive relationship between project manager competence and employee trust. Through employee training, employees can enhance their recognition of the project manager's competence, thereby increasing trust in the project manager (H. M. Wei & Long, 2009). This implies that after receiving relevant training, employees are more likely to identify with the project manager's professional abilities and management skills, resulting in greater trust in the project manager and improved cooperation and collaboration in the project. Based on these premises, this thesis establishes the following hypothesis:

Hypothesis 7 (H7): In Chinese private construction firms, training for employees

moderates the impact of project manager competence on employee trust.

Employee training can enhance team members' communication skills and awareness (Yimam, 2022), making it easier for them to comprehend and accept information conveyed by the project manager (Nor, 2023). Consequently, this strengthens the project manager's competence in facilitating communication within the team (Judeh & Khader, 2023). This implies that, after receiving relevant training, employees are more likely to engage in more effective communication with the project manager, leading to a better understanding of project goals and tasks. This, in turn, allows them to collaborate more effectively with other team members to accomplish tasks. Based on these premises, this thesis establishes the following hypothesis:

Hypothesis 8 (H8): In Chinese private construction firms, training for employees moderates the impact of project manager competence on team communication.

### 3.2 Conceptual model

Based on the hypotheses outlined above and the established pathways, the research model is constructed as depicted in Figure 3.1

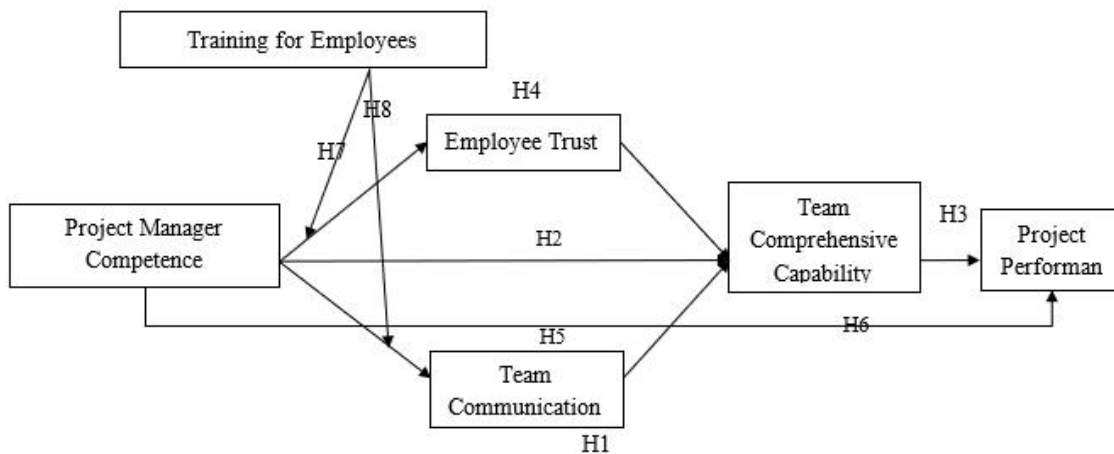


Figure 3.1 The conceptual model of this study

## **Chapter 4: Research Methods and Design**

This chapter introduces the research design and methodology used in this study. To systematically analyze the relationship between project manager competency and project performance, a combination of qualitative and quantitative research methods was adopted.

In the qualitative research section, existing literature and interview results were used to construct the various factors that constitute project manager competency. In the quantitative research section, a questionnaire survey was the primary method of data collection. This chapter first reviews the sources of the scales used in the questionnaire, followed by an introduction to the pre-test survey and formal survey. The data from the pre-test survey were mainly used to analyze the dimensions, reliability, and validity of the project manager competency scale, ultimately finalizing the scale used in the formal questionnaire. The final section presents the design of the formal survey and descriptive statistics of the formal sample.

### **4.1 Literature review**

To test the research hypotheses, the key task is to establish a measurement framework for project manager competency in China's construction industry. Extensive research on project manager competency has already been conducted in academia, resulting in a substantial body of literature. This study first reviews existing studies and relevant materials related to project manager competency, providing a solid theoretical foundation for constructing a competency model for project managers in Chinese construction enterprises.

### **4.2 Interview**

Following the literature review, an interview study was conducted to select appropriate competency indicators for project managers, considering the current situation of private construction enterprises in China. The interview method allows for the rapid collection of firsthand information and a deeper understanding of respondents' true thoughts and opinions. Based on its structure, interviews can be categorized into three types: structured interviews, unstructured interviews, and semi-structured interviews.

Considering the research objectives, content, and reference literature, this study adopted a semi-structured interview approach. During the interviews, respondents were asked to describe their job responsibilities in response to specific questions, ensuring flexibility while covering a broad range of topics. Additionally, careful observation of respondents' behaviors, language, and other details provided insights into their personality traits and behavioral styles, which were essential for this study.

The interview process consisted of three stages: preparation, outline drafting, and interview implementation. A total of 26 participants were selected from senior management and project managers in Chinese private construction enterprises. Basic information about respondents (see Table D.3) was collected. The interview objectives, content, and expression methods were defined. Questions were carefully designed to ensure relevance. Appropriate interview times were selected to complete the research within the given timeframe. The interview guide was used to maintain focus and direction. Interviewers guided respondents to express their true thoughts. The face-to-face format enabled researchers to collect firsthand data efficiently. The interview progressed from basic information to in-depth discussion.

### **4.3 Questionnaire survey**

#### **4.3.1 Questionnaire design**

The questionnaire consists of two main sections. The first section aims to gather fundamental demographic details of the respondents, including gender, age, and other background information. The second section focuses on evaluating the competency characteristics of project managers in Chinese construction enterprises. A five-point Likert scale is used to measure the importance of various competency factors, ranging from "very important" to "not important at all," where 1 represents "not important at all" and 5 represents "very important."

##### **4.3.1.1 Employee trust scale**

McAllister (1995) conducted theoretical analysis and proposed that interpersonal trust encompasses cognitive trust and affective trust. Based on these two dimensions, a measurement scale was designed. McAllister's (1995) ideas and scale have had a significant impact in academia. For instance, Schaubroeck et al. (2011) measured emotional and cognitive trust using McAllister's (1995) trust scale as intermediary variables when investigating the relationship between leadership behavior and team performance.

In China, many scholars conducting empirical research (Hwang et al., 2019; Shi et al.,

2019) have chosen this measurement scale. This scale has received widespread recognition in China. Therefore, this study also applied the scale designed by McAllister (1995) to measure affective and cognitive trust, with certain statements adjusted appropriately to fit the context of domestic engineering projects. The detailed measurement indicators are presented in Table D.5. Regarding the relationship between measurement items and theoretical constructs, this study mainly employed reflective indicators to measure affective and cognitive trust. These measurement indicators represent the external manifestations of the concepts of affective and cognitive trust that this study is concerned with.

#### **4.3.1.2 Team communication scale**

To quantify team communication, Hirst et al. (2004) designed a specific scale encompassing four dimensions: clarity of goals, information feedback, information flow, and clarity of client requirements. This scale includes a total of 13 measurement indicators. For this study, five indicators were selected from this scale to measure team communication, as detailed in Table D.6. Given the connection between measurement indicators and theoretical constructs, reflective indicators were used, all of which represent the external manifestations of the concept of team communication addressed in this research.

#### **4.3.1.3 Employee training scale**

Noe and Wilk (1993), Tharenou et al. (1994), and Tharenou et al. (2007) have all designed employee training scales through their research. In this study, referencing the scales mentioned above and considering the specific context of China's project engineering industry, an employee training scale was designed as shown in Table D.7.

#### **4.3.1.4 Team comprehensive capability scale**

There is no unified consensus on the scale to measure team comprehensive capability. L. R. Yang et al. (2011) suggested that it includes three dimensions: project manager's leadership style, team comprehensive capability, and project success. McDonough (2000) believed that team capability factors are mainly determined by member cooperation, goal commitment, proactiveness, and mutual respect. Chan et al. (2001) considered that team capability involves eight dimensions, including all project participants fully understanding their new roles and responsibilities, accepting changes in their roles and responsibilities, recognizing consistent project goals, effective collaboration, and more. Chow et al. (2005) proposed five dimensions for team capability: clear team goals, member interdependence, team cohesion, member trust, and member enthusiasm. Dionne et al. (2004) suggested assessing teamwork processes from

the aspects of team cohesion, team communication, and team conflict management.

Aronson et al. (2006) introduced several indicators for quantifying team capability: team members acknowledging conflicts and solving problems, team members proactively sharing information and providing assistance, team members encouraging different viewpoints and opinions, team members showing enthusiasm and interest in activities, recognizing contributions of other members, striving towards common goals, and sharing information with others freely.

Baiden and Price (2011) proposed assessing team capability from the following six aspects: members' sense of ownership, shared vision and goals, proactivity and openness in member communication, level of cooperation and participation among members, acceptance of disagreements during problem negotiation and resolution, and frequency of evaluating team member contributions and roles.

Although the scales designed by scholars are practical to a certain extent, their coverage of dimensions is not comprehensive. After a thorough understanding of the aforementioned scales, it is deemed that when assessing team comprehensive capability, various perspectives of evaluation should be considered. Therefore, it is recommended to design a team comprehensive capability scale that takes into account three dimensions: team members' perspectives, project manager's leadership, and project clients. Refer to Table D.8 for details.

#### **4.3.1.5 Project performance scale**

Scholars have designed scales with different dimensions to measure project performance. For instance, Atkinson (1999) considered dimensions of cost, schedule, and quality. Gardiner and Stewart (2000) focused on time, cost, and quality. Weston and Gibson Jr (1993) took into account more dimensions, primarily the needs of project team members, clients, and other relevant stakeholders. Scholars have also designed various scales (Belassi & Tukel, 1996; Sinkula et al., 1997; Feng & Chen, 2005).

In this study's perspective, quality, cost, schedule, and safety are the most tangible indicators of engineering project performance. Therefore, the dimensions of quality, cost, schedule, and safety were quantified, as presented in Table D.9.

### **4.3.2 Pre-test survey**

#### **4.3.2.1 Data collection**

The pre-test survey was conducted from June 2022 to October 2022, at several well-known Chinese construction companies. The questionnaire of the Pre-test survey is shown in Annex

B. The respondents included corporate executives, project managers, project management personnel, project team members, and corresponding clients. The pre-test survey details are as follows.

#### **4.3.2.2 Sample**

A total of 154 valid questionnaires were collected in the pre-test survey. The demographic information of the survey participants is detailed in Table D.10. Analyzing Table D.10 reveals that among the survey participants, 91.56% were male and 8.44% were female. This distribution aligns with the current situation in the Chinese construction industry, where the proportion of male workers is generally higher than that of females (National Bureau of Statistics, 2000). Considering the age structure, work experience, and job positions, there were a total of 139 participants who were over 26 years old, had at least 3 years of work experience in the private construction industry, and held positions at or above the project management level. This accounts for a significant proportion of 90.26%, indicating that project managers or management personnel are roles that require experienced individuals. Furthermore, participants were familiar with the content of the survey questionnaire, ensuring the validity and reliability of the research conclusions. Analyzing the educational background, it can be seen that 91.56% of the participants held a bachelor's or master's degree, showcasing the increasing educational requirements for project personnel in domestic private construction enterprises. Overall, the survey participants are representative of the personnel in the private construction industry in China and can accurately reflect the actual situation.

#### **4.3.3 Formal survey**

Following the Pre-test survey and revision of the scale, we obtained the final questionnaire, and then conducted the formal questionnaire (see Annex C) survey to collect data . The design of the formal survey is as follows:

Survey format design: Offline survey. Direct face-to-face interaction with subjects for data collection. This format can address potential issues in questionnaire completion.

Survey duration design: Six months, from January 2023 to June 2023.

Survey subject design: Construction enterprise project teams, selecting representative large construction enterprise teams in China, with teams consisting of more than 30 members, and those completing the questionnaires having been part of the team for over two years. This ensures respondents have adequate understanding and experience regarding project managers' competence and team performance, enhancing data reliability.

Survey questionnaire completion design:

Questionnaires are assigned unique numbers and distributed to project managers to maintain correspondence, e.g., No. 1 project manager corresponds to members 1-10, No. 2 manager to 11-20. Unique numbering ensures data accuracy and traceability.

Subjective questions on project manager competence, employee trust, team communication, and employee training are filled out by team members.

Overall team capability as a subjective question, with employees filling out the first two questions, leaders the next two, and clients the last two.

Project performance as an objective question, answered by the project manager's superior. Given the specificity of project performance issues, it's logical for superiors to respond as they may have more direct knowledge of it.

The designed scale (see Annex C) was distributed according to the above survey design. A total of 600 questionnaires were issued, with 311 valid questionnaires effectively recovered, yielding a recovery rate of 51.83%. The geographic characteristics of the surveyed project teams and the effective questionnaire status of each team are presented in Table D.36.

Table 4.1 presents the descriptive statistics for each questionnaire item, while Table 4.2 displays the descriptive statistics for each construct. Competency Model: The scores range from 1.0 to 5.0, with an average score of 3.9427, indicating that the overall level of competency model development and application is near the upper-middle level. Project Manager Competency: The average score is 3.9427, suggesting that the comprehensive ability of project managers is at a mid-to-high level. Employee Trust: The average score is 3.9518, showing a relatively high degree of mutual trust among employees. Team Communication: The average score is 3.9862, indicating that the level of team communication is relatively good. Employee Training: The average score of 3.8920 reflects that the investment and effectiveness in employee training are at an upper-middle level. Team Comprehensive Ability: The average score is 3.9603, similarly indicating that the team's overall strength is good. Project Performance: The average score of 3.9663 suggests that the overall execution of the project is good, yet there is still a need for continuous effort to strive for excellence and improve project success rates.

Table 4.1 Descriptive statistics for each item

|     | Number of<br>sample | Min | Max | Mean  | SD     |
|-----|---------------------|-----|-----|-------|--------|
| A11 | 311                 | 1.0 | 5.0 | 3.981 | .9536  |
| A12 | 311                 | 1.0 | 5.0 | 4.074 | .8932  |
| A13 | 311                 | 1.0 | 5.0 | 3.974 | 1.0061 |
| A14 | 311                 | 1.0 | 5.0 | 3.974 | .9154  |

|     |     |     |      |       |        |
|-----|-----|-----|------|-------|--------|
| A21 | 311 | 1.0 | 5.0  | 3.939 | .9900  |
| A22 | 311 | 1.0 | 5.0  | 3.965 | .9343  |
| A23 | 311 | 1.0 | 8.0  | 3.839 | 1.0410 |
| A24 | 311 | 1.0 | 5.0  | 3.781 | 1.0146 |
| A31 | 311 | 1.0 | 5.0  | 3.749 | 1.0843 |
| A32 | 311 | 1.0 | 5.0  | 3.997 | .9588  |
| A33 | 311 | 1.0 | 5.0  | 3.949 | .9658  |
| A34 | 311 | 1.0 | 5.0  | 3.961 | .8023  |
| A35 | 311 | 1.0 | 5.0  | 3.865 | .9744  |
| A36 | 311 | 1.0 | 5.0  | 4.013 | .9332  |
| A37 | 311 | 1.0 | 5.0  | 3.932 | .9698  |
| A38 | 311 | 1.0 | 5.0  | 4.090 | 1.0056 |
| B1  | 311 | 1.0 | 5.0  | 3.916 | 1.0833 |
| B2  | 311 | 1.0 | 5.0  | 3.952 | .9940  |
| B3  | 311 | 1.0 | 5.0  | 3.920 | .9854  |
| B4  | 311 | 1.0 | 5.0  | 4.019 | .9703  |
| C1  | 311 | 1.0 | 5.0  | 4.071 | .9713  |
| C2  | 311 | 2.0 | 5.0  | 3.994 | .9228  |
| C3  | 311 | 2.0 | 5.0  | 4.023 | .9102  |
| C4  | 311 | 2.0 | 5.0  | 3.949 | .9108  |
| C5  | 311 | 1.0 | 5.0  | 3.894 | 1.0056 |
| D1  | 310 | 1.0 | 5.0  | 3.916 | .9448  |
| D2  | 311 | 1.0 | 5.0  | 3.891 | .9842  |
| D3  | 311 | 1.0 | 5.0  | 3.900 | .9262  |
| D4  | 311 | 1.0 | 5.0  | 3.830 | .9263  |
| D5  | 311 | 1.0 | 5.0  | 3.923 | 1.0226 |
| E1  | 311 | 1.0 | 5.0  | 3.865 | 1.0228 |
| E2  | 311 | 2.0 | 5.0  | 3.958 | .8916  |
| E3  | 311 | 1.0 | 5.0  | 3.923 | .9090  |
| E4  | 311 | 1.0 | 33.0 | 4.154 | 2.5084 |
| E5  | 311 | 1.0 | 5.0  | 3.923 | 1.0413 |
| E6  | 311 | 1.0 | 5.0  | 3.939 | 1.0377 |
| F1  | 311 | 2.0 | 5.0  | 4.193 | .8584  |
| F2  | 311 | 2.0 | 5.0  | 3.871 | .9416  |
| F3  | 311 | 2.0 | 5.0  | 3.740 | .8030  |
| F4  | 311 | 2.0 | 5.0  | 4.061 | .8796  |

Table 4.2 Descriptive statistics for each construct

| Construct                  | Min | Max | Mean   |
|----------------------------|-----|-----|--------|
| Project Manager Competency | 1.0 | 5.0 | 3.9427 |
| Employee Trust             | 1.0 | 5.0 | 3.9518 |
| Team Communication         | 1.0 | 5.0 | 3.9862 |
| Employee Training          | 1.0 | 5.0 | 3.8920 |
| Team Comprehensive Ability | 1.0 | 5.0 | 3.9603 |

## **4.4 Statistical analysis**

### **4.4.1 Reliability and validity tests**

In this study, the collected questionnaire data were processed and analyzed using SPSS 22.0 to assess reliability and validity. This analysis aimed to evaluate the internal consistency, stability, and measurement structure's rationality, determining the questionnaire's reliability and validity. Based on the results, necessary adjustments and optimizations were made to the questionnaire.

#### **4.4.1.1 Reliability**

Reliability analysis was conducted using Cronbach's  $\alpha$  coefficient, which measures internal consistency. According to standard practices, a Cronbach's  $\alpha$  value above 0.70 is considered acceptable, with higher values indicating better reliability. If the Cronbach's  $\alpha$  coefficient falls below 0.70, the questionnaire content generally needs modification. In this study, SPSS 22.0 was used to test the competency factor items included in the questionnaire.

#### **4.4.1.2 Validity**

Validity analysis was performed to determine whether the questionnaire results aligned with the actual research objectives. This analysis included tests for content validity, criterion validity, and construct validity. Content validity assesses the degree to which the questionnaire items align with the research topic. Typically, expert evaluations are required to ensure that the assessment content and research theme are well-matched.

##### **(1) Correlation analysis**

For correlation analysis, the Pearson correlation test was employed, following a two-tailed test principle. The study referenced item discrimination criteria (Ebel, 1965), where correlation coefficients below 0.20 indicate items should be eliminated, values between 0.20 and 0.29 indicate marginal usability, values from 0.30 to 0.39 suggest acceptability, and values above 0.40 indicate high quality.

##### **(2) Significance of difference analysis**

In the significance of difference analysis, the means and variances of two samples with the same characteristic factors were compared to determine if there were significant differences. If significant differences were found, it indicated the sample's effectiveness; otherwise, the questionnaire required further revision. For this study, the total scores from the initial questionnaire sample were used to divide respondents into two groups, high and low,

each containing 77 participants, for comparative analysis.

Significance of difference analysis was conducted using SPSS 22.0. If Levene's test for equality of variances yielded a significance level above 0.05, it indicated that there was no significant variance difference between the two groups. In this case, the t-test significance level was compared, and if the two-tailed significance level was below 0.05, it confirmed a significant difference between the sample means; otherwise, no significant difference existed. If Levene's test showed a significance level below 0.05, indicating significant variance differences, an independent-samples t-test was conducted without assuming equal variances. If the two-tailed significance level was below 0.05, the null hypothesis was rejected, confirming a significant difference; otherwise, no significant difference was present.

### (3) Exploratory factor analysis

The core objective of exploratory factor analysis (EFA) is to classify original variables into several latent factors based on their correlations while retaining as much information from the original variables as possible. Specifically, this analysis identifies commonalities among variables to extract common factors that represent the data structure. These factors serve as the fundamental components used to explain variations in the original variables.

In this study, principal component analysis (PCA) with varimax orthogonal rotation was used for factor extraction. The number of factors was determined based on Kaiser's criterion and Cattell's scree plot (Gim Chung et al., 2004). The data analysis was conducted on 154 valid questionnaires, and factor analysis was performed using SPSS 22.0.

Before conducting the factor extraction, the Kaiser-Meyer-Olkin (KMO) test and Bartlett's sphericity test were used to assess the suitability of the data for factor analysis. A KMO value greater than 0.7 indicates that the variables have a strong factor structure. Additionally, if Bartlett's test of sphericity is significant ( $p < 0.05$ ), it confirms that the variables are sufficiently correlated, making them suitable for factor analysis.

Once factor extraction was performed, the factor loadings and cumulative variance contribution rates were examined to determine the key factors and establish the mapping relationships between factors and measurement variables. The results of the factor analysis identified three principal components, each representing a different competency dimension. These three competency dimensions contained various specific competency indicators. Given their importance, it was necessary to further conduct reliability analysis for each competency dimension.

### (4) Confirmatory factor analysis

The initial principal component analysis (PCA) extracted three principal components,

aligning well with theoretical expectations. Based on these findings, the measurement scale was refined by removing several items that did not fit the factor structure to ensure the rationality of the measurement model.

Building upon this, confirmatory factor analysis (CFA) was conducted to evaluate the measurement structure of the revised scale, ensuring the factor model's goodness-of-fit and verifying the validity and reliability of measurement variables for their respective latent factors. This study primarily focused on assessing the scale's convergent validity and discriminant validity.

Convergent validity measures how well the observed variables explain their corresponding latent factors. In this study, convergent validity was assessed using Average Variance Extracted (AVE) and Composite Reliability (CR). Generally, factor loadings should be greater than 0.5, AVE values should exceed 0.5 to indicate that the measurement variables adequately explain their latent constructs, and CR values should be greater than 0.7 to demonstrate high internal consistency. Using SPSS 22.0, AVE and CR values were calculated based on standardized factor loadings obtained in the previous analysis.

Discriminant validity assesses whether different latent factors are distinct from each other, ensuring that they measure different concepts within the measurement structure. The Fornell-Larcker criterion was used to test discriminant validity. According to this criterion, the square root of each factor's AVE should be greater than its correlation coefficients with other factors, confirming that the latent variables are distinct from each other and ensuring the structural validity of the measurement scale.

#### **4.4.2 Hypotheses test**

This study employs linear regression analysis to examine the data collected from the formal survey. Linear regression is a statistical method used to analyze the relationship between a dependent variable and one or more independent variables, revealing linear correlations and assessing the impact of each independent variable on the dependent variable. Given that this study involves multiple variables, such as project manager competency, employee trust, and team communication, it is essential to test the relationships between these variables. Linear regression analysis is used to validate the research hypotheses and evaluate the influence pathways and explanatory power of each variable. All data analyses were conducted using SPSS 22.0.

#### **4.4.2.1 Main effect**

To validate the hypotheses, this study first carefully assesses model fit to determine whether the constructed SEM effectively explains and describes the complex relationships among variables. Model fit is typically evaluated using statistical indicators such as Root Mean Square Error of Approximation (RMSEA), Chi-square/degree of freedom ( $\chi^2/df$ ), Goodness-of-Fit Index (GFI), Comparative Fit Index (CFI), and Tucker-Lewis Index (TLI). These indices help determine how well the model aligns with the data, ensuring its validity.

