

# Examining the Effects of Challenges Faced in Green Construction on Project Outcomes: A Chinese Perspective

Mohammed Shareef M. S. Hasan

**Abstract**—This study aims to investigate the common challenges that project managers encounter while managing green building construction projects and their impact on project success. Furthermore, the study aims to examine the mediating effect of project performance in the relationship between project management challenges related to green construction and their success. This paper seeks to contribute to the green construction in China. In total 500 questionnaires were distributed, and 376 completed survey questionnaires were received. Structural equation modelling (SEM) using AMOS was conducted to check various proposed relationships. The results reveal that Challenge 2 and Challenge 5 are insignificant and have no impact on project success, whereas Challenges 1, 3 and 4 are found to be the predictors of project success. No mediation effect of project performance is found between Challenges 1 and 5 and project success. However, a partial mediation effect is found between Challenge 1 and project success.

**Index Terms**—Green buildings, project success, project performance, challenges, SEM.

## I. INTRODUCTION

Better business efficiency in the building industry can play a significant role in future development and the sustainability of development. Generally, in Asia the demand for energy in the construction and design sector is growing rapidly along with the economic growth [1], [2]. The literature contains a number of studies related to the social benefits of green buildings (GB). GB projects are subject to uncertainties about project deliverables; therefore, they require contingencies in project budgets [3].

The construction industry is subject to many diverse problems and requirements [4].

Many countries are now focusing on improving the performance of the construction industry as part of their socioeconomic development at various levels. The construction industry, due to its complexity and difficulty, faces problems and challenges throughout the world. These issues are dominant in developing countries, as these countries face a lack in terms of resources, socioeconomic issues, an inability to deal with critical situations and organizational weaknesses.

China is facing green construction challenges, as the population is continuing to boom along with its economy and people are moving to cities, stimulating an increase in urbanization and development [5]. Today, 51% of China's

population lives in urban areas. Between 1990 and 2005, the population of China's urban centres doubled. This growing urban population has spurred on such a significant increase in development that, by the end of 2006, 65% of China's urban buildings were constructed within a 10-year span. In 2009 the McKinsey Global Institute estimated that China would build between 20,000 and 50,000 buildings of more than 30 floors by 2025 [6], [7]. However, with the population growth in China and the construction progress, the country is facing challenges in this sector, particularly green construction challenges, which are encountered in project management, affecting the project success and project outcomes in the construction sector.

In the construction industry, effective project management is crucial due to the nature of the industry [8], and the identification of effective approaches can lead to project success [9]. The success of building projects heavily depends on the project management methods, philosophy, techniques, procedures and processes and different tools. Additionally, the capability of the project manager (PM) is one of the most important elements for the success of construction building projects [10], [11]. A construction PM has to consider everything to prevent failure in any step of the project. However, in most cases undesirable challenges arise in project implementation.

Moreover, the job of project manager is diversifying due to the changing nature of the construction industry, technological development and information technology. Project managers also face different challenges related to climate change, environmental policies and sustainability issues. They need skills to face these challenges and issues [12]. With the increasing global pressure for environmental protection and sustainability, many construction companies are now thinking about green projects. Companies are now focusing on more sustainable and environment-friendly construction, and that is why they are now carrying out green construction projects and design [13].

Key gap persist in existing knowledge. Although there is much debate about the likely outcomes of green construction, surprisingly few empirical studies have examined the effects of challenges faced in green construction on projects outcomes. Thus, project managers need to identify the challenges being faced by the green construction.

The role of project managers is changing completely due to critical issues that were not relevant in traditional project building [14]. Green construction is the top priority in the construction sector, and project managers have to deal with the challenges of green construction to complete projects successfully. Hence, the purpose of this study is to investigate the effects of green construction challenges on

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project success and outcomes in China.

