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The Drivers and Performance of Environmental Practices in the Chinese Construction Industry

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Abstract: With the global concern of environmental protection and sustainability, construction firms are required to develop and implement environmental practices (EP) to mitigate the negative impacts of project activities on the environment. This paper attempts to explore two potential drivers (i.e., government regulations and project team's knowledge and skills) and performance outcomes (i.e., environmental performance and organizational performance) when the firm implementing EP in construction projects. A survey-based research design was developed to measure the drivers, EP implementation, and performance and to collect data in the Chinese construction industry. Structural equation modelling was used to test the hypothesized relationships. The results indicate that a project team's knowledge and skills, rather than government regulations, are the key driving factors for the implementation of EP in construction projects. EP implementation is proved to have a positive impact on both environmental and organizational performance. This study provides empirical evidence for project environmental management research and offers managerial insights on how to promote EP in the construction industry.

Keywords: environmental practices; government regulations; project team's knowledge and skills; environmental performance; organizational performance; structural equation modelling

1. Introduction

Building and infrastructure construction activities have a substantially negative impact on environment, producing waste water, air pollution, noise, and land pollution [1–3]. These activities also produce one third of greenhouse gas (GHG) emissions in the world [4], leveling up concerns about global climate change mediated by GHG [5]. In addition, Qi et al. [6] pointed out that "every ten thousand square meters of construction area would produce 500–600 tons of solid wastes" in China and 180 tons in the US. In the construction industry, environmental practices (EP) refer to the management of a construction project to minimize the negative impacts of construction processes on the environment [6–8]. Various environmental protection associations and government authorities on a global scale are therefore advocating EP implementation. In particular, Chinese construction companies are encouraged to implement environmental technologies, methods, and activities to meet the demands of society and consumers for sustainability, and to comply with governmental environmental regulations [9–11]. Therefore, in recent decades, EP in construction projects has attracted extensive attention from scholars.

The previous studies have increasingly explored the drivers or success factors for EP implementation in construction projects [8,12,13]. For example, Zhao et al. [2] identified the role of project managers' leadership in promoting green building projects. Li et al. [13] pointed out human resource factors as one critical success factor for delivering green building projects. Wong et al. [14] confirmed mandatory environmental regulations and governmental or non-governmental organization requirements were key factors facilitating green procurement in construction projects. Similarly, Yusof et al. [15] indicated organizational support and regulatory pressure are particularly critical of EP implementation in Malaysian construction projects. By using a systematic literature review and expert interview, Banihashemi et al. [16] identified 43 factors influencing the integration of environmental sustainability and construction project management practices, such as commitment to systematic methodologies of project management, knowledge and awareness of sustainable project delivery in the project management team (PMT), and implementing an effective decision making process by the PMT. In the literature review of Aarseth et al. [17], they summarized eight strategies adopted by project organizations to promote project (environmental) sustainability, among which were setting sustainability policies and developing sustainability competencies. It can be concluded that scholars have widely recognized the significant role of government regulations as external drivers and project team's knowledge and skills as internal drivers in EP implementation. However, to our best knowledge, no empirical studies simultaneously investigate their impact on EP implementation by using a large sample. Therefore, we propose the first research question:

Research Question 1: *What are the effects of government regulations and project team's knowledge and skills on EP implementation in Chinese construction projects?*

Moreover, in the extant literature, little empirical evidence has been provided to confirm the benefits of EP implementation, although some of the related literature have discussed the outcomes of green building or green strategy. For example, Lu et al. [18] demonstrated going green for construction firms can achieve better return on equity and economic value-added margin. Jiang et al. [19] analyzed the co-benefits of energy conservation and carbon reduction in the production and demolition stages in a building's lifecycle. Yusof et al. [15] confirmed EP implementation had a positive impact on environmental and economic performance for Malaysian construction firms. Carvalho and Jr [20] showed that project environmental sustainability practices positively influenced environmental performance and project success in two countries, Brazil and Peru. Indeed, government and communities expect the environmental performance through the implementation of environmental practices in construction projects, while companies focus more on the business benefits like market opportunities, reputations, improved capabilities, and government support. Thus, this paper focuses on environmental performance and organizational performance, and intends to establish the links between EP implementation and these two kinds of performance outcomes in Chinese construction industry. Specifically, environmental performance indicates the impacts of the construction activities on natural milieu [20], whereas organizational performance indicates the development in the organization's capacity for future opportunities and challenges and determines the long-term ultimate objective [21]. Overall, the second research question is:

Research Question 2: *What are the effects of EP implementation on environmental performance and organizational performance in Chinese construction projects?*