Next, the relationships among variables proposed in the research hypotheses are tested based on p-values, t-values, and regression coefficients. A p-value less than 0.05 indicates that the hypothesized path relationship is statistically significant. The sign of the regression coefficient determines whether the relationship is positive or negative, providing further insights into the direction and strength of the effects.

#### **4.4.2.2 Mediation effect**

For testing mediation effects, this thesis continues to utilize SPSS. The testing of mediation effects follows several key steps:

(1) Model determination

First, assess the fit of the model using the same fit indices described previously.

(2) Path Relationship

For a mediation effect to be considered, two path relationships must be established: a). Independent Variable  $\rightarrow$  Dependent Variable: This path assesses the direct effect of the independent variable on the dependent variable without the mediator. b). Independent Variable + Mediator  $\rightarrow$  Dependent Variable: This path tests the effect of the independent variable on the dependent variable through the mediator, thereby establishing the mediating role of the mediator variable.

(3) Effect values

The direct and indirect effects should be examined. The proportion of the indirect effect relative to the total effect (direct plus indirect) determines the size of the mediation effect. If the proportion of the indirect effect is 0, it indicates that there is no mediation effect. If the proportion of the indirect effect is between 0 and 1 (not including 0 or 1), it indicates that there is partial mediation. If the proportion of the indirect effect equals 1, it indicates complete mediation.

#### **4.4.2.3 Moderation effect**

The moderation testing comprises two main steps:

(1) Model determination

As with previous models, the fit of the model to the data is evaluated using the previous criteria.

(2) Path relationship.

Whether "independent variable + adjusting variable + independent variable \* adjusting variable → dependent variable" is significant should be determined, focusing on whether the interaction term is significant.

## **Chapter 5: Research Results**

### **5.1 Literature review results**

The review and summary of relevant literature on project manager competency are presented in Table D.1. After thoroughly reviewing existing literature and relevant theories, 37 preliminary competency indicators for project managers in Chinese construction enterprises were identified. The details are presented in Table D.2.

### **5.2 Interview results**

The analysis of the interview results led to the following conclusions: (1) identification of the actual situation and key focus areas of engineering project management personnel in private construction enterprises in China; (2) understanding of the interviewees' knowledge, skills, overall competencies, and job-person fit; (3) clarification of the competency characteristics that differentiate high-performing project managers from average performers, as perceived by construction enterprise managers and project managers; (4) analysis of the interview findings to determine the measures implemented by the interviewees to ensure smooth project management, as well as identifying frequently mentioned content and keywords during the interviews. Based on this analysis, 26 competency indicators were refined and summarized, ultimately narrowing them down to 19 key competency indicators. The details are presented in Table D.4.

### **5.3 Pre-test survey results**

Results from the pre-test survey were mainly used for the analysis of the project manager's competency scale.

#### **5.3.1 Reliability test of project manager competency scale**

An internal consistency test was conducted on the 29 competency elements in the questionnaire. The results, shown in Table D.11, revealed a Cronbach's  $\alpha$  coefficient of 0.975.

According to the criteria for internal consistency reliability, the questionnaire meets the requirements for internal consistency and reliability. However, the Corrected Item-Total Correlation (CITC) value for item 18 is less than 0.3, indicating that it needs to be removed from the questionnaire.

### **5.3.2 Validity test of project manager's competency scale**

The questionnaire in this study was developed based on literature analysis and expert interviews, with input from relevant experts to ensure sufficient content validity.

#### **5.3.2.1 Correlation analysis**

The Pearson correlation coefficient method was employed, following a two-tailed test principle. The results of the correlation analysis are detailed in Table D.12. Analysis of the content reveals that the correlation coefficients of each competency characteristic of Chinese construction enterprise project managers with the overall competency characteristics exceed 0.2 and are significant at the 0.01 level (two-tailed test). This demonstrates a significant correlation between the competency elements of Chinese construction enterprise project managers and the overall characteristics of project manager competency.

#### **5.3.2.2 Significance testing of differences**

The means and standard deviations show that the mean values of the low-score group do not exceed the interval of 2 to 4, while the mean values of the high-score group all exceed 4. Therefore, there is a significant difference in means between the groups. The variances and standard deviations are completely acceptable. However, an independent samples t-test is necessary to determine whether the differences are significant (see Table D.13).

The detailed results of the independent samples t-test are provided in Table D.14. In the independent samples t-test, each competency characteristic has two testing paths: assuming equal variances and assuming unequal variances.

#### **5.3.2.3 EFA**

In order to ensure the validity of the model and accurately reveal the relationship between competency dimensions and performance indicators for construction project managers, a factor analysis was conducted on the remaining 18 competency feature indicators after the reliability analysis that led to the removal of one item. After gathering and inputting the data from the 154 collected questionnaires into SPSS 22, we conducted a factor analysis to determine the KMO and Bartlett's test results for the competency indicators of Chinese

construction project managers. The results are presented in Table D.15.

Based on the results presented in the table above, according to the commonly accepted KMO criterion, with a KMO value of 0.910, the requirements for factor analysis are fully met. Furthermore, the significance value for the Bartlett's test is 0.000, which is less than 0.05. As the null hypothesis is not upheld, it aligns with the prerequisites for principal component analysis.

In this study, the principal component analysis method and the maximum variance rotation method were employed for factor extraction. Components with eigenvalues exceeding 1 were retained, and the cumulative variance contribution rate exceeding 60% was sought. As a result, three common factors were derived. The cumulative variance contribution rate amounted to 60.892%. For further details, please refer to Table D.16,.

Following the factor analysis, a total of three principal component factors representing various competency levels were extracted from the 18 competence characteristic indicators. These factors serve as the elements of competency characteristic, with each level encompassing several competence characteristic indicators. Hence, conducting reliability analysis on the three different levels of competency features is deemed necessary. The reliability assessment is based on two criteria.

An analysis for Dimension 1 (Personal Trait Dimension) was conducted (see Table D.17).

An analysis of Table D.17 reveals that both the KMO value ( $0.788 > 0.7$ ) and the Bartlett's test significance ( $0.000 < 0.05$ ) meet the requirements. The contents of Table D.17 indicate that from the perspective of communalities, the item "5. Maintaining a positive emotional state through self-control and effectively managing work-related stress." exhibits a communalities value below 0.4. This implies that the information contained within this research item is not effectively expressed. Consequently, the removal of this option is warranted, and a reanalysis was conducted after its exclusion, see results in Table D.18.

After excluding the item, a reliability and validity analysis was performed again, and all items passed the tests. At this point, the items for Dimension 1 (Personal Trait Dimension) can be finalized, as presented in Table D.19.

The analysis of Dimension Two (General Leadership Competence) is outlined in Table D.20. Employing the same criteria and methods, all four items for Dimension Two have successfully passed the tests.

Thus, the items for the competence dimension of general leadership ability in Chinese Construction Companies can be confirmed, as shown in Table D.21.

Next, an analysis is conducted for Dimension Three (Project Professional Management

Ability). Refer to Table D.22 for details. Applying the same criteria and methods, out of the nine items for Dimension Three, the item "19. Actively adopting new construction technologies, methods, and techniques to achieve higher efficiency and cost savings." did not pass the test.

After removing the item "19. The project manager actively adopts new construction techniques, processes, and methods to achieve higher efficiency and cost savings," a reanalysis was conducted to obtain the validity analysis results for Dimension three (Project Professional Management Ability), as presented in Table D.23.

With the remaining eight items passing the tests, the items for the dimension of project-Specific Management Ability in Chinese Construction Companies can now be confirmed, as outlined in Table D.24.

Based on the aforementioned analysis, it is evident that the competence feature structure of project managers in Chinese private construction enterprises comprises three dimensions: 16 specific competence characteristic indicators. This culminates in the establishment of the Project Manager Competence Feature Model in China Construction Enterprises, as depicted in Table D.25.

Analyzing Table D.25 allows for the determination that the China Construction Enterprises Project Manager Competence Feature Model consists of three hierarchical levels: The first level encompasses specific competence characteristic indicators. The second level involves the synthesis and refinement based on the previous level, where factor analysis was applied to the indicators from the first level to obtain three competency feature elements: personal traits, general leadership ability, and project professional management ability. This confirms that the competence of project managers in Chinese Construction Companies encompasses three dimensions of competency features, each of which has corresponding competence characteristic indicators. The third level represents the comprehensive performance of the second level, namely the comprehensive competence of project managers in Chinese Construction Companies. This outcome is the result of the interplay of Personal traits, general leadership ability, and project professional management ability, and the three competency feature elements are unified at a higher level, ensuring that project managers can lead their teams to achieve higher levels of performance.

#### **5.3.2.4 CFA**

The results, as shown in Table D.37, indicate that the three dimensions—personal traits, general leadership ability, and project-specific management ability—each have an AVE above 0.5 and a

CR exceeding 0.8. These findings suggest that the measurement items effectively explain their corresponding latent factors, demonstrating that the scale achieves good convergent validity and internal consistency. This confirms that, after removing and adjusting items that did not align with the factor structure, the measurement model for project manager competency exhibits high reliability and validity, establishing a solid foundation for subsequent research.

Using Factor Correlation Matrix and AVE Calculation Results, the Fornell-Larcker criterion was applied to assess discriminant validity, with the results presented in Table D.38.

The diagonal values in Table D.38 represent the square root of the AVE for each factor, indicating the internal explanatory power of each construct. The square root of the AVE is an essential measure of internal consistency, as it reflects the degree to which a factor explains the variance of its measurement variables. In this study, all AVE square root values exceed 0.70, confirming that each factor exhibits strong explanatory power over its measurement variables.

The correlation coefficients between factors are located outside the diagonal region. Specifically, the correlation coefficient between Personal Traits Dimension and General Leadership Ability is 0.524, the correlation between Personal Traits Dimension and Project-Specific Management Ability is 0.496, and the correlation between General Leadership Ability and Project-Specific Management Ability is 0.624. Comparing the square root of the AVE for each factor with the correlation coefficients between factors, it is evident that the AVE square root of each factor is greater than its correlation with other factors.

These results indicate that the three latent factors in this study are statistically distinguishable, meaning that the correlation between any two factors does not exceed their respective AVE square roots. This meets the Fornell-Larcker discriminant validity standard, further confirming the discriminant validity of the scale.

At the factor level, the measurement model in this study demonstrates good discriminant validity, signifying a reasonable structure where different dimensions exhibit high independence and can be effectively distinguished, without significant factor overlap. Additionally, since the AVE square roots are all greater than the inter-factor correlations, the statistical identifiability of the model is further confirmed. These findings validate the structural validity of the Project Manager Competency Scale for Chinese Construction Enterprises, establishing it as a reliable measurement tool that provides a strong empirical foundation for future research.

### **5.3.3 Reliability and validity tests of other scales**

In the pre-test survey, the same participants who received the Project Manager Competence Scale were also administered the Employee Trust Scale. The analysis results indicated that the Cronbach's reliability coefficient, KMO, and Bartlett's test all passed, confirming that the scale meets the requirements for reliability, as shown in Table D.26 and D.27.

The same participants who received the Project Manager Competence Scale were also administered the Team Communication Scale. The analysis results indicated that the Cronbach's reliability coefficient, KMO, and Bartlett's test all passed (see Table D.28 and Table D.29), confirming that the scale meets the requirements for reliability.

The same participants who received the Project Manager Competence Scale were also administered the Employee Training Scale. The analysis results indicated that the Cronbach's reliability coefficient, KMO, and Bartlett's test all passed (see Table D.30 and Table D.31), confirming that the scale meets the requirements for reliability.

The same participants who received the Project Manager Competence Scale were also administered the Team Comprehensive Ability Scale. The analysis results indicated that the Cronbach's reliability coefficient, KMO, and Bartlett's test all passed (see Table D.32 and D.33), confirming that the scale meets the requirements for reliability.

The same participants who received the Project Manager Competence Scale were also administered the Project Performance Scale during the first round of distribution. The analysis results indicated that the Cronbach's reliability coefficient, KMO, and Bartlett's test all passed (see Table D.34 and D.35), confirming that the scale meets the requirements for reliability.

## **5.4 Formal survey results**

### **5.4.1 Reliability and validity**

Table 5.3 and 5.4 provide reliability statistics for the research questionnaire or scale, specifically the Cronbach's Alpha coefficient, a commonly used measure of internal consistency reliability. This method assesses the reliability of a set of homogeneous questions (or items) within a multi-dimensional scale. The Cronbach's Alpha coefficient is 0.969, which is exceptionally high. Typically, this coefficient ranges from 0 to 1, with values closer to 1 indicating higher internal consistency, meaning all items in the scale consistently measure the same construct with high consistency and stability. In social science research, an alpha coefficient of 0.7 or above is generally considered acceptable, while a coefficient above 0.9 is

regarded as excellent internal consistency.

Table 5.1 Reliability testing results

| Cronbach's Alpha coefficient | Number of items |
|------------------------------|-----------------|
| .969                         | 40              |

Table 5.2 Total items statistics

|     | Scale Mean<br>after Item<br>Deletion | Scale Variance<br>after Item<br>Deletion | Item-Total<br>Correlation after<br>Correction | Cronbach's<br>Alpha after Item<br>Deletion |
|-----|--------------------------------------|------------------------------------------|-----------------------------------------------|--------------------------------------------|
| A11 | 154.074                              | 728.205                                  | .691                                          | .968                                       |
| A12 | 153.987                              | 732.757                                  | .639                                          | .968                                       |
| A13 | 154.081                              | 726.469                                  | .686                                          | .968                                       |
| A14 | 154.084                              | 731.941                                  | .640                                          | .968                                       |
| A21 | 154.116                              | 727.475                                  | .678                                          | .968                                       |
| A22 | 154.094                              | 729.561                                  | .675                                          | .968                                       |
| A23 | 154.216                              | 726.047                                  | .669                                          | .968                                       |
| A24 | 154.274                              | 726.802                                  | .673                                          | .968                                       |
| A31 | 154.306                              | 720.504                                  | .738                                          | .968                                       |
| A32 | 154.058                              | 727.569                                  | .700                                          | .968                                       |
| A33 | 154.106                              | 727.895                                  | .688                                          | .968                                       |
| A34 | 154.100                              | 736.750                                  | .621                                          | .968                                       |
| A35 | 154.190                              | 727.844                                  | .682                                          | .968                                       |
| A36 | 154.042                              | 730.636                                  | .658                                          | .968                                       |
| A37 | 154.129                              | 724.074                                  | .755                                          | .968                                       |
| A38 | 153.971                              | 726.682                                  | .678                                          | .968                                       |
| B1  | 154.139                              | 716.812                                  | .805                                          | .968                                       |
| B2  | 154.110                              | 726.441                                  | .691                                          | .968                                       |
| B3  | 154.135                              | 727.185                                  | .687                                          | .968                                       |
| B4  | 154.039                              | 725.105                                  | .736                                          | .968                                       |
| C1  | 153.984                              | 728.456                                  | .674                                          | .968                                       |
| C2  | 154.068                              | 727.953                                  | .716                                          | .968                                       |
| C3  | 154.032                              | 731.462                                  | .659                                          | .968                                       |
| C4  | 154.106                              | 728.872                                  | .712                                          | .968                                       |
| C5  | 154.161                              | 724.039                                  | .732                                          | .968                                       |
| D1  | 154.145                              | 729.024                                  | .678                                          | .968                                       |
| D2  | 154.165                              | 726.494                                  | .701                                          | .968                                       |
| D3  | 154.161                              | 731.780                                  | .635                                          | .968                                       |
| D4  | 154.226                              | 730.810                                  | .659                                          | .968                                       |
| D5  | 154.132                              | 726.264                                  | .678                                          | .968                                       |
| E1  | 154.194                              | 727.231                                  | .656                                          | .968                                       |
| E2  | 154.100                              | 731.385                                  | .670                                          | .968                                       |
| E3  | 154.139                              | 730.269                                  | .679                                          | .968                                       |
| E4  | 153.903                              | 727.680                                  | .225                                          | .976                                       |
| E5  | 154.132                              | 723.203                                  | .721                                          | .968                                       |
| E6  | 154.123                              | 725.169                                  | .683                                          | .968                                       |
| F1  | 153.865                              | 723.930                                  | .864                                          | .968                                       |
| F2  | 154.187                              | 722.612                                  | .810                                          | .968                                       |
| F3  | 154.319                              | 725.810                                  | .879                                          | .968                                       |
| F4  | 153.997                              | 723.874                                  | .843                                          | .968                                       |

Table 5.5 provides results for the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and the Bartlett's Test of Sphericity, both of which are statistical tests commonly used before factor analysis to validate the suitability of data for such analysis. The KMO

measure of sampling adequacy is 0.963, which is an exceptionally high value. Typically, a KMO value greater than 0.7 is considered suitable for factor analysis, and values close to 1, such as 0.963 in this case, strongly indicate excellent suitability for factor analysis. This suggests significant collinearity among variables, making them appropriate for factor extraction. The results of Bartlett's Test of Sphericity also support the appropriateness of factor analysis. In this test, the chi-square value is 9676.937 with 780 degrees of freedom, and a significance level (p-value) of .000. A significance level below the typical threshold (e.g., 0.05 or 0.01) means the null hypothesis (that the observed variables are not intercorrelated) is rejected, confirming that the data matrix is not an identity matrix (i.e., the variables are not entirely independent) but has a significant correlation structure, which is a requisite for factor analysis.

Table 5.3 KMO and Bartlett's test

| KMO Sampling Adequacy Measure |                       | .963     |
|-------------------------------|-----------------------|----------|
| Bartlett's Test of Sphericity | Last Chi-square Value | 9676.937 |
|                               | Degrees of Freedom    | 780      |
|                               | Significance Level    | .000     |

In Table 5.6, we conducted Harman's single-factor test for common method bias, a test used to detect if there is significant common method variance (CMV), which is potential bias that may result from errors due to the same source. The results show that the first principal component accounts for only 48.501% of the total variance, which does not exceed the critical threshold of 50%. Therefore, based on this, it is judged that the statistical data collected in this study are suitable for subsequent regression analysis or other related statistical research.

Table 5.4 Total variance explained

|    | Initial Eigenvalues |                        |              | Sum of Squared Loadings |                        |              |
|----|---------------------|------------------------|--------------|-------------------------|------------------------|--------------|
|    | Total               | Percentage of Variance | Cumulative % | Total                   | Percentage of Variance | Cumulative % |
| 1  | 20.600              | 48.501                 | 48.501       | 20.600                  | 48.501                 | 48.501       |
| 2  | 1.389               | 4.473                  | 52.974       | 1.389                   | 4.473                  | 52.974       |
| 3  | 1.267               | 4.168                  | 57.142       | 1.267                   | 4.168                  | 57.142       |
| 4  | 1.107               | 3.768                  | 60.91        | 1.107                   | 3.768                  | 60.91        |
| 5  | 1.080               | 3.700                  | 64.61        | 1.080                   | 3.700                  | 64.61        |
| 6  | .911                | 3.276                  | 67.886       | .911                    | 3.276                  | 67.886       |
| 7  | .880                | 2.200                  | 68.087       |                         |                        |              |
| 8  | .841                | 2.103                  | 70.190       |                         |                        |              |
| 9  | .753                | 1.882                  | 72.072       |                         |                        |              |
| 10 | .690                | 1.726                  | 73.797       |                         |                        |              |
| 11 | .673                | 1.682                  | 75.480       |                         |                        |              |
| 12 | .655                | 1.637                  | 77.116       |                         |                        |              |
| 13 | .644                | 1.609                  | 78.725       |                         |                        |              |
| 14 | .587                | 1.468                  | 80.193       |                         |                        |              |
| 15 | .554                | 1.386                  | 81.579       |                         |                        |              |
| 16 | .538                | 1.345                  | 82.924       |                         |                        |              |
| 17 | .513                | 1.282                  | 84.206       |                         |                        |              |

|    |      |       |         |
|----|------|-------|---------|
| 18 | .484 | 1.210 | 85.416  |
| 19 | .464 | 1.160 | 86.576  |
| 20 | .450 | 1.124 | 87.700  |
| 21 | .429 | 1.072 | 88.771  |
| 22 | .387 | .966  | 89.738  |
| 23 | .364 | .911  | 90.648  |
| 24 | .346 | .864  | 91.513  |
| 25 | .326 | .815  | 92.328  |
| 26 | .299 | .749  | 93.077  |
| 27 | .277 | .694  | 93.770  |
| 28 | .268 | .670  | 94.440  |
| 29 | .256 | .641  | 95.081  |
| 30 | .250 | .626  | 95.707  |
| 31 | .241 | .604  | 96.310  |
| 32 | .227 | .569  | 96.879  |
| 33 | .215 | .539  | 97.418  |
| 34 | .203 | .508  | 97.925  |
| 35 | .181 | .453  | 98.379  |
| 36 | .159 | .397  | 98.776  |
| 37 | .152 | .380  | 99.157  |
| 38 | .129 | .322  | 99.479  |
| 39 | .112 | .281  | 99.760  |
| 40 | .096 | .240  | 100.000 |

Extraction method: principal component analysis.

In the validity test results of Table 5.7, the bold diagonal represents the square roots of the Average Variance Extracted (AVE), all of which are greater than 0.7, thereby passing the validity test. Regarding discriminant validity, the bolded diagonal values, which are the square roots of AVE, exceed the correlations between the respective constructs and all other variables, indicating good validity test results. Additionally, the square roots of each variable's AVE are less than their corresponding Composite Reliability (CR), suggesting good discriminant validity.

Table 5.5 Validity test results

|                               | 1            | 2            | 3            | 4            | 5            | 6            |
|-------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|
| 1. Project Manager Competency | <b>0.858</b> |              |              |              |              |              |
| 2. Project Performance        | 0.231        | <b>0.812</b> |              |              |              |              |
| 3. Employee Trust             | 0.387        | 0.340        | <b>0.835</b> |              |              |              |
| 4. Team Communication         | 0.405        | 0.333        | 0.214        | <b>0.852</b> |              |              |
| 5. Employee Capability        | 0.220        | 0.326        | 0.236        | 0.153        | <b>0.844</b> |              |
| 6. Team Atmosphere            | 0.322        | 0.251        | 0.314        | 0.314        | 0.224        | <b>0.840</b> |
| CR                            | 0.946        | 0.884        | 0.901        | 0.895        | 0.894        | 0.906        |
| AVE                           | 0.736        | 0.659        | 0.697        | 0.725        | 0.712        | 0.705        |

Note: The bold diagonal represents the square root of the Average Variance Extracted (AVE).

Table 5.8 shows the results of factor loadings after factor rotation, where each column represents a latent factor, and each row corresponds to an observed variable (e.g., A11 to F4). Factor loadings indicate the degree of correlation between each observed variable and its corresponding latent factor, with the magnitude of the values reflecting the importance and weight of each observed variable on that factor. Observed variables in series A (A11 to A38)

predominantly load on Factor 1, with loadings above 0.4, indicating that items A11 to A38 belong to the dimension of Factor 1. Observed variables in series B (B1 to B4) mainly load on Factor 4, with loadings above 0.4, indicating they belong to the dimension of Factor 4. Observed variables in series C (C1 to C5) mainly load on Factor 5, with loadings above 0.4, indicating they belong to the dimension of Factor 5. Observed variables in series D (D1 to D5) mainly load on Factor 2, with loadings above 0.4, indicating they belong to the dimension of Factor 2. Observed variables in series E (E1 to E6) mainly load on Factor 3, with loadings above 0.4, indicating they belong to the dimension of Factor 3. Observed variables in series F (F1 to F4) mainly load on Factor 6, with loadings above 0.4, indicating they belong to the dimension of Factor 6. The division of factors into dimensions is reasonable, allowing for further analysis.