## II. LITERATURE REVIEW

### A. Concept of Green Building

The concept of green building (GB) was introduced by China's Government in 2004 with the platform of "Energy-Saving and Land-Saving Residential Building". GB projects are categorized as energy-saving, land-saving and material-saving projects. These are defined by the Chinese national standard, the Evaluation Standard for Green Building [15].

### B. Green Building Design

Green building designs are more complex than typical conventional building designs, because it is commonly necessary for the design team to evaluate alternative materials and systems [16]. In conventional building projects, the simple and general planned designs are used for project process regarding what the building should look like generally [17]. However, a more up-to-date process is used from the beginning of green projects because of the fact that green buildings have many unique designs, integration and features that are not generally present in conventional projects [18], [19].

### C. Challenges in Green Construction Projects

Based on previous studies, different skills and challenges related to project management in green building projects are found. These challenges are presented below:

#### 1) Higher costs for green construction practices and materials

GB projects are subject to higher costs than conventional building projects. [20] stated that the cost of green building projects is 2% to 25% higher than that of conventional projects. Green projects are costly due to the presence of complexities in building design and the modelling of green practices to integrate into the projects [21]. The use of green technologies and green materials is the main cause of the increased cost of these projects [22].

The cost of materials in green projects is about 4% higher than that in conventional projects, and a significant contribution is made by the cost of green board, which is 10 times higher than that of the ordinary board used in conventional projects [21]. This increased cost of green projects directly affects the performance of project managers, as they have to manage and deliver the project within the budget constraint [13], [18], [23].

#### 2) Technical difficulty during the construction process

The project manager is responsible for implementing the project plan by assigning activities and authority to deliver project outcomes [23]. Green constructions require complex techniques and building designs [21]. The project manager's performance can be adversely affected if he or she fails to address these complexities. [20] highlighted that technical difficulties and complexities are the main challenges of green projects faced by project managers. Similarly, these designs are more complicated and complex due to the presence of complex materials and systems than conventional buildings [18].

#### 3) Risk due to different contract forms of project delivery

The success of the development and implementation of green building design heavily depends on the type of contract selected for the project deliverables [20]. The type of contract used in green projects must incorporate the details of a fully integrated green design. If the design is locked prior to developing the green design fully, huge problems will arise in its implementation. In green projects numbers of changes are required at different stages, leading to their higher cost [18].

#### 4) Lengthy approval process for new green technologies and recycled materials

According to the environment of the market, the planning process of green projects can be prolonged due to the approval process of new green technologies and materials [20]. As shown by the survey reports of [21] and [24], green design projects are expected to require additional time for approval than conventional designs. This additional and delayed time is a challenge for project managers in developing the schedule for the project and making payments to dealers and suppliers [18], [23].

#### 5) Unfamiliarity with green technologies

Previous studies have documented certain obstacles and issues for design developers, contractors and clients. [24] identified that there are two main obstacles, insufficient knowledge and unfamiliarity with the design, material and systems. [20] pointed out that, compared with conventional technologies, green technologies are more complex and different. The same findings were suggested by [21]. The author suggests that the project manager is responsible for delivering the project within the required standards and performance measures as determined by the clients [23], and if the project manager is unfamiliar with the green technologies and does not have sufficient knowledge, it may affect his performance outcome [18].

### D. Project Performance

Ref. [22], [25] estimated a hierarchical structural equation model to make clear comparisons. Exhibiting the unique characteristics of pharmaceutical construction projects regarding delivery, the project cost, timetable and performance metrics were produced. The further studies by [26], [27] showed that different stakeholders can gauge and assess the performance of projects effectively using the given metrics.

Ref. [28] assessed the association between the project factors and the performance of a project. Their study indicated the causal association among several project factors and five performance indicators: "reward ratio", "unit cost", "progress growth", "cost increases" and "speed of completion".

### E. Project Success

During the actual execution of any project, several measurements, such as the environmental impact and the satisfaction of the clients regarding quality, cost and time, may be carried out [29].