Against this backdrop, this paper intends to develop the relationship among drivers (government regulations and project team's knowledge and skills), EP implementation, and performance (environmental and organizational performance). A survey-based method was applied to measure the relevant constructs, and structural equation modelling was used to test the hypothesized relationships. This study will contribute to the relevant research from three aspects. First, this study reveals the distinct role of government regulations and project team's knowledge and skills in EP implementation, and hence enhances the understanding on how to promote EP implementation. Second, this study establishes a significant relationship between EP implementation and environmental and organizational performance through empirically testing on a large sample dataset. The results confirm the effectiveness of EP implementation. Third, this study focuses on the Chinese construction industry as an emerging economy context. China is now in a rapidly developing stage and Chinese construction industry are characterized with high complexity and uncertainty. Thus, the empirical results can add new ideas to environmental management research.

2. Theoretical Background and Hypothesis Development

2.1. Drivers of EP Implementation in Construction Projects

This paper focuses on the impact of two potential drivers on EP implementation, i.e., government regulations from the perspective of legitimacy theory and project team's knowledge and skills based on resource-based view (RBV). Legitimacy theory suggests that the growth of organizations is the result of interaction with institutional environment, and thus the organization can only survive by adapting to external institutional environment [21]. Institutional legitimacy is especially crucial for Chinese construction firms. Chinese Ministry of Housing and Urban-Rural Development of PRC (MOHURD) has published many guides and regulations for green specifications, e.g., Evaluation Standard for Green Construction of Building (GB/T 50640-2010) in 2010 and Code for Green Construction of Building (GB/T 50905-2014) in 2014. Chinese companies are required to follow environmental protection specifications and guidelines by applying green construction techniques. For the construction firms, the implementation of EP following the regulations of government can help the firm achieve institutional legitimacy and can earn more government financial or information support. Previous studies of Qi et al. [6], Wong et al. [14] and Yusof et al. [15] have also recognized the stringency and integrity of government regulation as a primary driving force of EP implementation. Therefore, this study proposes that government regulations for construction firms will promote EP implementation in construction projects.

Hypothesis 1a (H1a). *Government regulations have a positive impact on EP implementation in construction projects.*

RBV indicates that the organization relies on its valuable, rare, imperfectly imitable, and non-substitutable resources to achieve sustainable competitive advantages [22]. From the perspective of RBV, a project team's knowledge and skills are competent resources for construction firms, and can enhance the firm's capabilities to implement EP in construction projects. While government regulations are identified as external drivers influencing EP implementation, the project team's knowledge and skills are key internal enablers for construction firms in implementing environmental practices. Particularly, Hwang and Ng [7] identified some critical knowledge areas and skills for success implementation of green construction projects, and pointed out that these knowledge and skills were essential to respond to new challenges of EP implementation. Li et al. [13] also found that human resource-oriented factors involving project team communication and motivation were critical for delivery green construction projects. Zhao et al. [2] identified project managers' leadership can promote the success of green building projects. It can be concluded that project managers and team members who specialize in knowledge and skills for environmental management are much more competent in EP implementation. On the other hand, lack of green technical knowledge [23] and inadequate project management capabilities [24] are recognized as the key barriers of EM implementation. Shi et al. [8] identified the barriers to implementing green construction including additional time and cost, technological issues, unawareness of green concept, and so on. Hence, the project team's knowledge and skills are supposed to promote EP implementation.

Hypothesis 1b (H1b). *Project team's knowledge and skills have a positive impact on EP implementation in construction projects.*

2.2. Performance of EP Implementation in Construction Projects

Environmental practices have been demonstrated to influence environmental performance in product development area [25] and supply chain area [26]. Examples of the environmental performance of a construction project include reduction of air emissions, effluent waste and solid wastes, and decrease in consumption for hazardous/harmful/toxic materials and frequency for environmental accidents [20]. This study proposes that in the context of the construction industry, EP implementation has a positive impact on environmental performance from two aspects. First, the firm can achieve environmental legitimacy through EP implementation in construction projects [21]. Environmental legitimacy implies that the organization's environmental practices and initiatives are perceived to be responsible and useful for the environment [21]. Construction firms are usually required to take measures for the reduction of noise, landfill waste and fugitive dust, the adoption of clean transportation and greening surrounding environment. Bortree [21] pointed out that an organization's environmental initiatives can effectively address key environmental concerns of the government and communities. Hence, environmental performance can be ensured through EP implementation. Second, the objective of EP implementation is to mitigate the negative impacts of construction projects on air, water, land, and environment by using green technologies or advanced management techniques. Based on legitimacy theory, Bossink [27] showed some management systems for sustainable construction such as design tools, waste management systems, and environmental management systems. The application of these green technical solutions, systems, standardized practices, and management methods can reduce the negative impacts of construction activities on environment. In short, environmental performance can be achieved effectively when firms execute environmental practices in construction projects [20]. Thus, this paper proposes that EP implementation in construction projects will promote environmental performance.