Table 5.6 Factor loading results after rotation

|     | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Factor 5 | Factor 6 |
|-----|----------|----------|----------|----------|----------|----------|
| A11 | 0.739    | 0.028    | 0.037    | -0.063   | -0.095   | 0.038    |
| A12 | 0.78     | -0.013   | 0.044    | -0.067   | -0.034   | 0.014    |
| A13 | 0.841    | 0.068    | -0.014   | -0.046   | 0.048    | 0.013    |
| A14 | 0.834    | 0.044    | -0.057   | -0.033   | 0.024    | 0.042    |
| A21 | 0.858    | 0.025    | -0.015   | -0.052   | -0.017   | -0.043   |
| A22 | 0.828    | 0.019    | 0.021    | -0.054   | -0.019   | -0.046   |
| A23 | 0.83     | 0.04     | -0.002   | -0.074   | 0.053    | -0.034   |
| A24 | 0.785    | -0.027   | 0.092    | -0.056   | 0.01     | -0.101   |
| A31 | 0.826    | 0.043    | 0.012    | -0.024   | 0.02     | 0.033    |
| A32 | 0.813    | -0.02    | -0.022   | -0.076   | 0.026    | 0.057    |
| A33 | 0.855    | 0.02     | 0.064    | -0.019   | 0.019    | 0.028    |
| A34 | 0.82     | 0.037    | 0.049    | -0.082   | -0.026   | 0.026    |
| A35 | 0.871    | -0.005   | 0.003    | -0.036   | 0.006    | 0.048    |
| A36 | 0.82     | -0.026   | 0.043    | -0.085   | -0.012   | -0.06    |
| A37 | 0.875    | 0.039    | -0.038   | -0.069   | -0.012   | -0.014   |
| A38 | 0.966    | 0.053    | 0.053    | -0.142   | 0.01     | 0.086    |
| B1  | -0.139   | 0.042    | 0.048    | 0.969    | 0.009    | 0.084    |
| B2  | -0.15    | 0.091    | 0.065    | 0.945    | 0.052    | -0.036   |
| B3  | -0.151   | 0.036    | 0.033    | 0.968    | 0.027    | 0.084    |
| B4  | -0.139   | 0.042    | 0.048    | 0.969    | 0.009    | 0.084    |
| C1  | 0.001    | 0.198    | 0.078    | -0.023   | 0.819    | -0.092   |
| C2  | -0.007   | 0.252    | 0.025    | -0.009   | 0.813    | -0.116   |
| C3  | 0.001    | 0.192    | 0.141    | 0.005    | 0.726    | -0.15    |
| C4  | -0.027   | 0.239    | 0.037    | 0.02     | 0.844    | -0.046   |
| C5  | -0.009   | 0.245    | -0.02    | 0.07     | 0.796    | -0.054   |
| D1  | 0.061    | 0.711    | 0.183    | 0.039    | 0.364    | -0.193   |
| D2  | 0.059    | 0.684    | 0.124    | 0.037    | 0.378    | -0.07    |
| D3  | 0.036    | 0.885    | 0.069    | 0.027    | 0.001    | -0.007   |
| D4  | 0.043    | 0.897    | 0.019    | 0.047    | 0.036    | -0.017   |
| D5  | 0.049    | 0.783    | 0.141    | 0.026    | 0.02     | -0.076   |
| E1  | 0.037    | 0.071    | 0.812    | 0.106    | 0.218    | -0.099   |
| E2  | 0.022    | 0.023    | 0.849    | -0.05    | -0.049   | 0.221    |
| E3  | 0.023    | 0.065    | 0.975    | 0.058    | 0.104    | 0.058    |
| E4  | 0.037    | 0.071    | 0.812    | 0.106    | 0.218    | -0.099   |

|    |        |        |       |       |        |        |
|----|--------|--------|-------|-------|--------|--------|
| E5 | 0.052  | 0.023  | 0.849 | -0.05 | -0.049 | 0.221  |
| E6 | -0.144 | 0.038  | 0.713 | 0.024 | 0.108  | -0.037 |
| F1 | 0.005  | -0.135 | 0.096 | 0.102 | 0.061  | 0.897  |
| F2 | 0.002  | -0.116 | 0.14  | 0.086 | 0.047  | 0.875  |
| F3 | 0.04   | -0.086 | 0.13  | 0.063 | 0.061  | 0.816  |
| F4 | -0.069 | 0.09   | 0.034 | 0.073 | 0.246  | 0.702  |

## 5.4.2 Direct effect hypothesis testing analysis

### 5.4.2.1 Hypothesis testing between project manager competency and project performance

#### (1) Model Determination

RMSEA: 0.086, which is less than 0.10, indicates a good fit of the model to the data, meaning the model structure can adequately explain data variability.  $\chi^2/\text{df}$ : 2.71, falls within the recommended range (3-5), suggesting minimal difference between the model and the data, hence a good fit. CFI is 0.924, greater than 0.9, implies a high fit level, indicating the model can explain the observed data patterns well. TLI is 0.926, above 0.9, further confirms the model's good fit. SRMR is 0.049, less than 0.1, indicates minimal model residuals, suggesting high precision of fit. VIF is 2.36, within the ideal range (1-10), shows that multicollinearity is not severe, and the variables are relatively independent. In summary, the model has a good fit, and further path analysis is carried out.

#### (2) Path Relationships:

Project Manager Competency → Project Performance: Path coefficient of 0.854, p-value of 0.000 (significance level typically set at 0.05), suggests a significant positive impact of project manager competency on project performance. The positive coefficient indicates that an increase in competency significantly enhances project performance, confirming H1 that in private Chinese construction enterprises, project manager competency positively affects project performance (see Table 5.9).

Table 5.7 Test results of hypothesis 1

| Model Determination |                                                  | Item               | Standard    |       | Value |
|---------------------|--------------------------------------------------|--------------------|-------------|-------|-------|
|                     |                                                  | RMSEA              | <0.10       |       | 0.086 |
|                     |                                                  | $\chi^2/\text{df}$ | <3 or 5     |       | 2.71  |
|                     |                                                  | CFI                | >0.9        |       | 0.924 |
|                     |                                                  | TLI                | >0.9        |       | 0.926 |
|                     |                                                  | SRMR               | <0.1        |       | 0.049 |
|                     |                                                  | VIF                | 1-10        |       | 2.36  |
|                     |                                                  |                    | Coefficient | T     | P     |
| Path Relationship   | Project Manager Competency → Project Performance |                    | 0.454       | 3.654 | 0.000 |
|                     | Personal Traits of Project Manager →             |                    | 0.487       | 4.056 | 0.000 |

| Project Performance                                                            |       |       |       |  |
|--------------------------------------------------------------------------------|-------|-------|-------|--|
| General Leadership Abilities of Project Manager → Project Performance          | 0.426 | 3.265 | 0.000 |  |
| Project-Specific Management Abilities of Project Manager → Project Performance | 0.442 | 3.346 | 0.000 |  |

Personal Traits of Project Manager → Project Performance: Coefficient of 0.687, t-value of 4.056, p-value of 0.000, demonstrates a significant positive effect of project manager's personal traits on project performance, confirming hypothesis H1a. This finding emphasizes the importance of considering personal traits in the selection of project managers.

General Leadership Abilities of Project Manager → Project Performance: A high coefficient of 0.926, t-value of 3.265, p-value of 0.000, shows that general leadership abilities have a significant and direct impact on project performance, confirming hypothesis H1b. This highlights the necessity of enhancing leadership skills for project managers.

Project-Specific Management Abilities of Project Manager → Project Performance: Coefficient of 0.842, t-value of 3.346, p-value of 0.000, proves that the project manager's professional management abilities have a significant positive effect on project performance, confirming hypothesis H1c. This indicates that technical skills are equally essential for project managers.

The comprehensive analysis of all path relationships reveals that multiple aspects of a project manager's abilities significantly influence project performance. Personal traits, general leadership abilities, and project-specific management skills are all key factors in enhancing the success rate of projects. This implies that organizations should adopt a holistic development strategy when nurturing and evaluating project managers, not only strengthening their professional skills but also focusing on developing personal traits and leadership abilities. Such a multi-dimensional enhancement strategy will more effectively drive projects toward success and ensure high-quality achievement of project goals.

#### 5.4.2.2 Hypothesis testing of project manager competency and team comprehensive ability

##### (1) Model Determination

Table 5.10 shows that RMSEA is 0.087, below the standard of 0.10, indicating a good fit between the model and the data, showing that the model can aptly describe the data patterns.  $\chi^2/df$  Ratio is 4.59. Although it is slightly high, it is within acceptable limits, suggesting that while there is room for improvement, the model generally fits well with the data. CFI and TLI are at 0.922 and 0.914, respectively, significantly above the ideal threshold

of 0.9, indicating a high degree of consistency between the model structure and the data. SRMR is 0.075, below the threshold of 0.1, indicating a good model fit. The average of VIF is 5.79, not exceeding the ideal range (1-10), indicating no issues with multicollinearity. Overall, the model demonstrates a good fit, and the analysis now proceeds to further path analysis.

Table 5.8 Test results of hypothesis 2

| Model Determination |                                                                                       | Item        | Standard    |       | Value |
|---------------------|---------------------------------------------------------------------------------------|-------------|-------------|-------|-------|
|                     |                                                                                       | RMSEA       | <0.10       |       | 0.087 |
|                     |                                                                                       | $\chi^2/df$ | <3 or 5     |       | 4.59  |
|                     |                                                                                       | CFI         | >0.9        |       | 0.922 |
|                     |                                                                                       | TLI         | >0.9        |       | 0.914 |
|                     |                                                                                       | SRMR        | <0.1        |       | 0.075 |
|                     |                                                                                       | VIF         | 1-10        |       | 5.79  |
|                     |                                                                                       |             | Coefficient | T     | P     |
| Path Relationship   | Project Manager Competency → Team Comprehensive Ability                               |             | 0.242       | 3.248 | 0.000 |
|                     | Personal Traits of Project Manager → Team Comprehensive Ability                       |             | 0.269       | 3.579 | 0.000 |
|                     | General Leadership Abilities of Project Manager → Team Comprehensive Ability          |             | 0.185       | 5.169 | 0.000 |
|                     | Project-Specific Management Abilities of Project Manager → Team Comprehensive Ability |             | 0.377       | 3.957 | 0.000 |

## (2) Path Relationship

Project Manager Competency → Team Comprehensive Ability: Coefficient of 0.242, T-value of 3.248, P-value of 0.000, shows that the project manager's overall competency has a significant positive impact on team comprehensive ability, confirming H2.

Personal Traits of Project Manager → Team Comprehensive Ability: The coefficient for personal traits is 0.269, T-value of 3.579, P-value of 0.000, indicating that the project manager's personal traits significantly positively affect the team's comprehensive ability, confirming H2a.

General Leadership Abilities of Project Manager → Team Comprehensive Ability: The coefficient for general leadership abilities is 0.185, T-value of 5.169, P-value of 0.000, demonstrating a significant positive effect, confirming H2b.

Project-Specific Management Abilities of Project Manager → Team Comprehensive Ability: The coefficient for project-specific management abilities is 0.377, T-value of 3.957, P-value of 0.000, proving a significant positive effect on team comprehensive ability, confirming H2c.

### 5.4.2.3 Hypothesis testing of team comprehensive ability and project performance

#### (1) Model Determination

Table 5.11 shows that RMSEA is 0.095. Though close, it is below the standard of 0.10, indicating a good fit between the model and the data. This suggests that the model is appropriately complex without being overly fitted to the data.  $\chi^2/\text{df}$  Ratio is 2.57. This value falls within the recommended range (<3 or 5), indicating that the model complexity is well matched with the data. CFI and TLI stand at 0.936 and 0.910 respectively, significantly exceeding the benchmark of 0.9, indicating very high model fit quality. This shows that the model structure effectively explains the data patterns observed. SRMR is 0.087, below the threshold of 0.1, suggesting that the model residuals are within an acceptable range, providing good explanatory power. The average value of VIF is 3.54, falling within the ideal range of 1-10, indicating no severe multicollinearity among the variables in the model. These results affirm that the model exhibits a good fit, paving the way for further path analysis.

Table 5.9 Test results of hypothesis 3

| Model Determination | Item                                             | Standard             | Value                    |
|---------------------|--------------------------------------------------|----------------------|--------------------------|
|                     | RMSEA                                            | <0.10                | 0.095                    |
|                     | $\chi^2/\text{df}$                               | <3 or 5              | 2.57                     |
|                     | CFI                                              | >0.9                 | 0.936                    |
|                     | TLI                                              | >0.9                 | 0.910                    |
|                     | SRMR                                             | <0.1                 | 0.087                    |
|                     | VIF                                              | 1-10                 | 3.54                     |
| Path Relationship   | Team Comprehensive Ability → Project Performance | Coefficient<br>0.541 | T<br>3.549<br>P<br>0.000 |

#### (2) Path Relationship

Team Comprehensive Ability → Project Performance: The coefficient of 0.541, T-value of 3.549, and P-value of 0.000 demonstrate a significant positive impact of team comprehensive ability on project performance. This finding underscores that in the context of private Chinese construction enterprises, enhancing the comprehensive capabilities of the team is a vital strategy for improving project performance.

### 5.4.3 Mediation effect

#### 5.4.3.1 Hypothesis testing of the mediating role of employee trust in the impact of project manager competency on team comprehensive ability

##### (1) Model determination

From Table 5.12, it is noted that the value of RMSEA is 0.071, below the 0.10 threshold,

indicating a good fit between the model and the data, suggesting that the model adequately reflects the real-world scenarios.  $\chi^2/df$  Ratio is 2.88, falling within the recommended range of <3 or 5 and indicating appropriate model complexity without overfitting. CFI and TLI are 0.934 and 0.915 respectively, significantly above 0.9, demonstrating high model fit quality and a good match between the model structure and the data. SRMR is 0.044, far below the standard of 0.1, indicating very minimal model residuals, showcasing strong explanatory power of the model. VIF average is 2.94, within the ideal range of 1-10, showing no severe multicollinearity among the model variables and confirming that the variables are relatively independent.

Table 5.10 Test results of hypothesis 4

| Model Determination |                                                                    | Item                       | Standard    |       | Value |
|---------------------|--------------------------------------------------------------------|----------------------------|-------------|-------|-------|
|                     |                                                                    | RMSEA                      | <0.10       |       | 0.071 |
|                     |                                                                    | $\chi^2/df$                | <3 or 5     |       | 2.88  |
|                     |                                                                    | CFI                        | >0.9        |       | 0.934 |
|                     |                                                                    | TLI                        | >0.9        |       | 0.915 |
|                     |                                                                    | SRMR                       | <0.1        |       | 0.044 |
|                     |                                                                    | VIF                        | 1-10        |       | 2.94  |
| Path Relationship   | Dependent variable                                                 | Independent variable       | Coefficient | T     | P     |
|                     | Employee Trust                                                     | Project Manager Competency | 0.223       | 3.512 | 0.000 |
|                     | Team Comprehensive Ability                                         | Project Manager Competency | 0.215       | 3.622 | 0.000 |
|                     |                                                                    | Employee Trust             | 0.106       | 4.126 | 0.000 |
| Effect Values       | Type of mediation                                                  |                            | Coefficient | T     | P     |
|                     | Project Manager Competency → Team Comprehensive Ability (Total)    |                            | 0.273       | 3.718 | 0.000 |
|                     | Project Manager Competency → Team Comprehensive Ability (direct)   |                            | 0.187       | 3.622 | 0.000 |
|                     | Project Manager Competency → Team Comprehensive Ability (indirect) |                            | 0.086       | 4.014 | 0.000 |

Overall, the model demonstrates an excellent fit, which allows for further analysis of the path relationships.

## (2) Path relationship

Project Manager Competency → Employee Trust: The p-value is 0.000, less than the 0.05 threshold, indicating a valid path relationship. The coefficient of 0.223, greater than 0, represents a positive correlation.

Project Manager Competency + Employee Trust → Team Comprehensive Ability: For project manager competency, the p-value is 0.000, less than 0.05, with a coefficient of 0.215, indicating a positive influence. For employee trust, the p-value is 0.000 with a coefficient of

0.106, also showing a valid and positive relationship.

### (3) Effect values

From Table 5.12, the indirect effect ratio is calculated as  $0.086/0.273 = 0.315$ , which lies between 0 and 1, indicating partial mediation. The mediation effect proportion of 0.315 confirms H4: In private Chinese construction enterprises, employee trust positively mediates the impact of project manager competency on team comprehensive ability.

## 5.4.3.2 Hypothesis testing of the mediating role of team communication in the impact of project manager competency on team comprehensive ability

### (1) Model determination

RMSEA: The value of 0.074 is below the threshold of 0.10, indicating a good fit between the model and the data, suggesting that the model accurately reflects the real-world scenarios.

$\chi^2/df$ : At 3.89, it slightly exceeds the recommended range of  $<3$  or 5, but is still within an acceptable limit, suggesting that the model might be slightly more complex than necessary but still maintains a reasonable fit.

CFI and TLI: Both indices, at 0.927 and 0.915 respectively, exceed the benchmark of 0.9, demonstrating high model fit quality and a good match between the model structure and the data.

SRMR: The value of 0.077, under the threshold of 0.1, indicates that model residuals are within an acceptable range.

VIF: An average of 4.15, within the acceptable range of 1-10, preliminarily suggests no significant multicollinearity issues among the model variables.

Overall, the model demonstrates an excellent fit, enabling further analysis of the path relationships.

### (2) Path relationship

Project Manager Competency  $\rightarrow$  Team Comprehensive Ability: The p-value is 0.000, less than 0.05, validating the path relationship. The coefficient of 0.241, greater than 0, indicates a positive correlation.

Project Manager Competency + Team Communication  $\rightarrow$  Team Comprehensive Ability: For project manager competency, the p-value is 0.000, less than 0.05, with a coefficient of 0.195, indicating a positive influence. For team communication, the p-value is 0.000 with a coefficient of 0.084, also showing a valid and positive relationship.

### (3) Effect values

From Table 5.13, the indirect effect ratio is calculated as  $0.064/0.231 = 0.277$ , which lies

between 0 and 1, indicating partial mediation. The mediation effect proportion of 0.277 confirms H5: In private Chinese construction enterprises, team communication positively mediates the impact of project manager competency on team comprehensive ability.

Table 5.11 Test results of hypothesis 5

| Model Determination |                                                                    | Item                       | Standard    |       | Value |
|---------------------|--------------------------------------------------------------------|----------------------------|-------------|-------|-------|
|                     |                                                                    | RMSEA                      | <0.10       |       | 0.074 |
|                     |                                                                    | $\chi^2/df$                | <3 or 5     |       | 3.89  |
|                     |                                                                    | CFI                        | >0.9        |       | 0.927 |
|                     |                                                                    | TLI                        | >0.9        |       | 0.915 |
|                     |                                                                    | SRMR                       | <0.1        |       | 0.077 |
|                     |                                                                    | VIF                        | 1-10        |       | 4.15  |
| Path Relationship   | Dependent variable                                                 | Independent variable       | Coefficient | T     | P     |
|                     | Team communication                                                 | Project Manager Competency | 0.241       | 3.647 | 0.000 |
|                     | Team Comprehensive Ability                                         | Project Manager Competency | 0.195       | 5.126 | 0.000 |
| Effect Values       | Team communication                                                 |                            | 0.084       | 3.789 | 0.000 |
|                     | Type of mediation                                                  |                            | Coefficient | T     | P     |
|                     | Project Manager Competency → Team Comprehensive Ability (Total)    |                            | 0.231       | 3.487 | 0.000 |
|                     | Project Manager Competency → Team Comprehensive Ability (direct)   |                            | 0.167       | 5.126 | 0.000 |
|                     | Project Manager Competency → Team Comprehensive Ability (indirect) |                            | 0.064       | 3.598 | 0.000 |

#### 5.4.3.2 Hypothesis testing analysis of the mediating role of team comprehensive ability in the impact of project manager competency on project performance

##### (1) Model determination

RMSEA: The value of 0.084 is below the threshold of 0.10, indicating a good fit between the model and the data, within an acceptable error range.

$\chi^2/df$ : At 2.77, this is below the typically recommended threshold of 3 or 5, suggesting a high model fit.

CFI and TLI: Both indices are at 0.936 and 0.941 respectively, exceeding the benchmark of 0.9, demonstrating an ideal fit of the model.

SRMR: With a value of 0.047, this is well below the threshold of 0.1, indicating minimal residuals and a good fit.

VIF: With a value of 6.25, this falls within the recommended range of 1-10, indicating no severe multicollinearity among the variables.

##### (2) Path Relationship

Project Manager Competency → Team Comprehensive Ability: The p-value is 0.000,

less than 0.05, validating the path relationship. The coefficient of 0.219, greater than 0, represents a positive correlation.

Project Manager Competency + Team Comprehensive Ability → Project Performance:  
For project manager competency, the p-value is 0.001, less than 0.05, with a coefficient of 0.187, indicating a positive influence. For team comprehensive ability, the p-value is 0.000 with a coefficient of 0.109, also showing a valid and positive relationship.

### (3) Effect Values

The indirect effect ratio is calculated as  $0.102/0.276 = 0.369$ , which lies between 0 and 1, indicating partial mediation. The mediation effect proportion of 0.369 confirms H6 (see Table 5.14): In private Chinese construction enterprises, team comprehensive ability positively mediates the impact of project manager competency on project performance.

Table 5.12 Test results of hypothesis 6

| Model Determination |                                                             | Item                       | Standard    | Value |       |
|---------------------|-------------------------------------------------------------|----------------------------|-------------|-------|-------|
|                     |                                                             | RMSEA                      | <0.10       | 0.073 |       |
|                     |                                                             | $\chi^2/df$                | <3 or 5     | 2.653 |       |
|                     |                                                             | CFI                        | >0.9        | 0.933 |       |
|                     |                                                             | TLI                        | >0.9        | 0.923 |       |
|                     |                                                             | SRMR                       | <0.1        | 0.038 |       |
|                     |                                                             | VIF                        | 1-10        | 6.25  |       |
| Path Relationship   | Dependent variable                                          | Independent variable       | Coefficient | T     | P     |
|                     | Team comprehensive ability                                  | Project manager competency | 0.219       | 3.517 | 0.000 |
|                     | Project performance                                         | Project manager competency | 0.187       | 3.258 | 0.001 |
|                     |                                                             | Team comprehensive ability | 0.109       | 3.752 | 0.000 |
| Effect Values       | Type of mediation                                           |                            | Coefficient | T     | P     |
|                     | Project manager competency → Project performance (Total)    |                            | 0.276       | 3.987 | 0.000 |
|                     | Project manager competency → Project performance (direct)   |                            | 0.174       | 3.258 | 0.001 |
|                     | Project manager competency → Project performance (indirect) |                            | 0.102       | 4.123 | 0.000 |

## 5.4.4 Moderation effect

### 5.4.4.1 Hypothesis testing of the moderating effect of employee training on the impact of project manager competency on employee trust

#### (1) Model Determination

RMSEA: The value of 0.055 indicates an excellent fit between the model and the data,

well below the 0.10 threshold, reflecting that model errors are acceptably low.

$\chi^2/df$ : With a value of 3.145, slightly above the ideal mark of 3 but well within the broader acceptable limit of 5, this suggests that the model fits the data reasonably well despite its slight complexity.

CFI: A value of 0.927, exceeding the critical level of 0.9, demonstrates that the model offers a very good fit to the data.

TLI: Similarly, a value of 0.925 also surpasses the 0.9 threshold, confirming the model's good fit.