The classical indicators used for gauging project success are the cost progress, safety and progress [30]. As far as the project cost and project progress success is concerned, a

project can be considered to be successful in the case that the actual cost is lower than the forecasted cost and the actual progress is accelerated more than anticipated; otherwise, it may be considered to be a failure.

### III. RESEARCH METHODOLOGY

To meet the research objectives, a comprehensive literature search was conducted. The review of the previous work aimed to understand the impact of the challenges faced in green construction on project outcomes. After reviewing the literature, the challenges were identified as the independent variable, whereas the project success and project outcome were set as dependent variables. Their relation is tested using structural equation modelling (SEM) by AMOS. A closed-ended question was prepared to collect primary data regarding the challenges of green construction, project performance and project success.

To collect the empirical data, a questionnaire was sent to a sample of green construction managers. Only green construction managers participated in this study, because they have experience and knowledge regarding green construction.

The purposive sampling technique is employed in this study. The use of purposive sampling in this study is parallel to previous studies, the logical reasoning being to obtain in-depth and meaningful information by purposefully selecting the most suitable sample. To ensure that the sample of this study consisted of the correct respondents, only construction managers who possess knowledge or experience in green construction were selected.

The first part of the questionnaire included information regarding the respondents' demographic factors. The following part listed the challenges faced by the managers in dealing with green construction projects. The questions to rate the effectiveness of the challenges used a five-point scale from not relevant at all to most relevant. The last part consisted of questions regarding project success and project performance using an interval scale with five points from strongly disagree to strongly agree. A total of 500 questionnaires were distributed to collect responses; however, 376 completed questionnaires were received, achieving a response rate of 75%. The numbers of items used to measure each construct are shown in Table I.

TABLE I: LIST OF CONSTRUCTS AND THE NUMBER OF ITEMS INCLUDED

CONSTRUCTS	LABEL	TYPE	ITEMS
Higher costs	Challenge 1	IV	3
Technical difficulty	Challenge 2	IV	4
Risk due to different contract forms	Challenge 3	IV	4
Lengthy approval	Challenge 4	IV	3
Unfamiliarity with Green Technology	Challenge 5	IV	4
Project Performance	PP	MV	3
Project Success	PS	DV	3

Note: IV: Independent variable. Items refer to number of questions for each variable. MV means mediation variable. DV means dependent variable.

#### A. Hypotheses

H1a: Higher cost is a predictor of project success.

H1b: Project performance mediates the relationship between higher cost and project success.

H2a: Technical cost is a predictor of project success.

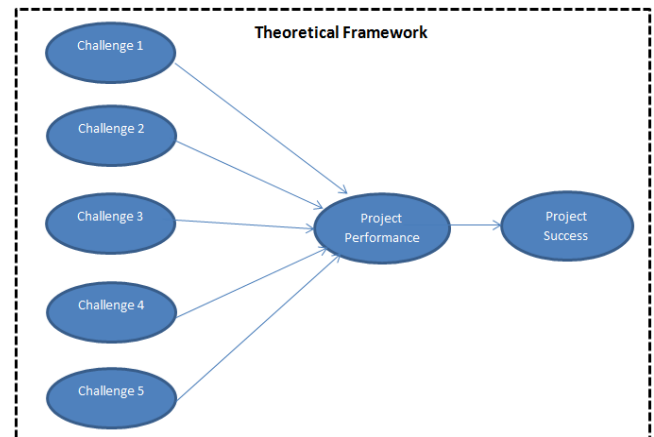
H3a: Risk due to different contract forms is a predictor of project success.

H3b: Project performance mediates the relationship between risk due to different contract forms and project success.

H4a: Lengthy approval is a predictor of project success.

H4b: Project performance mediates the relationship between lengthy approval and project success.

H5a: Unfamiliarity with green technology is a predictor of project success.



Based on (Hwang & Ng 2013; Chou & Yang, 2012)

Fig. 1. Theoretical framework.