Hypothesis 2a (H2a). *EP implementation in construction projects has a positive impact on environmental performance.*

Prior studies (e.g., [8,28–30]) have confirmed that EP implementation has a negative effect on financial performance, including additional costs and decreased revenue in the short term. In this paper, we argue that EP implementation in the construction industry will result in the improvement of organizational performance. Financial performance indicates the additional costs and time, income and revenue [31], whereas organizational performance indicates the development in the organization's capacity for future opportunities and challenges and determines the long-term ultimate objective [32]. Reputation, government support, improved capabilities, and future market opportunities are applied to measure organizational performance in this paper [32,33]. EP implementation is beneficial for organizational performance for two reasons. First, although some scholars point out the disadvantages of environmental practices, such as additional time and cost [8], more studies have recognized its advantages in the long term. According to legitimacy theory, EP implementation implies the firm is taking responsibility for society, and can be approved by the public, the market and government departments. Therefore, the firm implementing EP in construction projects can achieve market opportunities and government support more easily, leading to future benefits. Second, EP implementation can make the firm more competitive and help the firm enhance competitive advantage. Environmental practices in construction projects contribute to gaining reputation, saving energy and resources, reducing construction and operation costs, receiving government financial and information support, and improving customer satisfaction [34]. Lu et al. [18] emphasized the role of green initiatives in innovation, value creation, and competitive advantage formation, and hence turning green to gold in construction industry. Moreover, construction firms can improve productivity and achieve cost efficiency through waste management, resource conservation and lean construction principles. Overall, EP implementation in construction projects are supposed to promote organizational performance.

Hypothesis 2b (H2b). *EP implementation in construction projects has a positive impact on organizational performance.*

Prior studies have discussed how environmental performance resulting from environmental practices influences economic performance or financial performance. Some of them reveal the positive correlation between them [15,35], while others find that environmental performance has no significant relationship with economic performance [31,36]. In this study, environmental performance is supposed to promote organizational performance from the following aspects including government support, improved reputation, and market legitimacy. First, considering the desire of government and community on natural environment, the companies can achieve the political legitimacy through following the rules and regulations and acquiring professional environmental certifications [37]. Second, a positive environmental performance can help the companies establish a good social image and gain reputation through undertaking corporate social responsibility. Third, for construction companies, a better environmental performance must be also a source of market legitimacy because their "green" image contributes to winning trust and loyalty from the customers. Hence, construction firms' organizational performance will be improved in the case of a higher level of environmental performance.

Hypothesis 3 (H3). *Environmental performance has a positive impact on organizational performance.*

Figure 1 shows the conceptual model of this study.

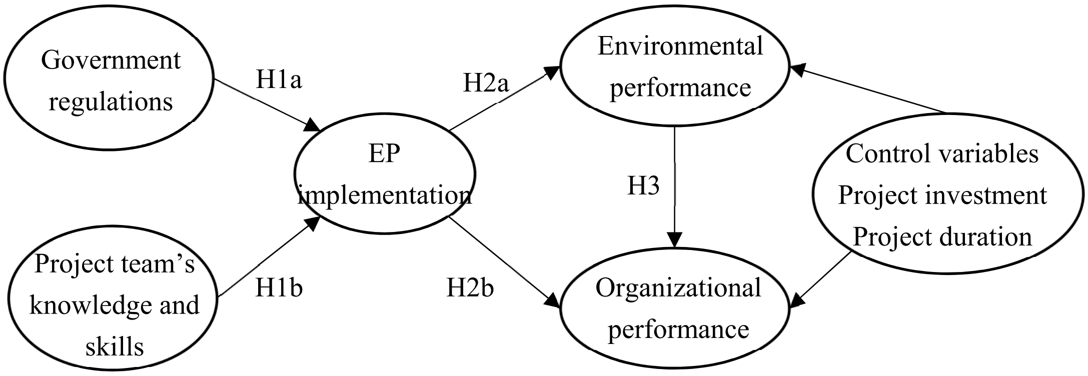

Figure 1. Conceptual model.

3. Research Methods

3.1. Sample and Data Collection

This study focuses on the Chinese construction industry. In recent years, the high-speed economic development of China has been accompanied by plenty of housing and infrastructure construction activities. These activities are causing great damage to the environment. The concerns surrounding environmental pollution and protection in China have been increasing gradually. The Chinese government has therefore made a big effort in the formulation of environmental policies, regulations, and laws, and Chinese construction companies are encouraged to take responsibility for environmental protection [8,14,38]. Therefore, we selected the Chinese construction industry as an ideal setting for conducting environmental management research. It should be highlighted that EP implementation may vary in each construction project due to its one-off and unique nature. Hence, the unit of analysis in this study is the project.