SRMR: The value of 0.048, significantly lower than 0.1, indicates small residuals, meaning the model's predictions are closely aligned with the observed data.

VIF: With a value of 3.98, falling within the recommended range of 1 to 10, it indicates that there are no severe multicollinearity issues among the independent variables in the model.

## (2) Path Relationship

According to Table 5.15, Project Manager Competency: The P-value of 0.000, less than 0.05, indicates a significant relationship, suggesting that project manager competency significantly affects employee trust. Employee Training: The P-value of 0.000, less than 0.05, also indicates a significant relationship, highlighting the importance of employee training as a factor in its own right. Interaction Term (Project Manager Competency \* Employee Training): The P-value of 0.049, just under the threshold of 0.05, demonstrates a significant interaction effect. This significant result indicates that employee training moderates the effect of project manager competency on employee trust.

Table 5.13 Test results of hypothesis 7

| Model Determination |                    | Item                                         | Standard    |       | Value |
|---------------------|--------------------|----------------------------------------------|-------------|-------|-------|
|                     |                    | RMSEA                                        | <0.10       |       | 0.055 |
|                     |                    | $\chi^2/df$                                  | <3 or 5     |       | 3.145 |
|                     |                    | CFI                                          | >0.9        |       | 0.927 |
|                     |                    | TLI                                          | >0.9        |       | 0.925 |
|                     |                    | SRMR                                         | <0.1        |       | 0.048 |
|                     |                    | VIF                                          | 1-10        |       | 3.98  |
| Path Relationship   | Dependent variable | Independent variable                         | Coefficient | T     | P     |
|                     | Employee Trust     | Project Manager Competency                   | 0.187       | 4.256 | 0.000 |
|                     |                    | Employee Training                            | 0.215       | 3.678 | 0.000 |
|                     |                    | Project Manager Competency*Employee Training | 0.159       | 1.971 | 0.049 |

#### 5.4.4.2 Hypothesis testing of the moderating effect of employee training on the impact of project manager competency on team communication

##### (1) Model Determination

Based on the fit indices, the evaluation shows:

RMSEA: The value of 0.047 is significantly below the 0.10 threshold, indicating an excellent fit between the model and the data. A low RMSEA value implies that model errors are minimal and the model structure reflects the actual conditions of the data very well.

$\chi^2/df$ : With a value of 4.029, although slightly higher than the ideal threshold of 3, it still falls under the acceptable limit of 5. This suggests that while there is a slight risk of overfitting, the overall fit of the model to the data is still acceptable.

CFI: A value of 0.937, which exceeds 0.9, indicates that the model performs very well in fitting the data compared to a baseline model (e.g., one with no correlations assumed).

TLI: Similarly, a value of 0.934, also above 0.9, further confirms that the model has a high quality of fit to the data.

SRMR: A value of 0.051, although slightly above the ideal threshold of 0.05, is still relatively low. This suggests that the residuals (i.e., the discrepancies between predicted values and actual observations) are relatively small, indicating a generally acceptable model fit.

VIF: With a value of 4.22, falling within the recommended range of 1 to 10, indicates that multicollinearity among the independent variables in the model is not a significant concern.

##### (2) Path Relationship

Based on the analysis from Table 5.16 regarding the moderating effect of employee training on the relationship between project manager competency and team communication: Project Manager Competency: The P-value of 0.000, less than 0.05, indicates a significant relationship, confirming that project manager competency has a notable influence on team communication. Employee Training: Similarly, the P-value of 0.000, less than 0.05, demonstrates a significant effect, underscoring the importance of employee training in its own right.

Table 5.14 Test results of hypothesis 7

| Model Determination | Item        | Standard | Value |
|---------------------|-------------|----------|-------|
|                     | RMSEA       | <0.10    | 0.047 |
|                     | $\chi^2/df$ | <3 or 5  | 4.029 |
|                     | CFI         | >0.9     | 0.937 |
|                     | TLI         | >0.9     | 0.934 |
|                     | SRMR        | <0.1     | 0.051 |

| Path Relationship | Dependent variable | VIF Independent variable                     | 1-10 Coefficient | T     | 4.22 P |
|-------------------|--------------------|----------------------------------------------|------------------|-------|--------|
|                   | Team Communication | Project Manager Competency                   | 0.184            | 5.041 | 0.000  |
|                   |                    | Employee Training                            | 0.197            | 3.587 | 0.000  |
|                   |                    | Project Manager Competency*Employee Training | 0.089            | 1.987 | 0.047  |

Interaction Term (Project Manager Competency \* Employee Training): The P-value of 0.047, just under the threshold of 0.05, shows a significant interaction effect. This result indicates that employee training modifies the impact of project manager competency on team communication.

## 5.5 Summary of hypotheses testing results

After testing each hypothesis, all research hypotheses are supported. The specific hypothesis test results are shown in Table 5.17 and Figure 5.1.

Table 5.15 Summary of hypotheses testing results

| Hypothesis                                                                                                                                                            | Conclusion |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| H1: In China's private construction companies, project manager competency positively affects project performance.                                                     | Supported  |
| H1a: In China's private construction companies, personal traits within project manager competency positively affect project performance.                              | Supported  |
| H1b: In China's private construction companies, general leadership abilities within project manager competency positively affect project performance.                 | Supported  |
| H1c: In China's private construction companies, project-specific management abilities within project manager competency positively affect project performance.        | Supported  |
| H2: In China's private construction companies, project manager competency positively affects team comprehensive ability.                                              | Supported  |
| H2a: In China's private construction companies, personal traits within project manager competency positively affect team comprehensive ability.                       | Supported  |
| H2b: In China's private construction companies, general leadership abilities within project manager competency positively affect team comprehensive ability.          | Supported  |
| H2c: In China's private construction companies, project-specific management abilities within project manager competency positively affect team comprehensive ability. | Supported  |
| H3: In China's private construction companies, team comprehensive ability positively affects project performance.                                                     | Supported  |
| H4: In China's private construction companies, employee trust positively mediates the impact of project manager competency on team comprehensive ability.             | Supported  |
| H5: In China's private construction companies, team communication positively mediates the impact of project manager competency on team comprehensive ability.         | Supported  |
| H6: In China's private construction companies, team comprehensive ability positively mediates the impact of project manager competency on project performance.        | Supported  |

|                                                                                                                                            |           |
|--------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| H7: In China's private construction companies, employee training moderates the impact of project manager competency on employee trust.     | Supported |
| H8: In China's private construction companies, employee training moderates the impact of project manager competency on team communication. | Supported |

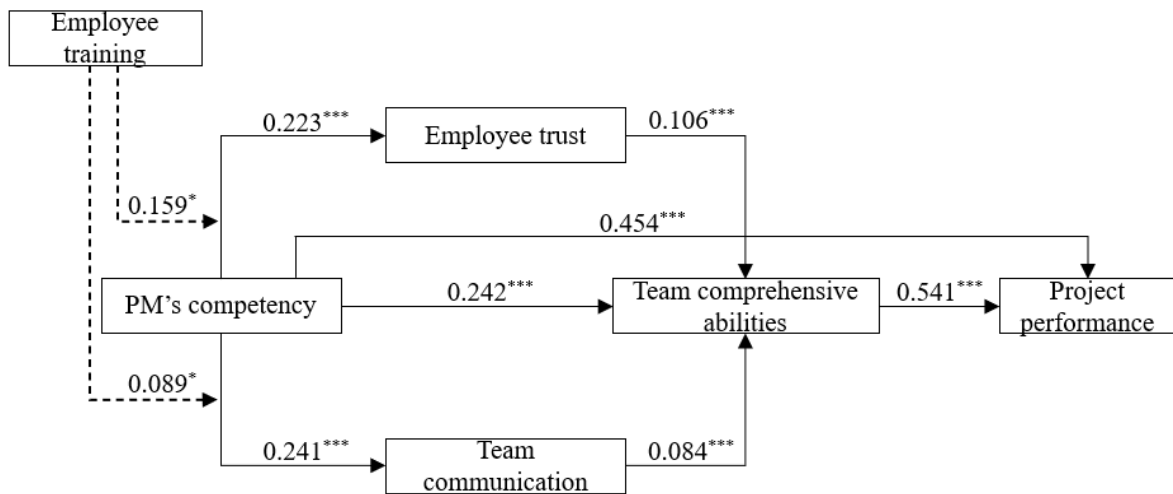


Figure 5.1 Results of the conceptual model

## Chapter 6: Discussion

### 6.1 Findings and discussion

This thesis primarily reaches the following research conclusions:

(1) In Chinese private construction companies, the competence of project managers positively impacts project performance. This conclusion is consistent with the existing studies (Agindano, 2021; Dlamini & Cumberlege, 2021; Montenegro et al., 2021; Sarpin et al., 2021; Sultana-Muchindu & Kabwe, 2022; Khalfan et al., 2022). Moreover, sub-hypothesis testing also found that individual traits in project manager competence positively affect project performance (H1a), general leadership skills in project manager competence positively affect project performance (H1b), and project-specific management skills in project manager competence positively affect project performance (H1c). The positive impact of project manager competence on project performance can be further elaborated from three sub-dimensions: individual traits, general leadership skills, and project-specific management skills, resonating with previously mentioned international research conclusions.

**Individual Traits (H1a):** A project manager's sense of responsibility, execution ability, proactive attitude, and excellent communication skills form the core of their personal traits. Responsibility drives project managers to be accountable for project outcomes, ensuring the accurate execution of each component; execution ability is reflected in quickly and accurately translating plans into action; being proactive is not limited to fulfilling one's duties but also involves actively assisting the team in solving problems and creating a positive work atmosphere; efficient communication skills are crucial for coordinating internal and external resources and ensuring accurate information transmission. Shi et al. (2014) also emphasized the positive impact of leaders' personal traits on project outcomes, which aligns with the findings of this study.

**General Leadership Skills (H1b):** Project managers who excel in team building, organizational coordination, decision-making, and analytical judgment capabilities can effectively enhance team cohesion and efficiency. Team building skills motivate members, develop talents, and ensure stable and efficient team operations; organizational coordination skills are demonstrated by the reasonable arrangement of tasks and mobilization of team

enthusiasm; decision-making skills require project managers to make accurate judgments and take actions swiftly in complex situations; analytical judgment skills help project managers anticipate problems and prevent risks. These capabilities align with the research of Moradi et al. (2020), who also emphasized the importance of leadership abilities for project success.

**Project-Specific Management Skills (H1c):** Deep professional knowledge in planning management, risk control, conflict management, schedule management, cost control, quality management, and contract management enables project managers to precisely plan project processes, effectively control costs, and ensure projects are completed on time, on quality, and within budget. For example, planning management skills ensure tasks are reasonably broken down and feasible; risk control skills require project managers to be proactive in identifying and addressing project risks; and quality management abilities ensure that the final product or service meets established standards. Research by Sonelma and Sucita (2022) highlight the direct impact of professional management skills on enhancing project performance

In summary, the competence of project managers in Chinese private construction companies, particularly in individual traits, general leadership skills, and project-specific management skills, is supported by multiple domestic and international studies and proven to have a significant positive impact on project performance. These findings not only provide empirical evidence for the training of talents and project management strategies in construction enterprises but also emphasize the importance of considering and strengthening these skills comprehensively in the selection and training of project managers to achieve project success in a highly competitive market environment.

(2) In Chinese private construction companies, the competence of project managers positively affects the overall capability of the team. In the specific context of China's private construction industry, the competence of project managers positively promotes team capabilities. This observation not only summarizes practical observations but also aligns with the classic management theory—Path-Goal Theory. This theory emphasizes that leaders should set clear goals, provide necessary support and guidance, and create a conducive work environment that facilitates the achievement of goals by subordinates, thereby motivating the team and enhancing its effectiveness. The competence of project managers deeply influences team capabilities across various dimensions within this theoretical framework.

**Hypothesis H2a:** The personal traits of project managers, such as a high sense of responsibility, firm execution, proactive attitude, and excellent communication skills, directly serve as a model for team behavior. These traits, like the center of a magnetic field, attract and inspire team members to emulate, thereby forming a collective atmosphere characterized by

responsibility, efficient communication, and proactivity. Thamhain (2004) also noted that a leader's personal charisma and integrity are foundational for building team trust and cooperation.

Hypothesis H2b: General leadership skills, encompassing team building, organizational coordination, decision-making, and analytical judgment, are crucial for project managers to lead their teams through challenges and achieve goals. The exhibition of these skills, as discussed by L. R. Yang et al. (2011), effectively enhances team cohesion and adaptability, supported by reasonable task distribution, effective incentive mechanisms, and flexible strategic adjustments, ensuring that the team remains efficient in a dynamically changing project environment.

Hypothesis H2c: Project-specific management skills, an important component of project manager competence, directly relate to every detail of project implementation. This not only requires project managers to have comprehensive planning management, strict risk control, and precise cost control abilities but also to master the art of conflict and schedule management. J. Yoon et al. (2023) emphasized that the enhancement of professional management skills ensures that the team can progress methodically in the face of technical challenges, time pressures, and cost constraints, thereby enhancing the team's overall execution ability and capacity to handle complex situations.

In summary, the competence of project managers promotes team capabilities comprehensively through the exemplary role of personal traits, the guidance and motivation of general leadership skills, and the meticulous operation of professional management skills. This conclusion not only echoes the aforementioned theories and previous studies but also provides empirical support in the specific context of Chinese private construction companies. It emphasizes the intrinsic connection between individual development of project managers and team building, offering significant insights for optimizing project management practices and enhancing project success rates.

(3) In Chinese private construction companies, the overall capability of the team positively affects project performance. This conclusion is consistent with existing studies (Dionne et al., 2004; Esch et al., 1992; McDonough III, 2000; Yoon et al., 2023), confirming the relationship between team capability and team performance. In the specific context of Chinese private construction companies, the positive impact of team capabilities on project performance not only reflects practical experience but also aligns closely with the findings of numerous scholars.

(4) In Chinese private construction companies, employee trust positively mediates the

impact of project manager competence on team capabilities. This aligns with the existing studies (Q. Q. Du, 2022; Hafeez et al., 2022; Le & Nguyen, 2023; Schaubroeck et al., 2011). The complete trust that employees have in project managers is not only a reflection of the managers' personal charisma and professional abilities but also an intrinsic driver for enhancing team capabilities. This trust not only strengthens collaboration and communication among team members but also promotes the free flow and sharing of information, enabling the team to more effectively integrate resources and respond to challenges, thereby demonstrating higher performance during project execution. These findings provide valuable theoretical and practical guidance for enhancing project manager leadership and building effective teams in Chinese private construction companies, emphasizing the importance of valuing and fostering a culture of employee trust in project management practices.

(5) In Chinese private construction companies, team communication positively mediates the impact of project manager competence on team capabilities. This is consistent with existing studies (Hirst et al., 2004; Hyeon & Bum, 2020; Y. C. Li & Ma, 2009; Manata et al., 2022; Samuel & Matthew, 2021; Sarker et al., 2011). Within the context of Chinese private construction companies, team communication, as a key mediating variable, has been proven to positively regulate the relationship between project manager competence and team capabilities. This conclusion aligns with a range of both domestic and international academic insights that deeply explore the core role of communication in organizational effectiveness, team collaboration, and project success.

(6) In Chinese private construction companies, the overall capability of the team positively mediates the impact of project manager competence on project performance. This conclusion aligns with existing studies (Fareed et al., 2021; Nauman et al., 2022; Siddiquei et al., 2022; Hashim et al., 2022). In the realm of China's private construction industry, the overall capability of the team effectively acts as a bridge that amplifies the positive impact of a project manager's individual competence on overall project performance. This mechanism reveals that in the complex and variable context of engineering project management, while individual capabilities of a project manager are crucial, they do not exist in isolation. Their effective deployment highly depends on the comprehensive qualities and collaborative efficiency of the team they lead. Specifically, a project manager's competence, covering professional skills, leadership, decision-making ability, and risk management, directly relates to the efficiency of controlling project direction, resource allocation, and problem-solving. However, when these individual strengths are embedded within a highly collaborative, skill-diverse, and smoothly communicating team environment, a significant positive

magnification effect occurs. The complementary strengths among team members, knowledge sharing, and mutual motivation can effectively compensate for any limitations a project manager might have, promoting the rapid circulation of information and optimizing decision execution, thus ensuring the efficient achievement of project objectives. Further, the enhancement of team capabilities is not only reflected in the technical depth and breadth on a professional level but also includes the shaping of team culture, building of trust among members, and the ability to adapt flexibly. The strengthening of these soft skills allows the team to exhibit greater resilience and innovative capacity when facing uncertainties and challenges during project execution, further driving the enhancement of project performance.

(7) In Chinese private construction companies, employee training moderates the effect of project manager competence on employee trust. This is consistent with existing studies (Le & Nguyen, 2023; H. M. Wei & Long, 2009). In the specific context of Chinese private construction companies, employee training has been identified as a key moderating variable affecting the relationship between project manager competence and employee trust. Project manager competence, including but not limited to their professional skills, leadership style, and decision-making abilities, is a direct factor influencing employee trust. However, the intervention of employee training, which supports systematic learning and development opportunities, provides employees with a platform to deeply understand the capabilities of project managers. Training not only allows employees to directly recognize the professional qualifications and management talents of project managers but also promotes alignment in work philosophies and goal consensus, thereby building stronger trust in the minds of employees. This enhanced sense of trust, in turn, improves team collaboration efficiency and reduces communication costs, creating more favorable conditions for the successful execution of projects.

(8) In Chinese private construction companies, employee training moderates the impact of project manager competence on team communication. This is consistent with the existing studies (Nor, 2023; Yimam, 2022; Judeh & Khader, 2023). In the real-world setting of Chinese private construction companies, employee training has been proven to play a crucial moderating role, harmonizing and enhancing the positive impact of project manager competence on the quality and efficiency of team communication. Project manager competence, covering professional skills, leadership, and decision-making abilities, directly affects team operational efficiency and project outcomes. However, this influence does not exist in isolation and requires effective communication mechanisms to be fully realized. Employee training acts as both a bridge and accelerator in this process. It not only enhances

employees' professional knowledge and skills but also improves communication skills, enabling team members to more effectively receive guidance from the project manager, understand project objectives and strategies, and achieve seamless integration in daily work.

Overall, compared to previous studies, this research undertakes further exploration. Montenegro et al. (2021) previously investigated the impact of project managers' emotional intelligence on project success, emphasizing the critical role of emotional intelligence in enhancing project performance. This study further validates the positive influence of project managers' personal traits, particularly emotional intelligence, on project performance, providing empirical support for private construction enterprises in China. Agindano (2021) explored the effects of senior management commitment, regulations, employee communication, capability, work environment, and participation on project performance. Through the testing of sub-hypotheses, this research further clarifies the positive impact of general leadership skills within project managers' competencies on project performance, offering a theoretical basis for enhancing project managers' leadership. Sarpin et al. (2021) discussed the influence of project managers' competencies on project success, highlighting the central role of project managers in project management. This study, through empirical analysis, validates the positive impact of project managers' professional management skills on project performance, providing empirical support for the professional development of project managers. Dlamini and Cumberlege (2021) examined the impact of project managers' competencies on project performance, particularly the crucial role of project managers in project management. This study further validates the combined effect of project managers' personal traits, general leadership abilities, and professional management skills on project performance, providing a theoretical basis for the comprehensive development of project managers. Lin (2021) investigated the effect of project managers' competencies on project performance, emphasizing their key role in project management. This study, through empirical analysis, validates the positive impact of project managers' personal traits on project performance, supporting the development of these traits. Elmezain et al. (2021) discussed the impact of project managers' competencies on project performance, particularly highlighting the key role of project managers in project management. This study further validates the positive influence of project managers' general leadership abilities on project performance, providing a theoretical foundation for enhancing project managers' leadership skills. Sultana-Muchindu and Kabwe (2022) explored the impact of project managers' emotional competencies and leadership on project performance, stressing the importance of emotional intelligence in project management. This study, through empirical analysis, validates the

positive impact of project managers' emotional competencies and interpersonal skills on team cohesion and project performance, providing empirical support for the cultivation of project managers' emotional intelligence. Sonelma and Sucita (2022) discussed the effect of project managers' competencies on project performance, with a particular focus on their professional management skills. Through empirical analysis, this study validates the positive influence of project managers' professional management skills on project performance, providing empirical support for their professional development. Through these studies, this research not only validates the positive impact of project managers' competencies on project performance but also further explores the specific impact mechanisms of various dimensions of project managers' competencies (personal traits, general leadership abilities, professional management skills) on project performance. This provides empirical evidence for talent development and project management strategies in private construction enterprises in China and offers theoretical and practical guidance for future research.

## **6.2 Further recommendations based on research findings**

Based on the discussion and analysis of the research hypotheses above, the following specific research recommendations can be proposed for improving the competency of project managers, team building, and project management optimization in private construction enterprises in China:

### **6.2.1 Further recommendations based on the positive impact of project manager competency on project performance**

In light of the positive impact of project manager competency on project performance (H1, H1a, H1b, H1c), the following research recommendations are proposed:

**Deepening the Application and Evaluation of Competency Models:** Enterprises should refine the project manager competency model based on the findings of this study. This involves designing an evaluation system that includes personal traits, general leadership abilities, and professional project management skills, and incorporating this system into the selection, training, and development processes for project managers.

**Personalized Training and Development Plans:** Based on the assessment results of project managers in various competency dimensions, personalized training plans should be developed. These plans should enhance personal traits such as responsibility, execution, proactivity, and communication skills, while also improving leadership and professional management skills,

ensuring that each project manager receives targeted development.

### **6.2.2 Further recommendations based on the positive impact of project manager competency on team comprehensive capability**

Considering the positive impact of project manager competency on team comprehensive capability (H2, H2a, H2b, H2c), the following research recommendations are proposed:

**Strengthening Path-Goal Leadership Practices:** Encourage project managers to adopt leadership strategies based on the path-goal theory. This involves clarifying team goals, providing support and guidance, and creating a work environment conducive to team members achieving their goals, thereby enhancing team comprehensive capability.

**Building a Learning-Oriented Team Culture:** Under the leadership of project managers, foster a team culture that encourages learning, sharing, and collaboration. Through team-building activities and regular training, enhance team members' personal traits, general leadership abilities, and professional skills.

### **6.2.3 Further recommendations based on the positive impact of team comprehensive capability on project performance**

Regarding the positive impact of team comprehensive capability on project performance (H3), the following research recommendations are proposed:

**Continuous Monitoring and Feedback Mechanism:** Establish a continuous monitoring system for project performance and team comprehensive capability. Regularly collect data to assess the actual impact of team capability improvement on project performance and adjust management strategies based on feedback.

**Incentive Mechanisms and Team Rewards:** Design incentive mechanisms directly linked to the improvement of team comprehensive capability, such as team performance bonuses and recognition systems, to reinforce team members' intrinsic motivation to enhance their capabilities.

### **6.2.4 Further recommendations based on the mediating role of employee trust and team communication**

Considering the mediating role of employee trust and team communication (H4, H5), the following research recommendations are proposed:

**Trust and Communication Workshops:** Regularly hold workshops on building trust and

effective communication. Teach project managers how to enhance trust and communication efficiency within the team through effective communication strategies and trust-building behaviours.

Transparent Management Practices: Promote transparent management to ensure open information flow within the team, thereby enhancing trust among team members and improving the quality and efficiency of communication.

#### **6.2.5 Further recommendations based on the moderating role of employee training**

Regarding the moderating role of employee training (H7, H8), the following research recommendations are proposed:

Customized Employee Training Programs: Design customized training programs based on the competency characteristics of project managers and team needs. Ensure that the training content strengthens the personal traits and professional abilities of project managers while also promoting the comprehensive capability of the team.