### IV. RESULTS AND DISCUSSION

#### A. Validity and Reliability

Measurement models were designed to assess the convergent validity. Table 2 provides a summary of the validity and reliability. A model was prepared for multi-dimensional constructs (CH1, CH2, CH3, CH4, CH5, PP and PS); items with a loading less than 0.50 were deleted [31]. Convergent validity was established through standardized estimates (standard regression weight [SRW] > 0.5) and average variance extracted (AVE > 0.05). To check the internal consistency, Cronbach's alpha was used, as it is an indicator of the reliability of the construct [32]. In this study the values of alpha for all the constructs are more than 0.80. The composite reliability values, which depict the degree to which the construct indicators indicate the latent construct, exceed the recommended value of 0.80 for all the constructs. The composite reliability for all the constructs is above 0.80 except for the variable "project success (PS)". However, it is at an acceptable level and may be used for further analysis. Hence, the scale reliability using Cronbach's alpha indicates sufficient reliability and the construct composite reliability is considerably above the acceptable level.

The assessment of discriminant validity enables researchers to determine how one construct differs from the others. The value of discriminant validity can be determined when the AVE square root of two constructs and their correlations are compared. Discriminant validity was tested for the model (Table III). The stringent approach to

ascertain the discriminant validity of the model is to compare the square root of the AVE value of each construct with the squared inter-construct correlations related to that construct. To confirm discriminant validity, these AVE estimates should be greater than the inter-construct squared correlations. Table III illustrates that the AVE values (in bold diagonally) in all the constructs are greater than their squared correlations. This indicates that the constructs have appropriate discriminant validity.

TABLE II: VALIDITY AND RELIABILITY OF SCALES

	Standard Estimates	AVE	Alpha	CR
CH1		0.61014	0.82	0.823623203
CH1a	0.853			
CH1b	0.771			
CH1c	0.713			
CH2		0.666374	0.88	0.888621304
CH2a	0.814			
CH2b	0.86			
CH2c	0.774			
CH2d	0.815			
CH3		0.647949	0.87	0.87950294
CH3a	0.707			
CH3b	0.77			
CH3c	0.911			
CH3d	0.818			
CH4		0.795598	0.92	0.921068315
CH4a	0.862			
CH4b	0.895			
CH4c	0.918			

TABLE III: DISCRIMINANT VALIDITY

	AVE	CH1	CH2	CH3	ch4	CH5	PP	PS
CH1	0.61014	<b>0.781114</b>						
CH2	0.666374	0.124609	<b>0.816317</b>					
CH3	0.647949	0.2704	0.126736	<b>0.804952</b>				
CH4	0.795598	0.306916	0.131044	0.393129	<b>0.891963</b>			
CH5	0.661773	0.386884	0.1225	0.367236	0.450241	<b>0.813494</b>		
PP	0.710339	0.358801	0.112896	0.2916	0.2916	0.274576	<b>0.842816</b>	
PS	0.560714	0.4225	0.222784	0.463761	0.389376	0.430336	0.855625	<b>0.748808</b>

Note: Diagonal values in bold are the square roots of AVE

TABLE IV: MODEL FIT

Absolute fit			Incremental fit			Parsimonious fit		
Fitness index	Critical value	Test value	Fitness index	Critical value	Test value	Fitness index	Critical value	Test value
RMSEA	<0.10	0.078	CFI	>0.90	0.91	ChiSq/df	<5	3.302

For the RMSEA, a value of 0 is interpreted as an exact fit; values less than .05 are a close fit; values between .05 and .08 are a fair fit; and values between .08 and .10 are a mediocre fit [33].