This research used an online questionnaire survey to collect data. After discussion with practitioners and academic researchers, we conducted a pilot study of 20 construction project managers. Then the survey details were placed on a questionnaire website. This study used a non-probabilistic sampling method to select respondents for ease of access to project data, which was considered appropriate to obtain a representative sample in the study of Carvalho and Jr [20]. Wu et al. [39] also pointed out that the non-probability convenience sampling method can improve response rated and has been widely used in the construction industry. An email with the survey link was sent out to all the general managers or project managers attending Executive Master of Business Administration (EMBA), Master of Business Administration (MBA), and Master of Engineering (ME) program in the authors' university, through which we presented our research objectives and an invitation to join the survey. These programs intend to train knowledgeable practitioners from various companies across the country. Since the authors were supervisors or course teachers of the programs, the attendees in the programs were very cooperative in the survey. Then the attendees in the construction industry helped us distribute the questionnaires to their colleagues who had sufficient project management experience. Finally, we obtained 221 responses, of which 159 were usable for analysis.

The demographics for the sample are presented in Table 1. As shown in Table 1, respondents include project managers, general managers, or project team members who were knowledgeable in answering the questions of environmental practices in construction projects. 87.43% of the respondents had more than 4 years' working experience in project management, and hence they are deemed to be knowledgeable and qualified to answer the questionnaire on EP implementation. The projects are of various types, such as residential buildings, commercial buildings, industrial projects and infrastructure construction, and of different sizes, with investment ranging from less than 100 million to more than 1000 million and durations ranging from less than 1 year to more than 3 years. Hence, the sample representativeness can be ensured to a certain extent.

Table 1. Sample demographics.

Characteristic	N	%	Characteristic	N	%
Job Position	159	100	Project Type	159	100
General manager	8	5.03	Residential	24	15.09
Project manager	46	28.93	Commercial	63	39.62
Project team member	78	49.05	Industrial	3	1.89
Engineer	25	15.73	Infrastructure	55	34.59
Others	2	1.26	Other	14	8.81
Work experience	159	100	Project investment	159	100
1–3	20	12.57	≤100 million	26	16.35
4–6	51	32.08	100 to 500 million	55	34.59
7–10	51	32.08	500 to 1000 million	36	22.64
>10	37	23.27	>1000 million	42	26.42
Company type	159	100	Project duration	159	100
Client	7	4.40	≤1 year	14	8.81
Contractor	138	86.79	1 to 2 years	43	27.04
Consultant	13	8.18	2 to 3 years	71	44.65
Others	1	0.63	>3 years	31	19.50

Non-response bias was checked in this research. The differences between early and late respondents were compared with the homogeneity test of variances and the independent sample t test of mean value in terms of project type and project duration [40]. The Levene test results indicate the project type (F = 2.135, p = 0.146) and project duration (F = 1.712, p = 0.193) meet the homogeneity of variance. In this case, the t test results show that there is no significant difference in the mean values of project type (t = −1.673, p = 0.096) and project duration (t = −0.766, p = 0.445). It can be concluded that non-response bias is not a concern in this study.

Moreover, both procedural and statistical remedies were adopted to control common method bias. First, respondents in our study were prequalified to ensure most of them have high levels of relevant knowledge. More than 50% of respondents had over 7 years' working experience. Second, we assured respondents of their anonymity to encourage them to answer truthfully. Third, Harman's one factor test was performed on the variables of government regulations, project team's knowledge and skills, EP implementation, environmental performance, and organizational performance. Five distinct factors were extracted. In addition, the first factor accounted for 18.873% of the total variance, which was not the majority. The common method bias was therefore not an issue in this study.

3.2. Measures

Based on the relevant environmental management literature and the theoretical framework developed above, a questionnaire was designed to measure government regulations, the project team's knowledge and skills, EP implementation, environmental performance and organizational performance. Table 2 shows the measures for each construct. All the measurements were presented as five-point Likert scales, with "1" indicating "strongly disagree" and "5" indicating "strongly agree".

Table 2. Construct measures.