Training Effectiveness Evaluation and Iteration: Establish a mechanism for evaluating the effectiveness of training. Regularly assess the impact of training on project manager competency, team trust, communication ability, and project performance, and continuously optimize the training content and methods based on evaluation results.

In conclusion, these recommendations aim to help enterprises better understand the importance and mechanisms of project manager competency. Through targeted measures, the overall capabilities of project managers and teams can be enhanced, ultimately leading to significant improvements in project performance.

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## Chapter 7: Conclusions and Prospects

### 7.1 Research question responses

Based on the findings, this section answers the four research questions proposed in Chapter 1.

Response to RQ1:

This study first conducted a literature review on project manager competency, systematically searching and summarizing relevant studies. Initially, 37 competency indicators for project managers in Chinese construction enterprises were identified. After conducting interviews, these indicators were refined and condensed into 26, and ultimately, 19 key competency indicators were determined. Finally, based on data collected through surveys, a measurement scale for project manager competency was established.

Response to RQ2:

The direct and indirect impact of project manager competency on project performance was analyzed. Project manager competency—which includes personal traits, general leadership abilities, and professional project management skills—positively influences project performance. In other words, a competent project manager can directly enhance project performance through their abilities. Additionally, project manager competency indirectly promotes project performance by improving the overall capability of the project team. In this process, the team's comprehensive capability plays a mediating role, indicating that not only is the project manager's individual ability important, but their ability to lead and integrate the team is also crucial for achieving outstanding project performance.

Response to RQ3:

In the process of project manager competency influencing the team's comprehensive capability, employee trust and communication among team members serve as mediating factors. Specifically, a project manager's competency enhances employees' trust in them and improves internal team communication and collaboration. These two factors further strengthen the team's overall operational effectiveness, thereby positively impacting project performance.

Response to RQ4:

What role does employee training play in the relationship between project manager

competency and project performance in Chinese construction enterprises?

Employee training plays a moderating role in the impact of project manager competency on employee trust and team communication. In other words, when enterprises provide effective training for employees, the competencies of project managers are more effectively translated into employee trust and efficient internal communication within the team. Through this moderating effect, employee training further strengthens the project manager's ability to enhance team competency through trust and communication, thereby indirectly improving project performance.

## 7.2 Research conclusions

This study has thoroughly explored the close relationship between the competency of project managers in private construction enterprises in China and the performance of the projects they oversee. Several key conclusions emerged, offering significant contributions both theoretically and practically. The main conclusions of this study are as follows:

(1) **Positive Correlation Between Project Manager Competency and Project Performance:** This study confirms that the competency of project managers in Chinese private construction enterprises has a significant positive impact on project performance. This conclusion aligns with numerous international studies (Agindano, 2021; Dlamini & Cumberlege, 2021; Montenegro et al., 2021; Sarpin et al., 2021; Sultana-Muchindu & Kabwe, 2022; Khalfan et al., 2022). Through detailed sub-hypothesis testing, we found that the three major components of project manager competency—personal traits, general leadership abilities, and professional project management skills—each independently positively influence project performance. This finding not only refines the relationship between competency and performance but also provides targeted guidance for human resource management in the construction industry.

(2) **Catalytic Role of Personal Traits:** In the dimension of personal traits, we observed that the responsibility, execution, proactive attitude, and effective communication skills of project managers directly promote project performance. Responsibility and execution ensure accurate execution of project tasks, while a proactive attitude and excellent communication skills create an open and efficient team environment. L. G. Shi et al. (2014) also emphasized the importance of leaders' personal traits, further consolidating the findings of this study.

(3) **Leading Role of General Leadership Abilities:** In terms of general leadership abilities, team building, organizational coordination, decision-making abilities, and analytical judgment skills have been shown to be crucial in enhancing team cohesion, efficiency, and project

adaptability. This aligns with the research by Moradi et al. (2020), which highlights the core role of leadership in project success. By demonstrating these abilities, project managers can not only inspire team potential but also make timely and correct decisions in complex and changing project environments, laying a foundation for project success.

(4) Assurance Role of Professional Project Management Skills: Professional project management skills, such as planning management, risk control, and conflict resolution, are direct factors ensuring that projects are completed on time, within quality standards, and within budget. Mastering these skills deeply enables project managers to foresee and solve various challenges that may arise during project execution. This complements the conclusions of studies by Sonelma and Sucita (2022), highlighting the direct role of professional management skills in improving project performance.

(5) Mediating Effect of Team Comprehensive Capability: This study further reveals that the competency of project managers indirectly promotes project performance by enhancing team comprehensive capability. Team comprehensive capability, as a mediating variable, depends not only on the personal traits and leadership abilities of project managers but also on team communication and employee trust. This finding aligns with the theoretical and empirical research of numerous scholars (Salas et al., 1999; L. R. Yang et al., 2011), emphasizing the bridging role of team comprehensive capability between individual abilities and project outcomes.

(6) Moderating Mechanisms of Employee Trust and Team Communication: High levels of employee trust in project managers and efficient team communication mechanisms have been shown to be important moderating variables in transforming project manager competency into team comprehensive capability and project performance. This indicates that trust and communication are not only the foundation of internal team collaboration but also key mediators for the effectiveness of project manager leadership. The findings align with many previous studies (Matthews et al., 2021; Dirks, 2000), highlighting the necessity of establishing and maintaining trust and promoting open communication in project management.

## **7.3 Research contributions**

### **7.3.1 Theoretical contributions**

(1) Theoretical extension and integration

Based on the Project Manager Competency Development Framework (PMCDF) (Project Management Institute [PMI], 2008), project manager competency is primarily classified into three dimensions: knowledge competency, performance competency, and personal competency. However, this study refines project manager competency into three specific aspects: personal traits, general leadership ability, and project-specific management ability.

In PMCDF, knowledge competency is treated as an independent dimension, typically assessed through examinations such as PMP certification, which evaluates a project manager's systematic understanding of project management theories and principles. This study, however, emphasizes a project manager's comprehensive performance in real-world scenarios, recognizing that theoretical knowledge is more effectively reflected in project-specific management ability—that is, how professional knowledge is translated into practical skills. While PMCDF adopts a broader classification, this study further subdivides personal competency into personal traits and general leadership ability, providing a more detailed analysis of how project managers contribute to team collaboration, employee trust, and communication.

## (2) Revealing the underlying mechanism

Beyond directly verifying the impact of different dimensions of project manager competency on project performance, this study further explores the mediating role of team capability in this relationship. Employee trust and team communication are introduced as key mediating variables, while employee training is examined as a moderating factor within this framework.

This research design deepens the understanding of how project manager competency translates into improved project performance, while also addressing a key gap in PMCDF—its lack of explanation regarding the competency-effect transmission mechanism. By identifying and analyzing these intermediary and moderating relationships, this study provides a more nuanced perspective on the competency-performance link, offering theoretical advancements and practical implications.

## (3) Empirical Validation in a Cross-Cultural and Industry-Specific Context

Using Chinese private construction enterprises as the research context, this study tests the applicability and validity of PMCDF in different cultural and industry environments. This provides empirical evidence supporting the international adaptability of project management theories, contributing to the cross-cultural and industry-specific development of PMCDF. By extending the framework beyond its original scope, this study facilitates broader applications and theoretical advancements in global project management research.

### **7.3.2 Practical contributions**

#### **(1) Guiding talent selection and training**

The findings of this study provide clear guidance for businesses in the selection and training of project managers, emphasizing the importance of cultivating personal traits, general leadership abilities, and project-specific management skills. The research also highlights the significance of enhancing team trust and improving team communication mechanisms, offering a practical guide for the talent development strategies of construction companies.

#### **(2) Optimizing project management strategies**

This study underscores the critical role of building team capabilities for project success, advising companies to strengthen team building and communication mechanisms on top of project manager leadership. This approach aims to enhance project execution efficiency and the ability to handle uncertainties, providing concrete strategic recommendations for project management practices.

#### **(3) Fostering corporate culture and organizational innovation**

The research results highlight the moderating role of employee training in enhancing interactions between project managers and their teams. This suggests that companies should invest in employee capability enhancement. Such investments can not only improve project performance but also promote the development of corporate culture and enhance organizational innovation capabilities, laying a foundation for sustainable development of the enterprise. These practical contributions are instrumental in aligning the theoretical insights with actionable strategies that can be implemented within organizations to achieve their strategic objectives and enhance overall performance.

## **7.4 Managerial recommendations**

#### **(1) Strengthening project manager competence development**

Businesses should recognize that project managers are central to the success of projects, and the cultivation of their personal traits is critical. This requires companies to not only nurture their sense of responsibility to ensure that every project phase is accounted for and executed efficiently but also to enhance their execution skills to respond swiftly and effectively in complex environments. Additionally, improving communication skills to facilitate unimpeded information flow and effective coordination with stakeholders is

essential. Moreover, companies should systematically strengthen the general leadership training of project managers, encompassing strategic vision, team motivation, and change leadership, as well as deepen education in project-specific management skills such as planning, risk management, and resource allocation, thus building a comprehensive and profound leadership and management quality framework.

(2) Enhancing team capabilities

Develop a scientific and systematic team-building program aimed at supporting multi-level team communication training to enhance internal and cross-departmental communication efficiency and information sharing; promote systematic improvement in collaborative abilities to ensure team members can work together effectively to address various challenges during project implementation; and organize regular goal consensus activities to strengthen team members' common understanding and pursuit of project visions and objectives, thereby fundamentally enhancing team cohesion and execution capabilities, laying a solid foundation for the efficient operation of projects.

(3) Establishing a culture of trust

Enterprises should strive to create a corporate culture centered around trust. This includes organizing effective team-building activities regularly to promote mutual understanding and respect among team members; establishing and maintaining a transparent, open information-sharing mechanism to ensure all decisions and progress are transparent, reducing misunderstandings and suspicions; implementing fair and just incentive policies based on actual results and contributions to motivate team members, thus fostering a trust-based positive work attitude and harmonious interpersonal relationships within the organization.

(4) Optimizing communication mechanisms

In today's digital age, enterprises should actively adopt and utilize advanced communication tools and technologies, such as project management software and instant messaging platforms, to ensure accurate and timely conveyance of project information. Additionally, establishing a regular project meeting system that goes beyond merely reporting progress encourages team members to provide constructive suggestions and feedback. This fosters a culture of open discussion and positive feedback, significantly enhancing the efficiency and quality of team communication.

(5) Implementing customized employee training

Considering the varied backgrounds and needs of each project manager and team member, enterprises should adopt personalized training strategies tailored to their job characteristics and personal development needs. This approach should not only deepen and expand

professional skills but also include the cultivation of leadership, enhancement of communication arts, and training in teamwork skills. Supported by this comprehensive and multi-level training method, the strategy promotes the maximum release of individual potential and balanced growth of overall team capabilities.

(6) Using employee training as a bridge for trust and communication

View employee training as a golden opportunity to enhance trust and communication between project managers and team members. Carefully design the training content to ensure it closely aligns with the actual needs of project management. Supported by a process of joint learning and practice, this deepens mutual understanding and respect. Training is not only a process of skill transfer but also a bridge for emotional connection and trust-building, helping to form a solid network of cooperation based on mutual understanding and trust within the team, providing strong interpersonal support for project success.

## **7.5 Research limitations**

While this study has achieved certain results in analyzing the interactive relationships between project manager competence, team capabilities, and project performance, it also faces several limitations:

(1) Sample selection and geographical specificity

The research focused on Chinese private construction companies. The geographical and industry specificity may limit the generalizability of the conclusions, making it difficult to fully reflect the common rules of the global construction industry or other economic sectors.

(2) Limitations of data collection methods

Relying on questionnaire surveys as the primary data source facilitates large-scale information gathering, but the objectivity and accuracy of the data may be affected by the subjectivity of respondents, memory biases, and other factors. There is a lack of support from diverse data sources such as in-depth interviews or field investigations.

(3) Cautious inference of causal relationships

Although the analysis reveals correlations, statistical analysis based on cross-sectional data has limitations in establishing causal relationships. More rigorous experimental designs or time-series data analysis are needed to strengthen the argument.

## 7.6 Future research directions

Given the aforementioned limitations, future research can delve deeper from several dimensions:

(1) Global comparative analysis

Expand the scope of research to include cross-border comparative studies that analyze the similarities and differences in project manager capability models across different cultural backgrounds and legal systems, as well as their impact on project performance. This approach would enhance the universal applicability of the theories.

(2) Dynamic analysis and longitudinal tracking

Implement longitudinal research designs to focus on the growth paths of project manager competencies, the evolution of teams, and their dynamic effects on project performance. This would help capture changing trends and key turning points, providing insights into how project outcomes evolve over time.

(3) Integration of multimethodology

Combine quantitative and qualitative research methods, such as in-depth case studies and participatory observations, to analyze the complex web of relationships between project manager behavior, team interactions, and project outcomes in a more comprehensive and multidimensional manner.

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## **Annex A: Interview Outline**

### Basic Information:

1. Gender:

A. Male      B. Female

2. Age Range:

A. 25-35 years    B. 36-45 years    C. 46-55 years

3. Occupation:

A. Corporate Executive    B. Project Manager    C. Project Management Staff    D. Other  
Project Staff

4. Years of Work Experience:

A. 0-5 years    B. 6-10 years    C. More than 10 years

5. Education:

A. Junior College or Below    B. Bachelor's Degree    C. Master's Degree or Above

6. Professional Title:

A. Junior    B. Intermediate    C. Senior

### Competency Questions:

1. Please describe your role and responsibilities in engineering projects.
2. What do you believe are the main duties and responsibilities of a project manager?
3. In the engineering projects you have been involved in, which abilities and qualities do you think contribute to the project's success?
4. How do you interact with and guide the team you lead in your daily work?
5. Can you provide 2-3 examples of successful work experiences? Please summarize the characteristics and qualities that led to your success.
6. In your opinion, what knowledge and qualities are required for an excellent project manager?

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## **Annex B: Questionnaire for the Pre-test Survey**

Dear Sir/Madam,

Greetings! The theme of this research is "The Impact of Project Manager Competencies on Project Performance in Chinese Construction Enterprises." This questionnaire is a crucial component of this study. Your responses hold significant value for this research and will influence the final results. Please provide your answers as accurately as possible. Thank you once again for your support!

Instructions: To answer this questionnaire, simply check the appropriate boxes in the questionnaire.

1. Gender:

A. Male      B. Female

2. Age Range:

A. 25-35 years    B. 36-45 years    C. 46-55 years

3. Occupation:

A. Corporate Executive    B. Project Manager    C. Project Management Staff    D. Other  
Project Staff

4. Years of Work Experience:

A. 0-5 years    B. 6-10 years    C. More than 10 years

5. Education:

A. Junior College or Below    B. Bachelor's Degree    C. Master's Degree or Above

6. Professional Title:

A. Junior    B. Intermediate    C. Senior

Survey on Competency Indicators of Construction Enterprise Project Managers:

We have categorized managerial competency indicators into 5 levels. Based on your personal experience and understanding, please select the level that you believe best corresponds to each indicator. Check the appropriate box for each indicator.

1. Project Manager Competency Survey

| Level-1 indicator            | Level-2 indicator               | Item                                                                                                                                                                                         | Degree of importance |                    |           |                |                     |
|------------------------------|---------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|--------------------|-----------|----------------|---------------------|
|                              |                                 |                                                                                                                                                                                              | Not Important        | Slightly Important | Important | Very Important | Extremely Important |
| Personal Traits              | Responsibility                  | Enthusiastic about the current profession, demonstrating a strong sense of responsibility, and taking an active and responsible approach.                                                    |                      |                    |           |                |                     |
|                              | Execution Ability               | Ensuring the implementation of relevant plans for engineering projects.                                                                                                                      |                      |                    |           |                |                     |
|                              | Proactivity                     | Proactively fulfilling work responsibilities, and even spontaneously assisting others in completing tasks.                                                                                   |                      |                    |           |                |                     |
|                              | Communication                   | Effectively communicating one's viewpoints through written or verbal means, facilitating efficient communication.                                                                            |                      |                    |           |                |                     |
|                              | Self-Control                    | Maintaining a positive emotional state through self-control and effectively managing work-related stress.                                                                                    |                      |                    |           |                |                     |
| General Leadership Abilities | Team Building                   | Project managers excel at nurturing talents and forming project teams through various strategies, igniting team members' work enthusiasm, enhancing cohesion, and improving work efficiency. |                      |                    |           |                |                     |
|                              | Organizational and Coordination | Coordinating various stakeholders to accomplish diverse management tasks.                                                                                                                    |                      |                    |           |                |                     |

The Influence of Project Managers' Competency on Project Performance

|                                       |                          |                                                                                                                                                |  |  |  |  |  |
|---------------------------------------|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|
|                                       | Decision-Making          | Displaying decisiveness and implementing effective measures in various situations.                                                             |  |  |  |  |  |
|                                       | Analytical and Judgement | Decomposing complex work systems into manageable tasks.                                                                                        |  |  |  |  |  |
| Project-Specific Management Abilities | Planning and Management  | Developing different work plans for various stages and milestones of the project and ensuring their effective execution.                       |  |  |  |  |  |
|                                       | Risk Management          | Identifying and predicting project risks, proactively assuming risks, and addressing unforeseen events.                                        |  |  |  |  |  |
|                                       | Conflict Management      | Implementing effective measures to mitigate or even eliminate potential conflicts among various stakeholders.                                  |  |  |  |  |  |
|                                       | Progress Management      | Taking measures to minimize the gap between actual progress and planned progress, ensuring the achievement of schedule objectives.             |  |  |  |  |  |
|                                       | Cost Control             | Recognizing the importance of cost control and implementing effective measures to keep costs within a lower range.                             |  |  |  |  |  |
|                                       | Quality Control          | Implementing measures to eliminate hidden quality issues in the project and ensuring the attainment of quality objectives.                     |  |  |  |  |  |
|                                       | Contract Management      | Clearly defining the management scope of project contracts and managing the rights and obligations of all parties based on the contract terms. |  |  |  |  |  |

|  |                     |                                                                                                                         |  |  |  |  |  |
|--|---------------------|-------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|
|  | Technical Expertise | Possessing the necessary professional technical knowledge required for the engineering project.                         |  |  |  |  |  |
|  | Foresight           | Demonstrating good insight and foresight, accurately predicting the future of the project.                              |  |  |  |  |  |
|  | Innovation          | Actively adopting new construction technologies, methods, and techniques to achieve higher efficiency and cost savings. |  |  |  |  |  |

## 2. Employee Trust Scale

| No. | Item                                                                                                                                         | Degree of Alignment |                     |         |                  |                  |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------|---------------------|---------------------|---------|------------------|------------------|
|     |                                                                                                                                              | Strongly Misaligned | Somewhat Misaligned | Neutral | Somewhat Aligned | Strongly Aligned |
| 1   | I can freely communicate my inner thoughts and feelings to the project manager (Affective Trust).                                            |                     |                     |         |                  |                  |
| 2   | I can share challenging issues encountered in my work with the project manager, knowing that they will listen attentively (Affective Trust). |                     |                     |         |                  |                  |
| 3   | I have sufficient confidence in the project manager's abilities and the decisions they make (Cognitive Trust).                               |                     |                     |         |                  |                  |
| 4   | I believe that the project manager is completely reliable and trustworthy                                                                    |                     |                     |         |                  |                  |

|  |                    |  |  |  |  |  |
|--|--------------------|--|--|--|--|--|
|  | (Cognitive Trust). |  |  |  |  |  |
|--|--------------------|--|--|--|--|--|

### 3. Team Communication Scale

| No. | Item                                                                                               | Degree of Alignment |                     |         |                  |                  |
|-----|----------------------------------------------------------------------------------------------------|---------------------|---------------------|---------|------------------|------------------|
|     |                                                                                                    | Strongly Misaligned | Somewhat Misaligned | Neutral | Somewhat Aligned | Strongly Aligned |
| 1   | Team members clearly define project goals.                                                         |                     |                     |         |                  |                  |
| 2   | Project performance feedback is strictly implemented.                                              |                     |                     |         |                  |                  |
| 3   | When encountering challenging problems at work, other team members provide timely assistance       |                     |                     |         |                  |                  |
| 4   | Project information flows efficiently, ensuring every member is well-informed of relevant matters. |                     |                     |         |                  |                  |
| 5   | A harmonious communication atmosphere has been established within the team.                        |                     |                     |         |                  |                  |

### 4. Employee Training Scale

| No. | Item | Degree of Alignment |                     |         |                  |                  |
|-----|------|---------------------|---------------------|---------|------------------|------------------|
|     |      | Strongly Misaligned | Somewhat Misaligned | Neutral | Somewhat Aligned | Strongly Aligned |
|     |      |                     |                     |         |                  |                  |

The Influence of Project Managers' Competency on Project Performance

|   |                                                                                                                                                 |  |  |  |  |  |
|---|-------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|
| 1 | I am able to participate in the training provided by the company during work.                                                                   |  |  |  |  |  |
| 2 | The training content provided by the company is highly practical and can be directly applied to my job.                                         |  |  |  |  |  |
| 3 | After participating in the training provided by the company, my professional skill level has improved.                                          |  |  |  |  |  |
| 4 | Following the company's training, I have a deeper appreciation for the company's management philosophy and project teams.                       |  |  |  |  |  |
| 5 | After receiving training from the company, I have a more optimistic view of the company's future prospects and intend to grow with the company. |  |  |  |  |  |

5. Team Comprehensive Capability Scale

| Different perspectives | No. | Item                                                                    | Degree of Alignment |                     |         |                  |                  |
|------------------------|-----|-------------------------------------------------------------------------|---------------------|---------------------|---------|------------------|------------------|
|                        |     |                                                                         | Strongly Misaligned | Somewhat Misaligned | Neutral | Somewhat Aligned | Strongly Aligned |
| Employees              | 1   | I believe the project team possesses strong comprehensive capabilities. |                     |                     |         |                  |                  |

The Influence of Project Managers' Competency on Project Performance

|         |   |                                                                             |  |  |  |  |  |
|---------|---|-----------------------------------------------------------------------------|--|--|--|--|--|
|         | 2 | I would choose to stay and work diligently as a member of the project team. |  |  |  |  |  |
| Leaders | 1 | I have a lot of confidence in the project team's overall capabilities.      |  |  |  |  |  |
|         | 2 | I am very willing for the project team to remain in its current state.      |  |  |  |  |  |
| Clients | 1 | I have a lot of confidence in the project team's overall capabilities.      |  |  |  |  |  |
|         | 2 | I plan to continue collaborating with the project team in the future.       |  |  |  |  |  |

#### 6. Project Performance Scale

Quantifiable Section (Please complete only the non-subjective questions. This section will be filled out directly by the project manager's superiors.)

| No. | Item                                                                                                                                                                  | Level |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 1   | Project Progress (including five levels: Ahead of Schedule, On Schedule, 10% Extension of Schedule, 10-30% Extension of Schedule, 30% or More Extension of Schedule). |       |
| 2   | Project Quality (including five levels: All Quality Tests Passed as                                                                                                   |       |

The Influence of Project Managers' Competency on Project Performance

|   |                                                                                                                                                                                                                                                                                  |  |
|---|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
|   | Expected, Below Standard by Less Than 5%, Below Standard by 5-10%, Below Standard by 10-20%, Below Standard by More Than 20%).                                                                                                                                                   |  |
| 3 | Project Profit (including five levels: Achieved Budgeted Profit, Lower Profit by 0-5% Compared to Budget, Lower Profit by 5-10% Compared to Budget, Lower Profit by 10-15% Compared to Budget, Lower Profit by at Least 15% Compared to Budget).                                 |  |
| 4 | Project Safety (including five levels: No Accidents Occurred, Only a Few Minor Accidents Occurred, Several Minor Accidents Occurred with No Major Liability Safety Incidents, One Major Liability Safety Incident Occurred, Multiple Major Liability Safety Incidents Occurred). |  |

## **Annex C: Formal Questionnaire**

Dear Sir/Madam,

Greetings! The theme of this research is "The Impact of Project Manager Competencies on Project Performance in Chinese Construction Enterprises." This questionnaire is a crucial component of this study. Your responses hold significant value for this research and will influence the final results. Please provide your answers as accurately as possible. Thank you once again for your support!