The chi-sq/df is 3.211, which is below 0.5; thus, the

CH5		0.661773	0.88	0.885897919
CH5a	0.915			
CH5b	0.786			
CH5c	0.826			
CH5d	0.714			
PP		0.710339	0.87	0.879631836
PP1	0.744			
PP2	0.874			
PP3	0.902			
PS		0.560714	0.78	0.791544897
PS1	0.771			
PS2	0.814			
PS3	0.652			

### B. Model Fit

SEM-AMOS version 22 was used to verify whether the proposed model fits the data. SEM was used because it is a second-generation version and provides graphs. Regarding the model fitness, [31] recommended three types of fitness: absolute fit, increment fit and parsimonious fit. All three fitness tests have their own indices. However, in this study one index was taken from each test to verify the proposed model.

To find the absolute fit index, the value of the root mean square error of approximation (RMSEA) was checked; for the increment fit purpose, the value of the comparative fit index (CFI) was checked; and for the parsimonious fit, the value of chi-sq/df was checked, as shown in Table 4. All these statistical indices suggest that the proposed model fits the data in this study.

model fits. CFI is achieved, the score being 929.

### C. Impact of Challenges on Project Success: The Mediating Role of Project Performance

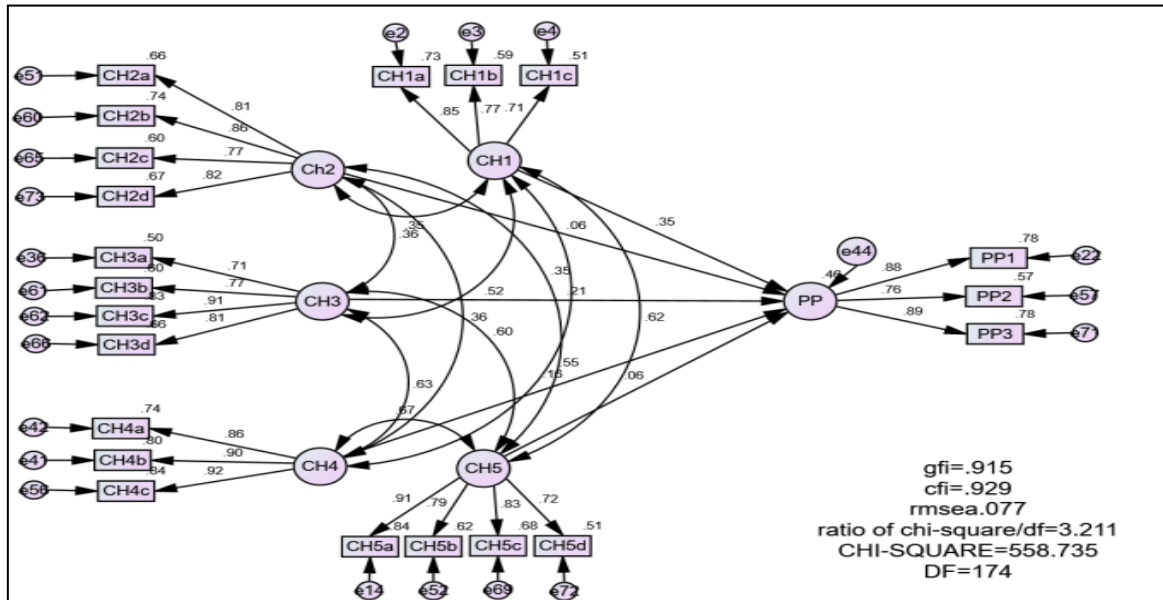


Fig. 2. The AMOS output showing regression (SEM) coefficient between the constructs (without mediator).