Constructs	Measures
EP implementation [6,8,41,42]	EP1-Apply advanced green technologies and methods EP2-Follow green construction specifications EP3-Satisfy green building evaluation requirements EP4-Monitor and report green construction processes regularly EP5-Optimize construction processes and technologies to reduce environmental impacts
Government regulations [6,41,43]	GR1-Central governmental environmental regulations are stringent GR2-Regional environmental regulations are stringent GR3-Future central environmental regulations are predictable GR4-Future local environmental regulations are predictable GR5-Environmental regulations are appropriate for China's construction market
Project team's knowledge and skills [7,41]	PKS1-Project team knows environmental related specifications and techniques well PKS2-Project team members communicate environmental knowledge, skills, and management methods PKS3-Project team takes the initiative to implement environmental practices PKS4-Project team establishes manuals, rules, and regulations on environmental practices
Environmental performance [20,26,44]	EP1-Reduction of air emissions EP2-Reduction of effluent waste EP3-Reduction of solid wastes EP4-Decrease in consumption for hazardous/harmful/toxic materials EP5-Decrease in frequency for environmental accidents
Organizational performance [20,26,32,33]	OP1-Good reputation OP2-Government support OP3-Improved green capabilities OP4-More market opportunities

EP implementation is defined as the organization and management of construction processes to reduce their negative impacts on environment [6]. The measures of EP implementation are adjusted from the literature of Lam et al. [41], Qi et al. [6], Robichaud and Anantatmula [42] and Shi et al. [8]. Five items are included, i.e., EP1-apply advanced green technologies and methods, EP2-follow environmental specifications, EP3-satisfy green building evaluation requirements, EP4-monitor and report green construction processes regularly, and EP5-optimize construction processes and technologies to reduce environmental impacts. The respondents were asked to indicate the extent to which they perceive the project was implementing these practices.

Two potential drivers, i.e., government regulations and the project team's knowledge and skills, are considered in this study. According to the literature of Qi et al. [6], Lam et al. [41] and Zhang et al. [43], government regulations are measured by five items. The respondents were required to indicate the extent to which they agree with the following questions. GR1-Central governmental environmental regulations are stringent; GR2-Regional environmental regulations are stringent; GR3-Future central environmental regulations are predictable; GR4-Future local environmental regulations are predictable; and GR5-Environmental regulations are appropriate for China's construction market. The measures for project team's knowledge and skills are adapted from the literature of Hwang and Ng [7] and Lam et al. [41]. Respondents were asked to indicate the level of agreement or disagreement. PKS1-Project team knows environmental related specifications and techniques well; PKS2-Project team members communicate environmental knowledge, skills, and management methods. PKS3-Project team takes the initiative to implement environmental practices; and PKS4-Project team establishes manuals, rules, and regulations on environmental practices.

Two kinds of performance outcomes are investigated. Environmental performance refers to the impacts of the construction activities on natural milieu [20]. In this paper, environmental performance is measured as EnP1-reduction of air emissions, EnP2-reduction of effluent waste, EnP3-reduction of solid wastes, EnP4-decrease in consumption for hazardous/harmful/toxic materials, and EnP5-decrease in frequency for environmental accidents based on the literature of Carvalho and Jr [20], Green Jr et al. [26] and Zhu [44]. Organizational performance is defined as the long-term benefits the organization achieves [33]. The scales of organizational performance were previously used and assessed by Richard et al. [33], Green Jr et al. [26], Yang et al. [32] and Carvalho and Jr [20]. Four items are included in this study, i.e., OP1-good reputation, OP2-government support, OP3-improved green capabilities, and OP4-more market opportunities.

3.3. Data Analysis Technique

This research adopted the Structural Equation Modeling (PLS-SEM) approach to analyze the survey data. In SEM, observable variables and latent variables are included. The former can be directly measured through questionnaire survey, whereas the latter are theoretical constructs inferred from the observable variables [45]. Also, SEM is composed of measurement and structural models [46]. In our study, the measurement model presents the relationships between each measurement item (i.e., the observable variable) and its theoretical construct (i.e., the latent variable), and the structural model provides the relationships among the theoretical constructs (i.e., the latent variable). SEM allows estimation of the complex and multi-stage relationships among variables, and simultaneously estimates the measurement model and structural model [45–47]. Covariance-based SEM (CB-SEM) and partial least-squares SEM (PLS-SEM) are two classical types of SEM [46]. Compared with CB-SEM, PLS-SEM can analyze a complex model with a small sample size and free data distribution [48–50]. Until now, PLS-SEM had been used widely by project management and construction management researchers [20,51–55] to investigate the multiple and interdependent relationships among constructs. Based on the suggestion of Hair et al. [48], a minimum sample size for PLS-SEM is 10 times the maximum number of paths in the model. In this research, the sample size (159 observations) satisfied the requirement.