Instructions: To answer this questionnaire, simply check the appropriate boxes in the questionnaire.

1. Gender:

A. Male      B. Female

2. Age Range:

A. 25-35 years    B. 36-45 years    C. 46-55 years

3. Occupation:

A. Corporate Executive    B. Project Manager    C. Project Management Staff    D. Other  
Project Staff

4. Years of Work Experience:

A. 0-5 years    B. 6-10 years    C. More than 10 years

5. Education:

A. Junior College or Below    B. Bachelor's Degree    C. Master's Degree or Above

6. Professional Title:

A. Junior    B. Intermediate    C. Senior

Survey on Competency Indicators of Construction Enterprise Project Managers:

We have categorized managerial competency indicators into 5 levels. Based on your personal experience and understanding, please select the level that you believe best corresponds to each indicator. Check the appropriate box for each indicator.

## 1. Project Manager Competency Survey

| Level-1 indicator            | Level-2 indicator               | Item                                                                                                                                                                                         | Degree of importance |                    |           |                |                     |
|------------------------------|---------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|--------------------|-----------|----------------|---------------------|
|                              |                                 |                                                                                                                                                                                              | Not Important        | Slightly Important | Important | Very Important | Extremely Important |
| Personal Traits              | Responsibility                  | Enthusiastic about the current profession, demonstrating a strong sense of responsibility, and taking an active and responsible approach.                                                    |                      |                    |           |                |                     |
|                              | Execution Ability               | Ensuring the implementation of relevant plans for engineering projects.                                                                                                                      |                      |                    |           |                |                     |
|                              | Proactivity                     | Proactively fulfilling work responsibilities, and even spontaneously assisting others in completing tasks.                                                                                   |                      |                    |           |                |                     |
|                              | Communication                   | Effectively communicating one's viewpoints through written or verbal means, facilitating efficient communication.                                                                            |                      |                    |           |                |                     |
|                              | Self-Control                    | Maintaining a positive emotional state through self-control and effectively managing work-related stress.                                                                                    |                      |                    |           |                |                     |
| General Leadership Abilities | Team Building                   | Project managers excel at nurturing talents and forming project teams through various strategies, igniting team members' work enthusiasm, enhancing cohesion, and improving work efficiency. |                      |                    |           |                |                     |
|                              | Organizational and Coordination | Coordinating various stakeholders to accomplish diverse management tasks.                                                                                                                    |                      |                    |           |                |                     |

The Influence of Project Managers' Competency on Project Performance

|                                       |                          |                                                                                                                                                |  |  |  |  |  |
|---------------------------------------|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|
|                                       | Decision-Making          | Displaying decisiveness and implementing effective measures in various situations.                                                             |  |  |  |  |  |
|                                       | Analytical and Judgement | Decomposing complex work systems into manageable tasks.                                                                                        |  |  |  |  |  |
| Project-Specific Management Abilities | Planning and Management  | Developing different work plans for various stages and milestones of the project and ensuring their effective execution.                       |  |  |  |  |  |
|                                       | Risk Management          | Identifying and predicting project risks, proactively assuming risks, and addressing unforeseen events.                                        |  |  |  |  |  |
|                                       | Conflict Management      | Implementing effective measures to mitigate or even eliminate potential conflicts among various stakeholders.                                  |  |  |  |  |  |
|                                       | Progress Management      | Taking measures to minimize the gap between actual progress and planned progress, ensuring the achievement of schedule objectives.             |  |  |  |  |  |
|                                       | Cost Control             | Recognizing the importance of cost control and implementing effective measures to keep costs within a lower range.                             |  |  |  |  |  |
|                                       | Quality Control          | Implementing measures to eliminate hidden quality issues in the project and ensuring the attainment of quality objectives.                     |  |  |  |  |  |
|                                       | Contract Management      | Clearly defining the management scope of project contracts and managing the rights and obligations of all parties based on the contract terms. |  |  |  |  |  |

|  |                     |                                                                                                                         |  |  |  |  |  |
|--|---------------------|-------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|
|  | Technical Expertise | Possessing the necessary professional technical knowledge required for the engineering project.                         |  |  |  |  |  |
|  | Foresight           | Demonstrating good insight and foresight, accurately predicting the future of the project.                              |  |  |  |  |  |
|  | Innovation          | Actively adopting new construction technologies, methods, and techniques to achieve higher efficiency and cost savings. |  |  |  |  |  |

## 2. Employee Trust Scale

| No. | Item                                                                                                                                         | Degree of Alignment |                     |         |                  |                  |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------|---------------------|---------------------|---------|------------------|------------------|
|     |                                                                                                                                              | Strongly Misaligned | Somewhat Misaligned | Neutral | Somewhat Aligned | Strongly Aligned |
| 1   | I can freely communicate my inner thoughts and feelings to the project manager (Affective Trust).                                            |                     |                     |         |                  |                  |
| 2   | I can share challenging issues encountered in my work with the project manager, knowing that they will listen attentively (Affective Trust). |                     |                     |         |                  |                  |
| 3   | I have sufficient confidence in the project manager's abilities and the decisions they make (Cognitive Trust).                               |                     |                     |         |                  |                  |
| 4   | I believe that the project manager is completely reliable and trustworthy                                                                    |                     |                     |         |                  |                  |

|  |                    |  |  |  |  |  |
|--|--------------------|--|--|--|--|--|
|  | (Cognitive Trust). |  |  |  |  |  |
|--|--------------------|--|--|--|--|--|

### 3. Team Communication Scale

| No. | Item                                                                                               | Degree of Alignment |                     |         |                  |                  |
|-----|----------------------------------------------------------------------------------------------------|---------------------|---------------------|---------|------------------|------------------|
|     |                                                                                                    | Strongly Misaligned | Somewhat Misaligned | Neutral | Somewhat Aligned | Strongly Aligned |
| 1   | Team members clearly define project goals.                                                         |                     |                     |         |                  |                  |
| 2   | Project performance feedback is strictly implemented.                                              |                     |                     |         |                  |                  |
| 3   | When encountering challenging problems at work, other team members provide timely assistance       |                     |                     |         |                  |                  |
| 4   | Project information flows efficiently, ensuring every member is well-informed of relevant matters. |                     |                     |         |                  |                  |
| 5   | A harmonious communication atmosphere has been established within the team.                        |                     |                     |         |                  |                  |

### 4. Employee Training Scale

| No. | Item | Degree of Alignment |                     |         |                  |                  |
|-----|------|---------------------|---------------------|---------|------------------|------------------|
|     |      | Strongly Misaligned | Somewhat Misaligned | Neutral | Somewhat Aligned | Strongly Aligned |
|     |      |                     |                     |         |                  |                  |

The Influence of Project Managers' Competency on Project Performance

|   |                                                                                                                                                 |  |  |  |  |  |
|---|-------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|
|   |                                                                                                                                                 |  |  |  |  |  |
| 1 | I am able to participate in the training provided by the company during work.                                                                   |  |  |  |  |  |
| 2 | The training content provided by the company is highly practical and can be directly applied to my job.                                         |  |  |  |  |  |
| 3 | After participating in the training provided by the company, my professional skill level has improved.                                          |  |  |  |  |  |
| 4 | Following the company's training, I have a deeper appreciation for the company's management philosophy and project teams.                       |  |  |  |  |  |
| 5 | After receiving training from the company, I have a more optimistic view of the company's future prospects and intend to grow with the company. |  |  |  |  |  |

5. Team Comprehensive Capability Scale

| Different perspectives | No. | Item                                        | Degree of Alignment |                     |         |                  |                  |
|------------------------|-----|---------------------------------------------|---------------------|---------------------|---------|------------------|------------------|
|                        |     |                                             | Strongly Misaligned | Somewhat Misaligned | Neutral | Somewhat Aligned | Strongly Aligned |
| Employees              | 1   | I believe the project team possesses strong |                     |                     |         |                  |                  |

|         |   |                                                                             |  |  |  |  |  |
|---------|---|-----------------------------------------------------------------------------|--|--|--|--|--|
|         |   | comprehensive capabilities.                                                 |  |  |  |  |  |
|         | 2 | I would choose to stay and work diligently as a member of the project team. |  |  |  |  |  |
| Leaders | 1 | I have a lot of confidence in the project team's overall capabilities.      |  |  |  |  |  |
|         | 2 | I am very willing for the project team to remain in its current state.      |  |  |  |  |  |
| Clients | 1 | I have a lot of confidence in the project team's overall capabilities.      |  |  |  |  |  |
|         | 2 | I plan to continue collaborating with the project team in the future.       |  |  |  |  |  |

#### 6. Project Performance Scale

Quantifiable Section (Please complete only the non-subjective questions. This section will be filled out directly by the project manager's superiors.)

| No. | Item                                                                                                                                          | Level |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 1   | Project Progress (including five levels: Ahead of Schedule, On Schedule, 10% Extension of Schedule, 10-30% Extension of Schedule, 30% or More |       |

The Influence of Project Managers' Competency on Project Performance

|   |                                                                                                                                                                                                                                                                                  |  |
|---|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
|   | Extension of Schedule).                                                                                                                                                                                                                                                          |  |
| 2 | Project Quality (including five levels: All Quality Tests Passed as Expected, Below Standard by Less Than 5%, Below Standard by 5-10%, Below Standard by 10-20%, Below Standard by More Than 20%).                                                                               |  |
| 3 | Project Profit (including five levels: Achieved Budgeted Profit, Lower Profit by 0-5% Compared to Budget, Lower Profit by 5-10% Compared to Budget, Lower Profit by 10-15% Compared to Budget, Lower Profit by at Least 15% Compared to Budget).                                 |  |
| 4 | Project Safety (including five levels: No Accidents Occurred, Only a Few Minor Accidents Occurred, Several Minor Accidents Occurred with No Major Liability Safety Incidents, One Major Liability Safety Incident Occurred, Multiple Major Liability Safety Incidents Occurred). |  |

## Annex D: Other Tables

Table D.1 Compositions of project manager competency

| Project Manager Competencies                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Source                         |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
| A questionnaire was used to summarize 18 characteristics of effective project managers, such as delegating authority and providing good technical support.                                                                                                                                                                                                                                                                                                                                                                           | Walsh (1988)                   |
| To summarize the characteristics of excellent project managers of Chinese construction companies, comb through the existing literature to understand the skills and personality traits they should possess, including their skills in management, interpersonal, and communication; their abilities in team management, system analysis, and coping with stress; and their personality traits such as adaptability, flexibility, and perseverance that they possess.                                                                 | Pettersen (1991)               |
| The behavior of project managers in domestic private construction enterprises includes two kinds: integrating projects and leading teams. The former is characterized by the project manager assembling the project's subsystems and all members of the team into a whole, with the scope of responsibilities covering planning, controlling, coordinating, communicating, etc.; the latter is mainly responsible for motivating the team members, obtaining support from the top level, and cooperating with external stakeholders. | Robert and Goodwin (1993)      |
| The key competencies of project managers in domestic private construction companies lie in management skills, as well as analyzing and judging, accepting reasonable suggestions from subordinates, and emphasizing collaboration.                                                                                                                                                                                                                                                                                                   | Donnelly and Kezsbom (1994)    |
| The 20 skills required of project managers in domestic private construction enterprises were extracted and a questionnaire survey was conducted, which showed that the five most important skills for project managers are, in order: communication, listening, project management, decision-making, leadership and motivation.                                                                                                                                                                                                      | Gushgari (1997)                |
| The results of the research show that today's project managers should not only have knowledge of the nine areas of project management, but also knowledge in the areas of finance and accounting, sales and marketing, and personal time management; and that the skills they should have been reflected in four areas, namely, leadership, communication, negotiation, and problem-solving skills.                                                                                                                                  | Edum-Fotwe and McCaffer (2000) |
| The analysis was conducted using the behavioral event interview method to distill 12 competency elements for engineering project managers, such as competencies in self-control, teamwork, and information-seeking, as well as conceptual and analytical thinking.                                                                                                                                                                                                                                                                   | M. I. Cheng et al. (2005)      |
| A study was conducted for private construction companies in China, using questionnaires and expert interviews to determine that the most important competencies lie in moral character, practical on-site skills, and learning ability.                                                                                                                                                                                                                                                                                              | Shi et al. (2014)              |
| A questionnaire survey was conducted to analyze the project managers of domestic private construction enterprises, and a model of engineering project manager's competency characteristics was constructed from six dimensions, including cognitive skills, social skills, and resource management skills.                                                                                                                                                                                                                           | Wang et al. (2014)             |
| Measuring the competency characteristics of project managers in domestic private construction enterprises, we establish a model of engineering project manager competency characteristics covering four dimensions, namely, emotional intelligence, charisma, project management and cognition, and                                                                                                                                                                                                                                  | Zhang et al. (2013)            |

demonstrate its validity.

Through structural equation modeling to analyze the main factors related to the competence of project managers in domestic private construction enterprises, according to the degree of influence in descending order of comprehensive management ability, personal traits, professional knowledge. Dong (2016)

Table D.2 Relevance descriptions of competency elements for project managers in Chinese construction companies

| No. | Competency elements             | Competency Element Characterization                                                                                                                                                          |
|-----|---------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | Responsibility                  | Enthusiastic about the current profession, demonstrating a strong sense of responsibility, and taking an active and responsible approach.                                                    |
| 2   | Execution Ability               | Ensuring the implementation of relevant plans for engineering projects.                                                                                                                      |
| 3   | Proactivity                     | Proactively fulfilling work responsibilities, and even spontaneously assisting others in completing tasks.                                                                                   |
| 4   | Communication                   | Effectively communicating one's viewpoints through written or verbal means, facilitating efficient communication.                                                                            |
| 5   | Team Building                   | Project managers excel at nurturing talents and forming project teams through various strategies, igniting team members' work enthusiasm, enhancing cohesion, and improving work efficiency. |
| 6   | Organizational and Coordination | Coordinating various stakeholders to accomplish diverse management tasks.                                                                                                                    |
| 7   | Decision-Making                 | Displaying decisiveness and implementing effective measures in various situations.                                                                                                           |
| 8   | Analytical and Judgement        | Decomposing complex work systems into manageable tasks.                                                                                                                                      |
| 9   | Planning and Management         | Developing different work plans for various stages and milestones of the project and ensuring their effective execution.                                                                     |
| 10  | Risk Management                 | Identifying and predicting project risks, proactively assuming risks, and addressing unforeseen events.                                                                                      |
| 11  | Conflict Management             | Implementing effective measures to mitigate or even eliminate potential conflicts among various stakeholders.                                                                                |
| 12  | Progress Management             | Taking measures to minimize the gap between actual progress and planned progress, ensuring the achievement of schedule objectives.                                                           |
| 13  | Cost Control                    | Recognizing the importance of cost control and implementing effective measures to keep costs within a lower range.                                                                           |
| 14  | Quality Control                 | Implementing measures to eliminate hidden quality issues in the project and ensuring the attainment of quality objectives.                                                                   |
| 15  | Contract Management             | Clearly defining the management scope of project contracts and managing the rights and obligations of all parties based on the contract terms.                                               |
| 16  | Technical Expertise             | Possessing the necessary professional technical knowledge required for the engineering project.                                                                                              |
| 17  | Foresight                       | Demonstrating good insight and foresight, accurately predicting the future of the project.                                                                                                   |
| 18  | Innovation                      | Actively adopting new construction technologies, methods, and techniques to achieve higher efficiency and cost savings.                                                                      |
| 19  | Self-Control                    | Maintaining a positive emotional state through self-control and effectively managing work-related stress.                                                                                    |
| 20  | Resilience                      | Maintaining composure and rational thinking in the face of challenges, aiming to swiftly resolve difficult problems in the most effective manner.                                            |

|    |                          |                                                                                                                                                                             |
|----|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 21 | Holistic Perspective     | Skillfully balancing both overarching objectives and localized interests, capable of analyzing and observing from multiple angles and layers.                               |
| 22 | Self-confidence          | Demonstrates confidence and strength even in difficult situations                                                                                                           |
| 23 | Honesty and Integrity    | Adhering to truthfulness and credibility, swiftly gaining the trust of other relevant stakeholders.                                                                         |
| 24 | Adaptability             | Swiftly adjusting to new project management environments, efficiently immersing oneself in the tasks at hand.                                                               |
| 25 | Rational Task Allocation | Grasping the bigger picture, accurately comprehending the characteristics of project personnel and job responsibilities, and assigning tasks based on project requirements. |
| 26 | Mentoring                | Willingness to nurture others, actively tracking their needs and skill levels, and proactively sharing personal knowledge, skills, and experiences.                         |

Table D.3 Fact sheet of interviewees

| Item                 | Composition      | Sample size | Percentage |
|----------------------|------------------|-------------|------------|
| Gender               | Male             | 21          | 80.80%     |
|                      | Female           | 5           | 19.20%     |
| Age                  | 25-35            | 16          | 61.50%     |
|                      | 36-45            | 7           | 27.00%     |
|                      | 46-55            | 3           | 11.50%     |
| Education Background | junior college   | 3           | 11.50%     |
|                      | Bachelor         | 18          | 69.20%     |
|                      | Master and above | 5           | 19.20%     |
| Position             | Executives       | 3           | 11.50%     |
|                      | Project manager  | 23          | 88.50%     |
| Years of Experience  | 3-5 years        | 6           | 23.10%     |
|                      | 5-10 years       | 12          | 46.20%     |
|                      | 10-20 years      | 5           | 19.20%     |
|                      | 20-30 years      | 3           | 11.50%     |
| Professional Title   | Junior level     | 7           | 26.90%     |
|                      | Middle level     | 17          | 65.40%     |
|                      | High level       | 2           | 7.70%      |

Table D.4 Descriptions of competency characteristic indicators

|                              | Competency Characteristic | Description                                                                                                                                                                                  |
|------------------------------|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Personal Traits              | 1 Responsibility          | Enthusiastic about the current profession, demonstrating a strong sense of responsibility, and taking an active and responsible approach.                                                    |
|                              | 2 Execution Ability       | Ensuring the implementation of relevant plans for engineering projects.                                                                                                                      |
|                              | 3 Proactivity             | Proactively fulfilling work responsibilities, and even spontaneously assisting others in completing tasks.                                                                                   |
|                              | 4 Communication           | Effectively communicating one's viewpoints through written or verbal means, facilitating efficient communication.                                                                            |
|                              | 5 Self-Control            | Maintaining a positive emotional state through self-control and effectively managing work-related stress.                                                                                    |
| General Leadership Abilities | 6 Team Building           | Project managers excel at nurturing talents and forming project teams through various strategies, igniting team members' work enthusiasm, enhancing cohesion, and improving work efficiency. |

|                                             |    |                                    |                                                                                                                                                      |
|---------------------------------------------|----|------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| Project-Specific<br>Management<br>Abilities | 7  | Organizational<br>and Coordination | Coordinating various stakeholders to accomplish<br>diverse management tasks.                                                                         |
|                                             | 8  | Decision-Making                    | Displaying decisiveness and implementing effective<br>measures in various situations.                                                                |
|                                             | 9  | Analytical and<br>Judgement        | Decomposing complex work systems into manageable<br>tasks.                                                                                           |
|                                             | 10 | Planning and<br>Management         | Developing different work plans for various stages and<br>milestones of the project and ensuring their effective<br>execution.                       |
|                                             | 11 | Risk<br>Management                 | Identifying and predicting project risks, proactively<br>assuming risks, and addressing unforeseen events.                                           |
|                                             | 12 | Conflict<br>Management             | Implementing effective measures to mitigate or even<br>eliminate potential conflicts among various<br>stakeholders.                                  |
|                                             | 13 | Progress<br>Management             | Taking measures to minimize the gap between actual<br>progress and planned progress, ensuring the<br>achievement of schedule objectives.             |
|                                             | 14 | Cost Control                       | Recognizing the importance of cost control and<br>implementing effective measures to keep costs within a<br>lower range.                             |
|                                             | 15 | Quality Control                    | Implementing measures to eliminate hidden quality<br>issues in the project and ensuring the attainment of<br>quality objectives.                     |
|                                             | 16 | Contract<br>Management             | Clearly defining the management scope of project<br>contracts and managing the rights and obligations of all<br>parties based on the contract terms. |
|                                             | 17 | Technical<br>Expertise             | Possessing the necessary professional technical<br>knowledge required for the engineering project.                                                   |
|                                             | 18 | Foresight                          | Demonstrating good insight and foresight, accurately<br>predicting the future of the project.                                                        |
|                                             | 19 | Innovation                         | Actively adopting new construction technologies,<br>methods, and techniques to achieve higher efficiency<br>and cost savings.                        |

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Table D.5 Employee Trust Scale

| Item                                                                                                                                         | Degree of Alignment |                    |         |              |             |
|----------------------------------------------------------------------------------------------------------------------------------------------|---------------------|--------------------|---------|--------------|-------------|
|                                                                                                                                              | Fully Aligned       | Moderately Aligned | Aligned | Less Aligned | Not Aligned |
| I can freely communicate my inner thoughts and feelings to the project manager (Affective Trust).                                            |                     |                    |         |              |             |
| I can share challenging issues encountered in my work with the project manager, knowing that they will listen attentively (Affective Trust). |                     |                    |         |              |             |
| I have sufficient confidence in the project manager's abilities and the decisions they make (Cognitive Trust).                               |                     |                    |         |              |             |
| I believe that the project manager is completely reliable and trustworthy (Cognitive Trust).                                                 |                     |                    |         |              |             |

Table D.6 Team Communication Scale

| No. | Item                                                                                               | Degree of Alignment |                    |         |              |             |
|-----|----------------------------------------------------------------------------------------------------|---------------------|--------------------|---------|--------------|-------------|
|     |                                                                                                    | Fully Aligned       | Moderately Aligned | Aligned | Less Aligned | Not Aligned |
| 1   | Team members clearly define project goals.                                                         |                     |                    |         |              |             |
| 2   | Project performance feedback is strictly implemented.                                              |                     |                    |         |              |             |
| 3   | When encountering challenging problems at work, other team members provide timely assistance       |                     |                    |         |              |             |
| 4   | Project information flows efficiently, ensuring every member is well-informed of relevant matters. |                     |                    |         |              |             |
| 5   | A harmonious communication atmosphere has been established within the team.                        |                     |                    |         |              |             |

Table D.7 Employee Training Scale

| No. | Item                                                                                                                      | Degree of Alignment |                    |         |              |             |
|-----|---------------------------------------------------------------------------------------------------------------------------|---------------------|--------------------|---------|--------------|-------------|
|     |                                                                                                                           | Fully Aligned       | Moderately Aligned | Aligned | Less Aligned | Not Aligned |
| 1   | I am able to participate in the training provided by the company during work.                                             |                     |                    |         |              |             |
| 2   | The training content provided by the company is highly practical and can be directly applied to my job.                   |                     |                    |         |              |             |
| 3   | After participating in the training provided by the company, my professional skill level has improved.                    |                     |                    |         |              |             |
| 4   | Following the company's training, I have a deeper appreciation for the company's management philosophy and project teams. |                     |                    |         |              |             |

- 5 After receiving training from the company, I have a more optimistic view of the company's future prospects and intend to grow with the company.