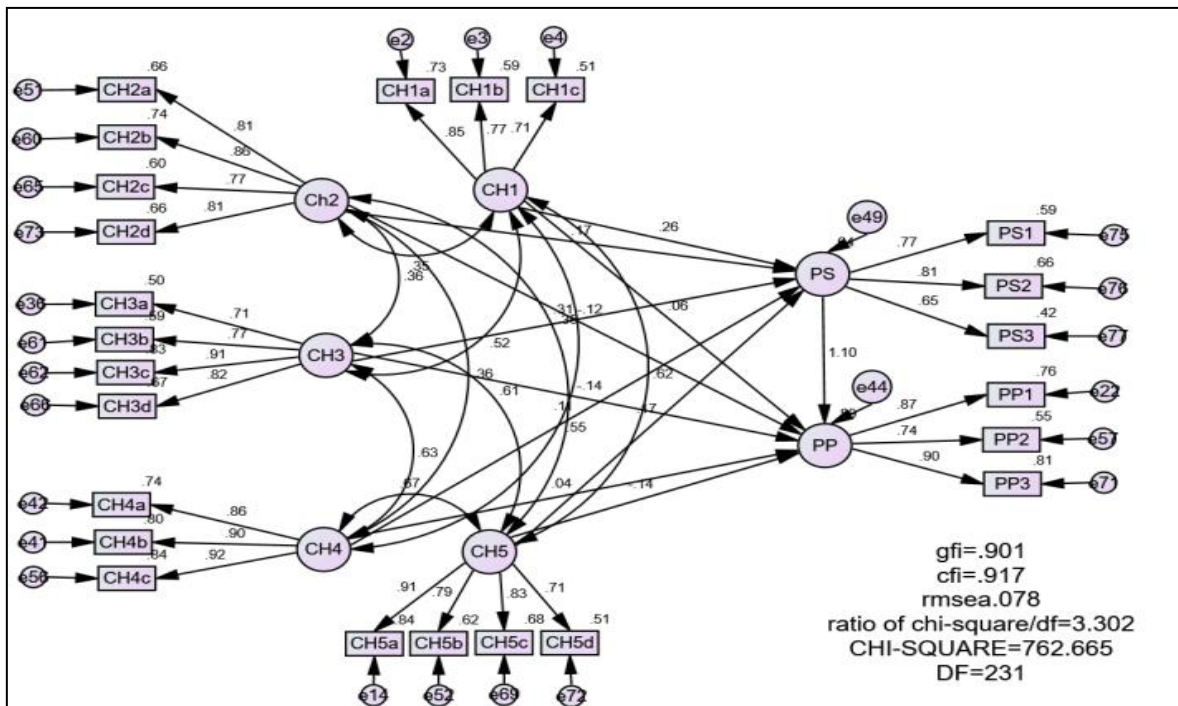


Fig. 3. The AMOS output showing regression (SEM) coefficient between the constructs (with mediator).

TABLE V: DIRECT AND INDIRECT EFFECTS OF CHALLENGES ON PROJECT SUCCESS

IVs	Direct without Med	Sig.	IV to Med	Sig.	Med to DV	p-value	Direct with Med	p-value	Results
Challenge 1	0.34	0.00	0.061	0.34	1.10	0.00	0.26	0.00	Direct Relationship
Challenge 2	0.06	0.24	-0.123	0.01	1.10	0.00	0.17	0.00	Indirect relationship
Challenge 3	0.20	0.00	-0.143	0.03	1.10	0.00	0.31	0.00	Partial mediation
Challenge 4	0.16	0.02	0.044	0.47	1.10	0.00	0.11	0.11	Direct Relationship
Challenge 5	0.06	0.43	-0.139	0.04	1.10	0.00	0.17	0.01	Indirect relationship

Note: challenges are Higher costs, Technical difficulty, Risk due to different contract forms, Lengthy approval, Unfamiliarity with Green Technology.

To assess the hypothesized relationship, structural equation modelling (SEM) was performed. SEM is a multivariate technique to analyse complex models and

explain multiple relations at a time [34]. In this study the relationship between dependent and independent variables was assessed. The variables were employed based on our

conceptual framework. All the results from the mediation testing are shown in Table V.