4. Data Analysis Results

4.1. Measurement Model

This research adopted a two-stage process to thoroughly evaluate the measurement model, following [56]. First, an exploratory factor analysis (EFA) with SPSS software was conducted to ensure the uni-dimensionality of the scales. The Kaiser-Meyer-Olkin measure of sampling adequacy (0.938) and the Bartlett's test of sphericity (Approx. $\chi 2$ = 4677.315, p = 0.000) confirmed that the data were suitable for EFA. The results shown in Table 3 indicate that all items had higher loadings (>0.50) on the construct that they are intended to measure and lower loadings on other irrelevant constructs [57].

Table 3. Cross loadings.

Factor Loadings	EP Implementation	Government Regulations	Project Team's Knowledge and Skills	Environmental Performance	Organizational Performance
GC1	0.766	0.209	0.137	0.313	0.273
GC2	0.804	0.286	0.261	0.222	0.233
GC3	0.800	0.274	0.283	0.186	0.215
GC4	0.745	0.286	0.297	0.175	0.300
GC5	0.700	0.218	0.250	0.299	0.317
GR1	0.351	0.791	0.132	0.185	0.114
GR2	0.196	0.843	0.220	0.145	0.140
GR3	0.161	0.798	0.155	0.243	0.252
GR4	0.219	0.760	0.075	0.281	0.326
GR5	0.187	0.759	0.234	0.100	0.256
PKS1	0.316	0.315	0.299	0.189	0.728
PKS2	0.438	0.354	0.359	0.247	0.580
PKS3	0.301	0.330	0.342	0.230	0.728
PKS4	0.361	0.362	0.299	0.281	0.677
PKS5	0.421	0.302	0.298	0.152	0.691
EP1	0.249	0.099	0.752	0.209	0.378
EP2	0.255	0.264	0.687	0.322	0.288
EP3	0.209	0.241	0.752	0.353	0.310
EP4	0.351	0.216	0.720	0.361	0.116
EP5	0.218	0.200	0.725	0.358	0.214
OP1	0.288	0.201	0.428	0.754	0.165
OP2	0.283	0.228	0.298	0.810	0.154
OP3	0.221	0.266	0.322	0.778	0.272
OP4	0.273	0.284	0.370	0.769	0.193

Next, the convergent and discriminant validity were assessed using confirmatory factor analysis (CFA). Table 4 presents the CFA results. For the measurement model, all of the factor loadings were greater than 0.80, significant at the level 0.000 [57,58]. The Cronbach's α coefficients for all the constructs are greater than 0.70 [59], indicating adequate reliability of internal consistency. The average variance extracted (AVE) and composite reliability (CR) for each construct are all larger than 0.70 [60]. Therefore, convergent validity can be confirmed. Discriminant validity can be ensured when the square-rooted AVE values are greater than its correlation with other constructs [61], and Heterotrait–Monotrait ratio of Correlation (i.e., HTMT) values are below 0.90 [48]. Table 5 shows the correlations, square-rooted AVE, and HTMT values for all the relevant constructs in this study. The results indicate that this survey has acceptable discriminant validity.

Table 4. Constructs and items with convergent validity.

Measurement	Factor Loadings	Standard Deviation	T Statistics
EP implementation (α = 0.952; CR = 0.963; AVE = 0.840)			
EP1	0.895	0.026	34.072
EP2	0.944	0.014	65.102
EP3	0.929	0.018	51.339
EP4	0.917	0.015	61.771
EP5	0.898	0.027	33.169
Government regulations (α = 0.929; CR = 0.947; AVE = 0.780)			
GR1	0.889	0.029	30.187
GR2	0.897	0.025	36.133
GR3	0.894	0.020	45.247
GR4	0.896	0.020	43.809
GR5	0.839	0.033	25.275

Table 4. *Cont.*

Measurement	Factor Loadings	Standard Deviation	T Statistics
Project team's knowledge and skills (α = 0.961; CR = 0.970; AVE = 0.865)			
PKS1	0.910	0.021	43.574
PKS2	0.925	0.015	61.015
PKS3	0.943	0.016	58.583
PKS4	0.946	0.015	64.163
Environmental performance (α = 0.942; CR = 0.955; AVE = 0.811)			
EnP1	0.882	0.023	38.551
EnP2	0.894	0.022	40.972
EnP3	0.940	0.011	87.466
EnP4	0.896	0.023	38.739
EnP5	0.890	0.024	37.049
Organizational performance (α = 0.959; CR = 0.970; AVE = 0.891)			
OP1	0.947	0.013	75.092
OP2	0.942	0.017	56.614
OP3	0.946	0.017	54.538
OP4	0.940	0.029	32.625