Table D.8 Team Comprehensive Capability Scale

| Perspectives | No. | Item                                                                        | Degree of Alignment |                    |         |              |             |
|--------------|-----|-----------------------------------------------------------------------------|---------------------|--------------------|---------|--------------|-------------|
|              |     |                                                                             | Fully Aligned       | Moderately Aligned | Aligned | Less Aligned | Not Aligned |
| Employee     | 1   | I believe the project team possesses strong comprehensive capabilities.     |                     |                    |         |              |             |
|              | 2   | I would choose to stay and work diligently as a member of the project team. |                     |                    |         |              |             |
| Leaders      | 1   | I have a lot of confidence in the project team's overall capabilities.      |                     |                    |         |              |             |
|              | 2   | I am very willing for the project team to remain in its current state.      |                     |                    |         |              |             |
| Clients      | 1   | I have a lot of confidence in the project team's overall capabilities.      |                     |                    |         |              |             |
|              | 2   | I plan to continue collaborating with the project team in the future.       |                     |                    |         |              |             |

Table D.9 Project Performance Scale

| No. | Item                                                                                                                                                                                                                                                                             | Level |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 1   | Project Progress (including five levels: ahead of schedule, on schedule, 10% extension of schedule, 10-30% extension of schedule, 30% or more extension of schedule).                                                                                                            |       |
| 2   | Project Quality (including five levels: all quality tests passed as expected, below standard by less than 5%, below standard by 5-10%, below standard by 10-20%, below standard by more than 20%).                                                                               |       |
| 3   | Project Profit (including five levels: achieved budgeted profit, lower profit by 0-5% compared to budget, lower profit by 5-10% compared to budget, lower profit by 10-15% compared to budget, lower profit by at least 15% compared to budget).                                 |       |
| 4   | Project Safety (including five levels: no accidents occurred, only a few minor accidents occurred, several minor accidents occurred with no major liability safety incidents, one major liability safety incident occurred, multiple major liability safety incidents occurred). |       |

Table D.10 Fact sheet of survey respondents

| Item                      | Indicator                    | Quantity | Proportion |
|---------------------------|------------------------------|----------|------------|
| Gender                    | Male                         | 141      | 91.56%     |
|                           | Female                       | 13       | 8.44%      |
| Position                  | Executives                   | 12       | 7.79%      |
|                           | Project Managers             | 80       | 51.95%     |
|                           | Project Management Personnel | 47       | 30.52%     |
| Age                       | Project Member               | 15       | 9.74%      |
|                           | Below 26                     | 15       | 9.74%      |
|                           | 26-35                        | 77       | 50.00%     |
|                           | 36-45                        | 47       | 30.52%     |
|                           | Above 44                     | 15       | 9.74%      |
| Education background      | Below junior college         | 0        | 0.00%      |
|                           | Junior college               | 13       | 8.44%      |
|                           | Bachelor                     | 94       | 61.04%     |
|                           | Master and above             | 47       | 30.52%     |
| Length of Work Experience | 0-3 years                    | 15       | 9.74%      |
|                           | 3-6 years                    | 49       | 31.82%     |
|                           | 6-10 years                   | 28       | 18.18%     |
|                           | Above 10 years               | 62       | 40.26%     |

Table D.11 Cronbach's  $\alpha$  reliability analysis

| Item                                                                                                                                         | CITC  | Coefficient with Item Removed | Cronbach's $\alpha$ Coefficient |
|----------------------------------------------------------------------------------------------------------------------------------------------|-------|-------------------------------|---------------------------------|
| 1. Enthusiastic about the current profession, demonstrating a strong sense of responsibility, and taking an active and responsible approach. | 0.656 | 0.905                         | 0.911                           |
| 2. Ensuring the implementation of relevant plans for engineering projects.                                                                   | 0.627 | 0.905                         |                                 |
| 3. Proactively fulfilling work responsibilities, and even spontaneously assisting others in completing tasks.                                | 0.675 | 0.904                         |                                 |
| 4. Effectively communicating one's viewpoints through written or verbal means, facilitating efficient communication.                         | 0.618 | 0.905                         |                                 |
| 5. Maintaining a positive emotional state through self-control and effectively managing work-related stress.                                 | 0.459 | 0.909                         |                                 |
| 6. Project managers excel at nurturing talents and                                                                                           | 0.633 | 0.905                         |                                 |

|                                                                                                                                                    |       |       |
|----------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|
| forming project teams through various strategies, igniting team members' work enthusiasm, enhancing cohesion, and improving work efficiency.       |       |       |
| 7. Coordinating various stakeholders to accomplish diverse management tasks.                                                                       | 0.654 | 0.905 |
| 8. Displaying decisiveness and implementing effective measures in various situations.                                                              | 0.626 | 0.905 |
| 9. Decomposing complex work systems into manageable tasks.                                                                                         | 0.697 | 0.903 |
| 10. Developing different work plans for various stages and milestones of the project and ensuring their effective execution.                       | 0.718 | 0.903 |
| 11. Identifying and predicting project risks, proactively assuming risks, and addressing unforeseen events.                                        | 0.672 | 0.904 |
| 12. Implementing effective measures to mitigate or even eliminate potential conflicts among various stakeholders.                                  | 0.639 | 0.905 |
| 13. Taking measures to minimize the gap between actual progress and planned progress, ensuring the achievement of schedule objectives.             | 0.666 | 0.905 |
| 14. Recognizing the importance of cost control and implementing effective measures to keep costs within a lower range.                             | 0.636 | 0.905 |
| 15. Implementing measures to eliminate hidden quality issues in the project and ensuring the attainment of quality objectives.                     | 0.684 | 0.904 |
| 16. Clearly defining the management scope of project contracts and managing the rights and obligations of all parties based on the contract terms. | 0.679 | 0.904 |
| 17. Possessing the necessary professional technical knowledge required for the engineering project.                                                | 0.668 | 0.904 |
| 18. Demonstrating good insight and foresight, accurately predicting the future of the project.                                                     | 0.152 | 0.938 |
| 19. Actively adopting new construction technologies, methods, and techniques to achieve higher efficiency and cost savings.                        | 0.567 | 0.907 |

# The Influence of Project Managers' Competency on Project Performance

Table D.12 Pearson correlation results

|     |                           | Q1     | Q2     | Q3     | Q4     | Q5     | Q6     | Q7     | Q8     | Q9     | Q10    | Q11    | Q12    | Q13    | Q14    | Q15    | Q16    | Q17    | Q19    |
|-----|---------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Q1  | Pearson Correlation       | 1      | .447** | .524** | .428** | .250** | .420** | .605** | .460** | .511** | .496** | .417** | .594** | .402** | .406** | .480** | .463** | .471** | .355** |
|     | Significance (Two-Tailed) |        | .000   | .000   | .000   | .002   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   |
|     | N                         | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    |
| Q2  | Pearson Correlation       | .447** | 1      | .420** | .402** | .265** | .514** | .549** | .397** | .410** | .458** | .479** | .408** | .399** | .436** | .409** | .550** | .487** | .408** |
|     | Significance (Two-Tailed) | .000   |        | .000   | .000   | .001   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   |
|     | N                         | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    |
| Q3  | Pearson Correlation       | .524** | .420** | 1      | .403** | .383** | .445** | .440** | .530** | .553** | .624** | .483** | .536** | .472** | .520** | .421** | .524** | .512** | .351** |
|     | Significance (Two-Tailed) | .000   | .000   |        | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   |
|     | N                         | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    |
| Q4  | Pearson Correlation       | .428** | .402** | .403** | 1      | .374** | .429** | .515** | .399** | .359** | .384** | .568** | .475** | .413** | .389** | .630** | .474** | .390** | .285** |
|     | Significance (Two-Tailed) | .000   | .000   | .000   |        | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   |
|     | N                         | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    |
| Q5  | Pearson Correlation       | .250** | .265** | .383** | .374** | 1      | .340** | .268** | .436** | .334** | .339** | .349** | .374** | .328** | .311** | .342** | .313** | .286** | .424** |
|     | Significance (Two-Tailed) | .002   | .001   | .000   | .000   |        | .000   | .001   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   |
|     | N                         | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    |
| Q6  | Pearson Correlation       | .420** | .514** | .445** | .429** | .340** | 1      | .504** | .498** | .493** | .455** | .426** | .445** | .439** | .458** | .363** | .511** | .542** | .467** |
|     | Significance (Two-Tailed) | .000   | .000   | .000   | .000   | .000   |        | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   |
|     | N                         | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    |
| Q7  | Pearson Correlation       | .605** | .549** | .440** | .515** | .268** | .504** | 1      | .433** | .427** | .495** | .430** | .446** | .454** | .435** | .486** | .467** | .409** | .379** |
|     | Significance (Two-Tailed) | .000   | .000   | .000   | .000   | .001   | .000   |        | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   |
|     | N                         | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    |
| Q8  | Pearson Correlation       | .460** | .397** | .530** | .399** | .436** | .498** | .433** | 1      | .548** | .499** | .467** | .525** | .412** | .444** | .414** | .568** | .479** | .433** |
|     | Significance (Two-Tailed) | .000   | .000   | .000   | .000   | .000   | .000   | .000   |        | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   |
|     | N                         | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    |
| Q9  | Pearson Correlation       | .511** | .410** | .553** | .359** | .334** | .493** | .427** | .548** | 1      | .611** | .593** | .369** | .707** | .445** | .490** | .497** | .526** | .417** |
|     | Significance (Two-Tailed) | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   |        | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   |
|     | N                         | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    |
| Q10 | Pearson Correlation       | .496** | .458** | .624** | .483** | .536** | .472** | .520** | .421** | .524** | 1      | .557** | .415** | .539** | .787** | .474** | .580** | .489** | .466** |
|     | Significance (Two-Tailed) | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   |        | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   |
|     | N                         | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    |
| Q11 | Pearson Correlation       | .417** | .594** | .402** | .406** | .480** | .463** | .471** | .355** |        |        | 1      | .429** | .601** | .426** | .814** | .482** | .485** | .402** |
|     | Significance (Two-Tailed) |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
|     | N                         | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    |

# The Influence of Project Managers' Competency on Project Performance

|   |                              |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
|---|------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 1 | Significance<br>(Two-Tailed) | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   |        | .000   | .000   | .000   | .000   | .000   | .000   | .000   |
|   | N                            | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    |
| Q | Pearson                      | .594** | .408** | .536** | .475** | .374** | .445** | .446** | .525** | .369** | .415** | .429** | 1      | .384** | .371** | .445** | .502** | .503** | .331** |
| 1 | Correlation                  |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| 2 | Significance<br>(Two-Tailed) | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   |        | .000   | .000   | .000   | .000   | .000   | .000   |
|   | N                            | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    |
| Q | Pearson                      | .402** | .399** | .472** | .413** | .328** | .439** | .454** | .412** | .707** | .539** | .601** | .384** | 1      | .435** | .592** | .470** | .416** | .487** |
| 1 | Correlation                  |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| 3 | Significance<br>(Two-Tailed) | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   |        | .000   | .000   | .000   | .000   | .000   |
|   | N                            | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    |
| Q | Pearson                      | .406** | .436** | .520** | .389** | .311** | .458** | .435** | .444** | .445** | .787** | .426** | .371** | .435** | 1      | .403** | .529** | .452** | .510** |
| 1 | Correlation                  |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| 4 | Significance<br>(Two-Tailed) | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   |        | .000   | .000   | .000   | .000   |
|   | N                            | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    |
| Q | Pearson                      | .480** | .409** | .421** | .630** | .342** | .363** | .486** | .414** | .490** | .474** | .814** | .445** | .592** | .403** | 1      | .471** | .470** | .361** |
| 1 | Correlation                  |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| 5 | Significance<br>(Two-Tailed) | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   |        | .000   | .000   | .000   |
|   | N                            | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    |
| Q | Pearson                      | .463** | .550** | .524** | .474** | .313** | .511** | .467** | .568** | .497** | .580** | .482** | .502** | .470** | .529** | .471** | 1      | .464** | .406** |
| 1 | Correlation                  |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| 6 | Significance<br>(Two-Tailed) | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   |        | .000   | .000   |
|   | N                            | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    |
| Q | Pearson                      | .471** | .487** | .512** | .390** | .286** | .542** | .409** | .479** | .526** | .489** | .485** | .503** | .416** | .452** | .470** | .464** | 1      | .447** |
| 1 | Correlation                  |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| 7 | Significance<br>(Two-Tailed) | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   |        | .000   |
|   | N                            | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    |
| Q | Pearson                      | .355** | .408** | .351** | .285** | .424** | .467** | .379** | .433** | .417** | .466** | .402** | .331** | .487** | .510** | .361** | .406** | .447** | 1      |
| 1 | Correlation                  |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| 9 | Significance<br>(Two-Tailed) | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   | .000   |
|   | N                            | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    | 154    |

Table D.13 Statistics of low- and high-level groups

|     | Group | Number | Mean (E) | S      | Standard error of the mean |
|-----|-------|--------|----------|--------|----------------------------|
| Q1  | Low   | 77     | 3.104    | .8364  | .0953                      |
|     | High  | 77     | 4.221    | .7885  | .0899                      |
| Q2  | Low   | 77     | 3.273    | 1.0083 | .1149                      |
|     | High  | 77     | 4.390    | .6912  | .0788                      |
| Q3  | Low   | 77     | 3.026    | .9730  | .1109                      |
|     | High  | 77     | 4.325    | .6578  | .0750                      |
| Q4  | Low   | 77     | 3.208    | 1.1509 | .1312                      |
|     | High  | 77     | 4.286    | .5586  | .0637                      |
| Q5  | Low   | 77     | 3.688    | .8924  | .1017                      |
|     | High  | 77     | 4.364    | .6050  | .0689                      |
| Q6  | Low   | 77     | 2.987    | 1.1527 | .1314                      |
|     | High  | 77     | 4.325    | .6165  | .0703                      |
| Q7  | Low   | 77     | 3.065    | .9081  | .1035                      |
|     | High  | 77     | 4.234    | .7236  | .0825                      |
| Q8  | Low   | 77     | 2.727    | .7718  | .0880                      |
|     | High  | 77     | 4.325    | .7854  | .0895                      |
| Q9  | Low   | 77     | 2.753    | 1.0151 | .1157                      |
|     | High  | 77     | 4.208    | .7667  | .0874                      |
| Q10 | Low   | 77     | 2.545    | .9111  | .1038                      |
|     | High  | 77     | 4.234    | .6863  | .0782                      |
| Q11 | Low   | 77     | 3.104    | .9260  | .1055                      |
|     | High  | 77     | 4.364    | .7054  | .0804                      |
| Q12 | Low   | 77     | 3.156    | .9468  | .1079                      |
|     | High  | 77     | 4.182    | .8542  | .0973                      |
| Q13 | Low   | 77     | 3.325    | .9381  | .1069                      |
|     | High  | 77     | 4.299    | .6084  | .0693                      |
| Q14 | Low   | 77     | 2.935    | .9643  | .1099                      |
|     | High  | 77     | 4.234    | .6668  | .0760                      |
| Q15 | Low   | 77     | 3.247    | 1.0407 | .1186                      |
|     | High  | 77     | 4.312    | .6932  | .0790                      |
| Q16 | Low   | 77     | 2.935    | .9225  | .1051                      |
|     | High  | 77     | 4.312    | .6932  | .0790                      |
| Q17 | Low   | 77     | 3.052    | 1.1909 | .1357                      |
|     | High  | 77     | 4.442    | .6385  | .0728                      |
| Q19 | Low   | 77     | 3.468    | 1.0710 | .1220                      |
|     | High  | 77     | 4.481    | .5985  | .0682                      |

Table D.14 Independent sample test of competency characteristic elements for project managers in construction companies

|    |                                       | Levene's Homogeneity of Variance Test |              | Independent Samples t-test for Equality of Means |                    |                           |                 |                              |                                       |             |
|----|---------------------------------------|---------------------------------------|--------------|--------------------------------------------------|--------------------|---------------------------|-----------------|------------------------------|---------------------------------------|-------------|
|    |                                       | F                                     | Significance | t                                                | Degrees of Freedom | Significance (Two-Tailed) | Mean Difference | Standard Error of Difference | 95% Confidence Interval of Difference |             |
|    |                                       |                                       |              |                                                  |                    |                           |                 |                              | Lower Limit                           | Upper Limit |
| Q1 | Assuming Homogeneity of Variances     | .018                                  | .893         | -8.526                                           | 152                | .000                      | -1.1169         | .1310                        | -1.3757                               | -.8581      |
|    | Not Assuming Homogeneity of Variances |                                       |              | -8.526                                           | 151.473            | .000                      | -1.1169         | .1310                        | -1.3757                               | -.8581      |
| Q2 | Assuming Homogeneity of Variances     | 6.285                                 | .013         | -8.017                                           | 152                | .000                      | -1.1169         | .1393                        | -1.3921                               | -.8416      |
|    | Not Assuming Homogeneity of Variances |                                       |              | -8.017                                           | 134.508            | .000                      | -1.1169         | .1393                        | -1.3924                               | -.8413      |
| Q3 | Assuming Homogeneity of Variances     | 2.044                                 | .155         | -9.703                                           | 152                | .000                      | -1.2987         | .1338                        | -1.5631                               | -1.0343     |
|    | Not Assuming Homogeneity of Variances |                                       |              | -9.703                                           | 133.466            | .000                      | -1.2987         | .1338                        | -1.5634                               | -1.0340     |
| Q4 | Assuming Homogeneity of Variances     | 31.919                                | .000         | -7.393                                           | 152                | .000                      | -1.0779         | .1458                        | -1.3660                               | -.7899      |
|    | Not Assuming Homogeneity of Variances |                                       |              | -7.393                                           | 109.922            | .000                      | -1.0779         | .1458                        | -1.3669                               | -.7890      |
| Q5 | Assuming Homogeneity of Variances     | 7.914                                 | .006         | -5.497                                           | 152                | .000                      | -.6753          | .1229                        | -.9181                                | -.4326      |
|    | Not Assuming Homogeneity of Variances |                                       |              | -5.497                                           | 133.681            | .000                      | -.6753          | .1229                        | -.9183                                | -.4323      |
| Q6 | Assuming Homogeneity of Variances     | 11.532                                | .001         | -8.979                                           | 152                | .000                      | -1.3377         | .1490                        | -1.6320                               | -1.0433     |
|    | Not Assuming Homogeneity of Variances |                                       |              | -8.979                                           | 116.186            | .000                      | -1.3377         | .1490                        | -1.6327                               | -1.0426     |
| Q7 | Assuming Homogeneity of Variances     | .850                                  | .358         | -8.833                                           | 152                | .000                      | -1.1688         | .1323                        | -1.4303                               | -.9074      |
|    | Not Assuming Homogeneity of Variances |                                       |              | -8.833                                           | 144.780            | .000                      | -1.1688         | .1323                        | -1.4304                               | -.9073      |
| Q8 | Assuming Homogeneity of Variances     | .359                                  | .550         | -12.729                                          | 152                | .000                      | -1.5974         | .1255                        | -1.8453                               | -1.3495     |
|    | Not Assuming Homogeneity of Variances |                                       |              | -12.729                                          | 151.954            | .000                      | -1.5974         | .1255                        | -1.8453                               | -1.3495     |
| Q9 | Assuming Homogeneity of Variances     | 3.720                                 | .056         | -10.03                                           | 152                | .000                      | -1.4545         | .1450                        | -1.7410                               | -1.1681     |

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|     |                                       |        |      |        |         |      |         |       |         |         |
|-----|---------------------------------------|--------|------|--------|---------|------|---------|-------|---------|---------|
|     |                                       |        |      | 3      |         |      |         |       |         |         |
|     | Not Assuming Homogeneity of Variances |        |      | -10.03 | 141.422 | .000 | -1.4545 | .1450 | -1.7411 | -1.1680 |
| Q10 | Assuming Homogeneity of Variances     | 9.006  | .003 | -12.98 | 152     | .000 | -1.6883 | .1300 | -1.9451 | -1.4315 |
|     |                                       |        |      | 8      |         |      |         |       |         |         |
|     | Not Assuming Homogeneity of Variances |        |      | -12.98 | 141.236 | .000 | -1.6883 | .1300 | -1.9453 | -1.4313 |
| Q11 | Assuming Homogeneity of Variances     | 1.389  | .240 | -9.496 | 152     | .000 | -1.2597 | .1327 | -1.5218 | -.9976  |
|     | Not Assuming Homogeneity of Variances |        |      | -9.496 | 141.986 | .000 | -1.2597 | .1327 | -1.5220 | -.9975  |
| Q12 | Assuming Homogeneity of Variances     | 2.657  | .105 | -7.060 | 152     | .000 | -1.0260 | .1453 | -1.3131 | -.7389  |
|     | Not Assuming Homogeneity of Variances |        |      | -7.060 | 150.418 | .000 | -1.0260 | .1453 | -1.3131 | -.7388  |
| Q13 | Assuming Homogeneity of Variances     | 8.639  | .004 | -7.644 | 152     | .000 | -.9740  | .1274 | -1.2258 | -.7223  |
|     | Not Assuming Homogeneity of Variances |        |      | -7.644 | 130.320 | .000 | -.9740  | .1274 | -1.2261 | -.7219  |
| Q14 | Assuming Homogeneity of Variances     | 4.885  | .029 | -9.720 | 152     | .000 | -1.2987 | .1336 | -1.5627 | -1.0347 |
|     | Not Assuming Homogeneity of Variances |        |      | -9.720 | 135.153 | .000 | -1.2987 | .1336 | -1.5629 | -1.0345 |
| Q15 | Assuming Homogeneity of Variances     | 9.966  | .002 | -7.473 | 152     | .000 | -1.0649 | .1425 | -1.3465 | -.7834  |
|     | Not Assuming Homogeneity of Variances |        |      | -7.473 | 132.347 | .000 | -1.0649 | .1425 | -1.3468 | -.7831  |
| Q16 | Assuming Homogeneity of Variances     | 2.790  | .097 | -10.46 | 152     | .000 | -1.3766 | .1315 | -1.6364 | -1.1168 |
|     |                                       |        |      | 9      |         |      |         |       |         |         |
|     | Not Assuming Homogeneity of Variances |        |      | -10.46 | 141.079 | .000 | -1.3766 | .1315 | -1.6366 | -1.1167 |
| Q17 | Assuming Homogeneity of Variances     | 13.082 | .000 | -9.024 | 152     | .000 | -1.3896 | .1540 | -1.6939 | -1.0854 |
|     | Not Assuming Homogeneity of Variances |        |      | -9.024 | 116.360 | .000 | -1.3896 | .1540 | -1.6946 | -1.0846 |
| Q19 | Assuming Homogeneity of Variances     | 19.423 | .000 | -7.245 | 152     | .000 | -1.0130 | .1398 | -1.2892 | -.7368  |
|     | Not Assuming Homogeneity of Variances |        |      | -7.245 | 119.249 | .000 | -1.0130 | .1398 | -1.2898 | -.7362  |

Table D.15 KMO and Bartlett's Test

| KMO                        |                        | 0.910    |
|----------------------------|------------------------|----------|
| Bartlett's Sphericity Test | Approximate Chi-Square | 1631.777 |
|                            | <i>df</i>              | 153      |
|                            | <i>p</i>               | 0.000    |