## V. DISCUSSION

The results reveal that Challenge 2 and Challenge 5 are insignificant and have no impact on project success; thus, we reject our null hypotheses 2a and 5a with the  $p$ -value  $< .05$ . However, Challenges 1, 3 and 5 are found to be predictors of project success with the  $p$ -value  $< .05$ . Consequently, we can interpret technical difficulty and unfamiliarity with green technology as not exerting an impact on project success. Project success has a lot to do with technical difficulty, and it depends on how complicated the technical procedures are. The results indicate that no significant impact of technical difficulty on project success is apparent in the particular context of the Chinese construction industry, so technical difficulty is not a relevant challenge affecting project success. Another particularly related challenge is familiarity with green technology, which is also not significantly related to project success. One of the valid reasons for this could be China's development in science and technology. Hence, project managers who are technically and technologically well qualified do not think that these challenges have any impact on project success.

To test the mediating effect of project performance between Challenges 1, 3 and 5 and project performance, the decision points from [31] are used. Table 4 reveals that Challenge 1 (higher cost) has an insignificant relationship with project performance; therefore, we can infer that there is a direct relation between higher cost and project success and that project performance has no significant mediating role between them. This result indicates that higher cost may have an impact on project success; however, the performance of the project has nothing to do with the higher cost.

Challenge 3 (risk due to different contract forms) has a significant relation with project performance, and project performance is a significant predictor of project success; thus, we can conclude that there is a partial mediation of project performance between risk due to different contract forms and project success.

Lengthy approval, which is Challenge 4 in our research, is found to have an insignificant impact on project success; thus, we can interpret lengthy approval as having a direct relation with project success and project performance as having no role between them.

Challenge 2 and Challenge 5 are initially found to be insignificant predictors of project success; however, they have a significant relation with project performance and project performance is a predictor of project success in both challenges. Therefore, we may summarize that there is somewhat indirect relationship between technical difficulty and unfamiliarity with green technology and project success.

## VI. CONCLUSIONS

This study aimed to examine the challenges that are usually faced by project managers during the management of green building construction projects and their impact on

project success. Furthermore, the study intended to examine the mediating effect of project performance between the relationship of project management challenges related to green construction and their success. The study proposes some possible ideas to improve green construction project management. The previous literature suggested that there are five big challenges that project managers face: 1) increased cost; (2) lack of communication and interest; (3) high implementation cost; (4) lack of credible research; and (5) lack of interest from clients. The challenges were found to be predictors of project success except Challenges 2 and 5. Thus, we can state that technical difficulty and unfamiliarity with green technology do not have an impact on project success. Project success is considerably related to technical difficulty and depends on how complicated the technical procedures are. The results indicate no significant impact of technical difficulty on project success, so it may be seen that, in the particular context of the Chinese construction industry, technical difficulty is not a relevant challenge that affects project success. Another particularly related challenge, familiarity with green technology, is also not significantly related to project success. One of the valid reasons for this could be China's development in science and technology. Hence, project managers who are technically and technologically well qualified do not think that these challenges have any impact on project success. The findings from this study suggest that competent project managers who are capable of overcoming the challenges may be especially helpful in ensuring the success of projects, ultimately adding value to the success of the construction industry.

## VII. LIMITATIONS AND FUTURE AVENUES FOR RESEARCH

Although the study aimed to achieve certain objectives, it is still limited to the conclusions that we may draw from it. The analyses were performed on a fairly small sample, so caution should be taken in generalizing the results. Moreover, the study did not take the experience of the respondents into consideration. The study is limited to the context of China, as the respondents were all from China. The study recommends future research areas, indicating the identifying characteristics that a project manager should have not only from the perspective of project managers but also from the perspective of other relevant parties. The study also recommends investigating ways to improve and strengthen the critical knowledge areas and capabilities explored in this research.

Further research can be performed using the characteristics of project managers and the challenges that may relate to the particular types of project managers. Moreover, the perspective of other stakeholders may be taken into account to draw an in-depth understanding of the phenomenon. We also recommend carrying out research regarding the awareness of project managers about the challenges and their remedy. This type of research may be helpful in identifying areas for improvement and later on will be helpful in improving the capabilities of project managers; ultimately, the probability of successful and better-performing green projects will be increased.



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