Table 5. Correlation coefficients, square-rooted AVE, and HTMT values.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
EP implementation (1)	0.917						
Government regulations (2)	0.638 (0.675)	0.883					
Project team's knowledge and skills (3)	0.792 (0.826)	0.708 (0.748)	0.930				
Environmental performance (4)	0.697 (0.734)	0.570 (0.608)	0.765 (0.803)	0.900			
Organizational performance (5)	0.676 (0.707)	0.594 (0.629)	0.783 (0.699)	0.783 (0.822)	0.944		
Project investment (6)	−0.049 (0.051)	−0.031 (0.053)	0.033 (0.034)	−0.026 (0.028)	−0.148 (0.151)	-	
Project duration (7)	−0.081 (0.082)	0.055 (0.066)	−0.127 (0.130)	−0.222 (0.230)	−0.147 (0.150)	0.189 (0.189)	-

Note: Square-rooted AVE values are on the diagonal. Correlation coefficients are in the off-diagonal matrix. HTMT values are in brackets.

4.2. Structural Model

This study uses a bootstrapping procedure with 159 cases and 5000 subsamples to assess the significance of all factor loadings and path coefficients. The results of structural model analysis are summarized in Figure 2. All the constructs have a variance inflation factor (VIF) tolerance value ranging from 1.008 to 2.060. VIF values are less that the threshold value of 5, therefore indicating that collinearity is not an issue [53]. Additionally, the coefficient of determination R^2 is used to assess predictive validity of the structural model [62]. As presented in Figure 2, the structural model explains 64% of the variance in green construction, 51.5% of the variance in environmental performance, and 53.1% of the variance in organizational performance. This study then obtained Q^2 values of 0.486, 0.380, and 0.531 (all above zero) for green construction, environmental performance, and organizational performance by running the blindfolding procedure. It can be concluded that the structural model has a significant level of predictive relevance.

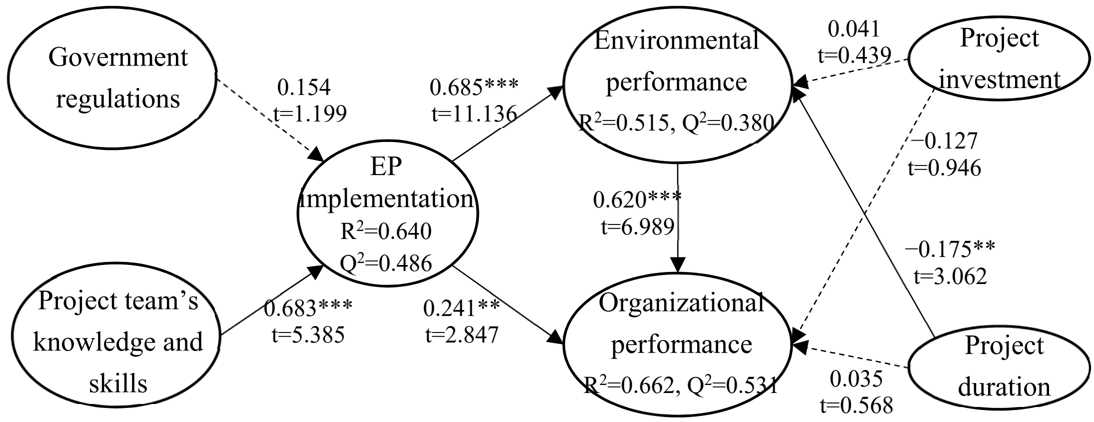

Figure 2. Results of structural model.

Table 6 summarizes the results of structural model evaluation. Based on the results, Hypothesis 1a was not supported, suggesting government regulations did not directly influence EP implementation in the Chinese construction industry. Nevertheless, the results provide support for Hypothesis 1b. Thus, the project team's knowledge and skills are confirmed to influence EP implementation directly and positively. Additionally, it should be noted that the influence of the project team's knowledge and skills is much stronger than government regulations based on the results.

The hypotheses H2a and H2b were both supported. EP implementation is confirmed to be directly and positively related to the improvement of environmental and organizational performance. Moreover, the direct impact of EP implementation on environmental performance is much stronger than organizational performance. The path coefficient for H3 (environmental performance organizational performance) is significant. This indicates that environmental performance is significantly and positively associated with organizational performance.

This study used project investment and duration as control variables. The influence of project investment on environmental and organizational performance is not significant. Also, project duration has no significant effect on organizational performance. Nevertheless, project duration is proved to be significantly and negatively related to environmental performance. This is easily understandable, because long-running construction projects usually have great negative impacts on the environment.

Table 6. Structural model evaluation.