Table D.16 Total variance explained

| No. | Initial Eigenvalues |            |              | Sum of Squares of Loadings |            |              |
|-----|---------------------|------------|--------------|----------------------------|------------|--------------|
|     | Total               | Variance % | Cumulative % | Total                      | Variance % | Cumulative % |
| 1   | 8.801               | 48.894     | 48.894       | 8.801                      | 48.894     | 48.894       |
| 2   | 1.121               | 6.227      | 55.120       | 1.121                      | 6.227      | 55.120       |
| 3   | 1.039               | 5.772      | 60.892       | 1.039                      | 5.772      | 60.892       |
| 4   | .924                | 5.136      | 66.028       |                            |            |              |
| 5   | .817                | 4.539      | 70.567       |                            |            |              |
| 6   | .753                | 4.182      | 74.749       |                            |            |              |
| 7   | .648                | 3.602      | 78.351       |                            |            |              |
| 8   | .592                | 3.287      | 81.639       |                            |            |              |
| 9   | .509                | 2.830      | 84.469       |                            |            |              |
| 10  | .502                | 2.790      | 87.258       |                            |            |              |
| 11  | .442                | 2.455      | 89.713       |                            |            |              |
| 12  | .359                | 1.992      | 91.705       |                            |            |              |
| 13  | .355                | 1.970      | 93.675       |                            |            |              |
| 14  | .329                | 1.830      | 95.505       |                            |            |              |
| 15  | .304                | 1.688      | 97.193       |                            |            |              |
| 16  | .220                | 1.222      | 98.415       |                            |            |              |
| 17  | .160                | .888       | 99.303       |                            |            |              |
| 18  | .125                | .697       | 100.000      |                            |            |              |

Note: extraction method: principal component analysis

Table D.17 Dimension one (personal traits) validity analysis results

| Item                                                                                                                                         | Factor Loading Coefficients Factor 1 | Communalities (Common Factor Variances) |
|----------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|-----------------------------------------|
| 1. Enthusiastic about the current profession, demonstrating a strong sense of responsibility, and taking an active and responsible approach. | 0.755                                | 0.570                                   |
| 2. Ensuring the implementation of relevant plans for engineering projects.                                                                   | 0.710                                | 0.504                                   |
| 3. Proactively fulfilling work responsibilities, and even spontaneously assisting others in completing tasks.                                | 0.775                                | 0.601                                   |
| 4. Effectively communicating one's viewpoints through written or verbal means, facilitating efficient communication.                         | 0.730                                | 0.532                                   |
| 5. Maintaining a positive emotional state through self-control and effectively managing work-related stress.                                 | 0.602                                | 0.363                                   |
| Eigenvalues (Before Rotation)                                                                                                                | 2.571                                | -                                       |
| Variance Explained % (Before Rotation)                                                                                                       | 51.424%                              | -                                       |
| Cumulative Variance Explained % (Before Rotation)                                                                                            | 51.424%                              | -                                       |
| Eigenvalues (After Rotation)                                                                                                                 | 2.571                                | -                                       |
| Variance Explained % (After Rotation)                                                                                                        | 51.424%                              | -                                       |
| Cumulative Variance Explained % (After Rotation)                                                                                             | 51.424%                              | -                                       |
| KMO value                                                                                                                                    | 0.788                                | -                                       |
| Bartlett's Sphericity                                                                                                                        | 171.877                              | -                                       |

|         |       |   |
|---------|-------|---|
| df      | 10    | - |
| p value | 0.000 | - |

Table D.18 Adjusted validity analysis results for dimension one (personal traits)

| Item                                                                                                                                         | Factor Loading Coefficients<br>Factor 1 | Communalities (Common Factor Variances) |
|----------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|-----------------------------------------|
| 1. Enthusiastic about the current profession, demonstrating a strong sense of responsibility, and taking an active and responsible approach. | 0.798                                   | 0.636                                   |
| 2. Ensuring the implementation of relevant plans for engineering projects.                                                                   | 0.741                                   | 0.549                                   |
| 3. Proactively fulfilling work responsibilities, and even spontaneously assisting others in completing tasks.                                | 0.777                                   | 0.604                                   |
| 4. Effectively communicating one's viewpoints through written or verbal means, facilitating efficient communication.                         | 0.725                                   | 0.525                                   |
| Eigenvalues (Before Rotation)                                                                                                                | 2.314                                   | -                                       |
| Variance Explained % (Before Rotation)                                                                                                       | 57.856%                                 | -                                       |
| Cumulative Variance Explained % (Before Rotation)                                                                                            | 57.856%                                 | -                                       |
| Eigenvalues (After Rotation)                                                                                                                 | 2.314                                   | -                                       |
| Variance Explained % (After Rotation)                                                                                                        | 57.856%                                 | -                                       |
| Cumulative Variance Explained % (After Rotation)                                                                                             | 57.856%                                 | -                                       |
| KMO value                                                                                                                                    | 0.770                                   | -                                       |
| Bartlett's Sphericity                                                                                                                        | 137.312                                 | -                                       |
| df                                                                                                                                           | 6                                       | -                                       |
| p value                                                                                                                                      | 0.000                                   | -                                       |

Table D.19 Items of the competency scale (personal trait dimension) for Chinese construction companies

| Level-1 indicator | Level-2 indicator | Item                                                                                                                                      |
|-------------------|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| Personal traits   | Responsibility    | Enthusiastic about the current profession, demonstrating a strong sense of responsibility, and taking an active and responsible approach. |
|                   | Execution Ability | Ensuring the implementation of relevant plans for engineering projects.                                                                   |
|                   | Proactivity       | Proactively fulfilling work responsibilities, and even spontaneously assisting others in completing tasks.                                |
|                   | Communication     | Effectively communicating one's viewpoints through written or verbal means, facilitating efficient communication.                         |

Table D.20 Validity analysis results of dimension two (general leadership capability)

| Item                                                                                                                                                                                            | Factor Loading Coefficients<br>Factor 1 | Communalities (Common Factor Variances) |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|-----------------------------------------|
| 6. Project managers excel at nurturing talents and forming project teams through various strategies, igniting team members' work enthusiasm, enhancing cohesion, and improving work efficiency. | 0.800                                   | 0.639                                   |
| 7. Coordinating various stakeholders to accomplish diverse management tasks.                                                                                                                    | 0.746                                   | 0.557                                   |

|                                                                                       |         |       |
|---------------------------------------------------------------------------------------|---------|-------|
| 8. Displaying decisiveness and implementing effective measures in various situations. | 0.795   | 0.632 |
| 9. Decomposing complex work systems into manageable tasks.                            | 0.790   | 0.625 |
| Eigenvalues (Before Rotation)                                                         | 2.453   | -     |
| Variance Explained % (Before Rotation)                                                | 61.316% | -     |
| Cumulative Variance Explained % (Before Rotation)                                     | 61.316% | -     |
| Eigenvalues (After Rotation)                                                          | 2.453   | -     |
| Variance Explained % (After Rotation)                                                 | 61.316% | -     |
| Cumulative Variance Explained % (After Rotation)                                      | 61.316% | -     |
| KMO value                                                                             | 0.780   | -     |
| Bartlett's Sphericity                                                                 | 168.533 | -     |
| df                                                                                    | 6       | -     |
| <i>p</i> value                                                                        | 0.000   | -     |

Table D.21 Items of the Competency Scale (general leadership dimension) for Chinese construction companies

| Level-1 indicator          | Level-2 indicator               | Item                                                                                                                                                                                         |
|----------------------------|---------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| General leadership ability | Team Building                   | Project managers excel at nurturing talents and forming project teams through various strategies, igniting team members' work enthusiasm, enhancing cohesion, and improving work efficiency. |
|                            | Organizational and Coordination | Coordinating various stakeholders to accomplish diverse management tasks.                                                                                                                    |
|                            | Decision-Making                 | Displaying decisiveness and implementing effective measures in various situations.                                                                                                           |
|                            | Analytical and Judgement        | Decomposing complex work systems into manageable tasks.                                                                                                                                      |

Table D.22 Validity analysis results of dimension three (project-specific professional management capability)

| Item                                                                                                                                   | Factor Loading Coefficients<br>Factor 1 | Communalities (Common Factor Variances) |
|----------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|-----------------------------------------|
| 10. Developing different work plans for various stages and milestones of the project and ensuring their effective execution.           | 0.809                                   | 0.655                                   |
| 11. Identifying and predicting project risks, proactively assuming risks, and addressing unforeseen events.                            | 0.793                                   | 0.629                                   |
| 12. Implementing effective measures to mitigate or even eliminate potential conflicts among various stakeholders.                      | 0.650                                   | 0.422                                   |
| 13. Taking measures to minimize the gap between actual progress and planned progress, ensuring the achievement of schedule objectives. | 0.747                                   | 0.558                                   |
| 14. Recognizing the importance of cost control and implementing effective measures to keep costs within a lower range.                 | 0.745                                   | 0.555                                   |
| 15. Implementing measures to eliminate hidden quality issues in the project and ensuring the attainment of quality objectives.         | 0.767                                   | 0.588                                   |
| 16. Clearly defining the management scope of project contracts and managing the rights and obligations of all                          | 0.741                                   | 0.549                                   |

|                                                                                                                             |         |       |
|-----------------------------------------------------------------------------------------------------------------------------|---------|-------|
| parties based on the contract terms.                                                                                        |         |       |
| 17. Possessing the necessary professional technical knowledge required for the engineering project.                         | 0.708   | 0.501 |
| 19. Actively adopting new construction technologies, methods, and techniques to achieve higher efficiency and cost savings. | 0.656   | 0.390 |
| Eigenvalues (Before Rotation)                                                                                               | 4.887   | -     |
| Variance Explained % (Before Rotation)                                                                                      | 54.296% | -     |
| Cumulative Variance Explained % (Before Rotation)                                                                           | 54.296% | -     |
| Eigenvalues (After Rotation)                                                                                                | 4.887   | -     |
| Variance Explained % (After Rotation)                                                                                       | 54.296% | -     |
| Cumulative Variance Explained % (After Rotation)                                                                            | 54.296% | -     |
| KMO value                                                                                                                   | 0.859   | -     |
| Bartlett's Sphericity                                                                                                       | 734.961 | -     |
| df                                                                                                                          | 36      | -     |
| p value                                                                                                                     | 0.000   | -     |

Table D.23 Adjusted validity analysis results for dimension three (project professional management competence)

| Item                                                                                                                                               | Factor Loading Coefficients<br>Factor 1 | Communalities (Common Factor Variances) |
|----------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|-----------------------------------------|
| 10. Developing different work plans for various stages and milestones of the project and ensuring their effective execution.                       | 0.812                                   | 0.660                                   |
| 11. Identifying and predicting project risks, proactively assuming risks, and addressing unforeseen events.                                        | 0.807                                   | 0.652                                   |
| 12. Implementing effective measures to mitigate or even eliminate potential conflicts among various stakeholders.                                  | 0.661                                   | 0.437                                   |
| 13. Taking measures to minimize the gap between actual progress and planned progress, ensuring the achievement of schedule objectives.             | 0.742                                   | 0.551                                   |
| 14. Recognizing the importance of cost control and implementing effective measures to keep costs within a lower range.                             | 0.735                                   | 0.540                                   |
| 15. Implementing measures to eliminate hidden quality issues in the project and ensuring the attainment of quality objectives.                     | 0.785                                   | 0.616                                   |
| 16. Clearly defining the management scope of project contracts and managing the rights and obligations of all parties based on the contract terms. | 0.748                                   | 0.559                                   |
| 17. Possessing the necessary professional technical knowledge required for the engineering project.                                                | 0.705                                   | 0.497                                   |
| Eigenvalues (Before Rotation)                                                                                                                      | 4.512                                   | -                                       |
| Variance Explained % (Before Rotation)                                                                                                             | 56.400%                                 | -                                       |
| Cumulative Variance Explained % (Before Rotation)                                                                                                  | 56.400%                                 | -                                       |
| Eigenvalues (After Rotation)                                                                                                                       | 4.512                                   | -                                       |
| Variance Explained % (After Rotation)                                                                                                              | 56.400%                                 | -                                       |
| Cumulative Variance Explained % (After Rotation)                                                                                                   | 56.400%                                 | -                                       |
| KMO value                                                                                                                                          | 0.850                                   | -                                       |
| Bartlett's Sphericity                                                                                                                              | 664.962                                 | -                                       |
| df                                                                                                                                                 | 28                                      | -                                       |
| p value                                                                                                                                            | 0.000                                   | -                                       |

Table D.24 Items of the competency project professional management dimension scale for Chinese construction companies

| Level-1 indicator                   | Level-2 indicator       | Item                                                                                                                                               |
|-------------------------------------|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| Project-Specific Management Ability | Planning and Management | Developing different work plans for various stages and milestones of the project and ensuring their effective execution.                           |
|                                     | Risk Management         | Identifying and predicting project risks, proactively assuming risks, and addressing unforeseen events.                                            |
|                                     | Conflict Management     | Implementing effective measures to mitigate or even eliminate potential conflicts among various stakeholders.                                      |
|                                     | Progress Management     | Taking measures to minimize the gap between actual progress and planned progress, ensuring the achievement of schedule objectives.                 |
| General Leadership Ability          | Cost Control            | Recognizing the importance of cost control and implementing effective measures to keep costs within a lower range.                                 |
|                                     | Quality Control         | Implementing measures to eliminate hidden quality issues in the project and ensuring the attainment of quality objectives.                         |
|                                     | Contract Management     | 16. Clearly defining the management scope of project contracts and managing the rights and obligations of all parties based on the contract terms. |
|                                     | Technical Expertise     | 17. Possessing the necessary professional technical knowledge required for the engineering project.                                                |

Table D.25 Competency characteristic elements and their indicators for project managers in Chinese construction companies

| Level-1 indicator                   | Level-2 indicator               | Item                                                                                                                                                                                         |
|-------------------------------------|---------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Personal traits                     | Responsibility                  | Enthusiastic about the current profession, demonstrating a strong sense of responsibility, and taking an active and responsible approach.                                                    |
|                                     | Execution Ability               | Ensuring the implementation of relevant plans for engineering projects.                                                                                                                      |
|                                     | Proactivity                     | Proactively fulfilling work responsibilities, and even spontaneously assisting others in completing tasks.                                                                                   |
|                                     | Communication                   | Effectively communicating one's viewpoints through written or verbal means, facilitating efficient communication.                                                                            |
| General leadership ability          | Team Building                   | Project managers excel at nurturing talents and forming project teams through various strategies, igniting team members' work enthusiasm, enhancing cohesion, and improving work efficiency. |
|                                     | Organizational and Coordination | Coordinating various stakeholders to accomplish diverse management tasks.                                                                                                                    |
|                                     | Decision-Making                 | Displaying decisiveness and implementing effective measures in various situations.                                                                                                           |
|                                     | Analytical and Judgement        | Decomposing complex work systems into manageable tasks.                                                                                                                                      |
| Project-Specific Management Ability | Planning and Management         | Developing different work plans for various stages and milestones of the project and ensuring their effective execution.                                                                     |

|                     |                                                                                                                                                |
|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| Risk Management     | Identifying and predicting project risks, proactively assuming risks, and addressing unforeseen events.                                        |
| Conflict Management | Implementing effective measures to mitigate or even eliminate potential conflicts among various stakeholders.                                  |
| Progress Management | Taking measures to minimize the gap between actual progress and planned progress, ensuring the achievement of schedule objectives.             |
| Cost Control        | Recognizing the importance of cost control and implementing effective measures to keep costs within a lower range.                             |
| Quality Control     | Implementing measures to eliminate hidden quality issues in the project and ensuring the attainment of quality objectives.                     |
| Contract Management | Clearly defining the management scope of project contracts and managing the rights and obligations of all parties based on the contract terms. |
| Technical Expertise | Possessing the necessary professional technical knowledge required for the engineering project.                                                |

Table D.26 Reliability analysis for Employee Trust Scale

| Number of items | Sample size | Cronbach $\alpha$ |
|-----------------|-------------|-------------------|
| 4               | 154         | 0.770             |

Table D.27 KMO and Bartlett test for employee trust

|                            |                        |         |
|----------------------------|------------------------|---------|
|                            | KMO                    | 0.767   |
| Bartlett's Sphericity Test | Approximate Chi-Square | 151.587 |
|                            | df                     | 6       |
|                            | <i>p</i>               | 0.000   |

Table D.28 Reliability analysis for Team Communication Scale

| Item                                                                                               | CITC  | Coefficient $\alpha$ with Item Removed | Cronbach $\alpha$ |
|----------------------------------------------------------------------------------------------------|-------|----------------------------------------|-------------------|
| Team members clearly define project goals.                                                         | 0.559 | 0.721                                  | 0.770             |
| Project performance feedback is strictly implemented.                                              | 0.533 | 0.730                                  |                   |
| When encountering challenging problems at work, other team members provide timely assistance       | 0.462 | 0.753                                  |                   |
| Project information flows efficiently, ensuring every member is well-informed of relevant matters. | 0.562 | 0.721                                  |                   |
| A harmonious communication atmosphere has been established within the team.                        | 0.589 | 0.710                                  |                   |

Note: Standardized Cronbach's  $\alpha$  Coefficient: 0.769

Table D.29 KMO and Bartlett test for Team Communication Scale

|                            |                        |         |
|----------------------------|------------------------|---------|
| KMO                        |                        | 0.782   |
| Bartlett's Sphericity Test | Approximate Chi-Square | 178.289 |
|                            | df                     | 10      |
|                            | <i>p</i>               | 0.000   |

Table D.30 Reliability analysis for Employee Training Scale

| Item                                                                                                                                               | CITC  | Coefficient $\alpha$<br>with Item<br>Removed | Cronbach $\alpha$ |
|----------------------------------------------------------------------------------------------------------------------------------------------------|-------|----------------------------------------------|-------------------|
| 1. I am able to participate in the training provided by the company during work.                                                                   | 0.447 | 0.747                                        | 0.762             |
| 2. The training content provided by the company is highly practical and can be directly applied to my job.                                         | 0.584 | 0.699                                        |                   |
| 3. After participating in the training provided by the company, my professional skill level has improved.                                          | 0.479 | 0.736                                        |                   |
| 4. Following the company's training, I have a deeper appreciation for the company's management philosophy and project teams.                       | 0.578 | 0.702                                        |                   |
| 5. After receiving training from the company, I have a more optimistic view of the company's future prospects and intend to grow with the company. | 0.564 | 0.706                                        |                   |

Note: Standardized Cronbach's  $\alpha$  Coefficient: 0.761

Table D.31 KMO and Bartlett test for Employee Training Scale

|                            |                            |         |
|----------------------------|----------------------------|---------|
| KMO                        |                            | 0.795   |
| Bartlett's Sphericity Test | Bartlett's Sphericity Test | 167.322 |
|                            | df                         | 10      |
|                            | <i>p</i>                   | 0.000   |

Table D.32 Reliability analysis for Team Comprehensive Ability Scale

| Item                                                                           | CITC  | Coefficient $\alpha$<br>with Item<br>Removed | Cronbach $\alpha$ |
|--------------------------------------------------------------------------------|-------|----------------------------------------------|-------------------|
| 1. I believe the project team possesses strong comprehensive capabilities.     | 0.458 | 0.479                                        | 0.621             |
| 2. I would choose to stay and work diligently as a member of the project team. | 0.488 | 0.509                                        |                   |
| 3. I have a lot of confidence in the project team's overall capabilities.      | 0.409 | 0.506                                        |                   |
| 4. I am very willing for the project team to remain in its current state.      | 0.402 | 0.51                                         |                   |
| 5. I have a lot of confidence in the project team's overall capabilities.      | 0.426 | 0.492                                        |                   |
| 6. I plan to continue collaborating with the project team in the future.       | 0.420 | 0.495                                        |                   |

Note: Standardized Cronbach's  $\alpha$  Coefficient: 0.701

Table D.33 KMO and Bartlett's test for Team Comprehensive Ability Scale

|                            |                            |         |
|----------------------------|----------------------------|---------|
| KMO                        |                            | 0.795   |
| Bartlett's Sphericity Test | Bartlett's Sphericity Test | 167.322 |
|                            | df                         | 10      |
|                            | <i>p</i>                   | 0.000   |

Table D.34 Reliability analysis for Project Performance Scale

| Item                | CITC  | Coefficient $\alpha$ with Item Removed | Cronbach $\alpha$ |
|---------------------|-------|----------------------------------------|-------------------|
| 1. Project progress | 0.808 | 0.859                                  | 0.900             |
| 2. Project quality  | 0.702 | 0.897                                  |                   |
| 3. Project profit   | 0.776 | 0.873                                  |                   |
| 4. Project safety   | 0.831 | 0.851                                  |                   |

Note: Standardized Cronbach's  $\alpha$  Coefficient: 0.901

Table D.35 KMO and Bartlett's test for Project Performance Scale

|                            |                            |         |
|----------------------------|----------------------------|---------|
| KMO                        |                            | 0.838   |
| Bartlett's Sphericity Test | Bartlett's Sphericity Test | 385.858 |
|                            | df                         | 6       |
|                            | <i>p</i>                   | 0.000   |

Table D.36 Sample file

| Team No. | Team size | Region    | Questionnaire<br>issued | Questionnaire<br>returned |
|----------|-----------|-----------|-------------------------|---------------------------|
| 1        | 129       | Chengdu   | 20                      | 11                        |
| 2        | 105       | Chengdu   | 20                      | 9                         |
| 3        | 168       | Chengdu   | 20                      | 8                         |
| 4        | 171       | Shanghai  | 20                      | 12                        |
| 5        | 98        | Beijing   | 20                      | 7                         |
| 6        | 141       | Chengdu   | 20                      | 12                        |
| 7        | 77        | Chongqing | 20                      | 15                        |
| 8        | 69        | Shenzhen  | 20                      | 11                        |
| 9        | 84        | Chengdu   | 20                      | 11                        |
| 10       | 71        | Chongqing | 20                      | 9                         |
| 11       | 59        | Mianyang  | 20                      | 8                         |
| 12       | 43        | Chengdu   | 20                      | 14                        |
| 13       | 57        | Mianyang  | 20                      | 7                         |
| 14       | 64        | Chengdu   | 20                      | 12                        |
| 15       | 131       | Mianyang  | 20                      | 9                         |
| 16       | 46        | Leshan    | 20                      | 8                         |
| 17       | 39        | Lasa      | 20                      | 12                        |
| 18       | 55        | Chengdu   | 20                      | 13                        |
| 19       | 74        | Chengdu   | 20                      | 7                         |
| 20       | 56        | Jiangsu   | 20                      | 8                         |
| 21       | 42        | Leshan    | 20                      | 8                         |
| 22       | 57        | Leshan    | 20                      | 16                        |
| 23       | 66        | Chengdu   | 20                      | 11                        |
| 24       | 57        | Chengdu   | 20                      | 9                         |
| 25       | 51        | Mianyang  | 20                      | 12                        |
| 26       | 49        | Chengdu   | 20                      | 7                         |
| 27       | 41        | Chengdu   | 20                      | 13                        |
| 28       | 39        | Chongqing | 20                      | 9                         |
| 29       | 35        | Chengdu   | 20                      | 13                        |
| 30       | 42        | Chengdu   | 20                      | 10                        |
| Total    |           |           | 600                     | 311                       |

Table D.37 Convergent validity test results for the project manager competency scale

| Dimension                              | Number of<br>Items | AVE (Average Variance<br>Extracted) | CR (Composite<br>Reliability) |
|----------------------------------------|--------------------|-------------------------------------|-------------------------------|
| Personal Traits<br>Dimension           | 4                  | 0.579                               | 0.846                         |
| General Leadership<br>Ability          | 4                  | 0.613                               | 0.864                         |
| Project-Specific<br>Management Ability | 8                  | 0.564                               | 0.912                         |

Table D.38 Fornell-Larcker test results for the project manager competency scale

|                                     | Personal Traits | General Leadership Ability | Project-Specific Management Ability |
|-------------------------------------|-----------------|----------------------------|-------------------------------------|
| Personal Traits                     | 0.76            | 0.524                      | 0.496                               |
| General Leadership Ability          | 0.524           | 0.78                       | 0.624                               |
| Project-Specific Management Ability | 0.496           | 0.624                      | 0.75                                |