Hypotheses	Coefficient	T Statistics	*p* Values	Inference
H1a: Government regulations → EP implementation	0.154	1.199	0.231	Not Supported
H1b: Project team's knowledge and skills → EP implementation	0.683 ***	5.385	0.000	Supported
H2a: EP implementation → Environmental performance	0.685 ***	11.136	0.000	Supported
H2b: EP implementation → Organizational performance	0.241 **	2.847	0.004	Supported
H3: Environmental performance → Organizational performance	0.620 ***	6.989	0.000	Supported
Project investment → Environmental performance	0.041	0.439	0.661	-
Project investment → Organizational performance	−0.127	0.946	0.344	-
Project duration → Environmental performance	−0.175 **	3.042	0.002	-
Project duration → Organizational performance	0.035	0.568	0.570	-

Note: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

5. Discussion

5.1. Theoretical Implications

This study establishes the links among two potential drivers (i.e., government regulations and project team's knowledge and skills), EP implementation, and performance outcomes (environmental and organizational performance). The results contribute to the literature of environmental management from three aspects.

First, the findings reveal the driving effects of government regulations and the project team's knowledge and skills; the former being an external factor influences EP implementation based on legitimacy theory, while the latter is an internal factor affecting EP implementation based on RBV. Setting sustainability policies and developing sustainability competencies are recognized as two critical strategies for project sustainability [17]. In prior studies, scholars have always emphasized the dominant role of government regulations or policies [14,15]. However, according to our results, government regulations have no significant impact on EP implementation in the Chinese construction industry. A possible reason for this is that as an emerging market, the Chinese government is gradually improving environmental regulations to adapt to new situations and to solve new problems. The current regulations could be inadequate to guiding construction firms' behaviors in a relatively complex and uncertain context. As indicated by Shi et al. [8], the government should continuously amend environmental regulations on a timely basis to reflect the development situations and requirements. Moreover, the findings indicate that the project team's knowledge and skills have a significant impact on EP implementation. It can be concluded that internal capability is the determinant factor for environmental practices, which supports the role of RBV in explaining EP implementation [22]. Moreover, Li et al. [13] also emphasized project management capabilities as critical successful factors for delivering green building projects. Hwang and Ng [7] presented knowledge areas and skills for green construction. The findings in this study complementing with [7] and [13] further demonstrate the role of project team's competence.

Second, although previous studies have explored the benefits of environmental practices through case studies or qualitative analysis [20,63], this study establishes the positive links between EP implementation and performance outcomes through empirically testing on a large sample dataset. Prior studies indicate the challenges such as additional cost and incremental time, which impede EP implementation [8]. Our study shows that EP implementation in construction projects is beneficial for both the environment and the organization. Indeed, prior studies have pointed out that the adoption of EP may increase project complexity and additional time and cost in the short term for construction firms [7,8,29,63]. This study confirms that organizational reputation, improved capabilities, government support, and market opportunities can be achieved through EP implementation in construction projects, which indicate long-term benefits for the construction firm. Lu et al. [18] compared 22 green versus conventional firms in terms of short-term financial performance and long-term economic value by using t-test methods. Carvalho and Jr [20] also showed a significant and positive relationship between project sustainability management and project success. This paper supports their idea about the relationship between EP implementation and performance in construction projects further.

Third, this study provides empirical evidence for environmental management research through a survey in the Chinese construction industry. Since Chinese government and society attach increasing importance to environmental protection practices in the stage of rapid economic development, construction firms are making great efforts towards EP implementation. Meanwhile, the Chinese construction industry is characterized by high complexity and uncertainty [8], which increases the difficulty of EP implementation. However, both scholars and practitioners hardly know the drivers and resulting performance. Prior studies discuss EP or project sustainability management practices in Singapore [13], United States [18], Malaysian [15] and Brazil and Peru [20]. Our research focuses on the Chinese construction industry in an emerging economy context, and adds new ideas to these studies as discussed above.

5.2. Managerial Implications

This study provides some managerial insights for government officials and managers of construction firms. First, the findings in this paper imply that government departments should promote environmental practices in construction projects so that the negative impacts of construction activities on environment can be eliminated. However, this study reveals that government regulations are not key drivers of EP implementation. We argue that in the context of the Chinese construction industry, government environmental regulations are still not adequate or rigorous enough. Particularly, China is now in a period of rapid development, and the construction industry is characterized by high complexity and uncertainty [8]. The current government regulations are still inadequate for adapting to the complex and uncertain environment. We conducted a short interview with one construction project manager about EP implementation. He expressed confusion about central and local environmental regulations and guidelines. Therefore, government offices could make more efforts with regard to the formulation of green laws, regulations, standards, and guidelines in order to provide a healthy and sound institutional environment for EP implementation.

Second, this study confirms that construction firms can achieve long-term benefits through the implementation of EP in construction projects. Although EP implementation requires additional time and cost in the short term, firms can achieve good reputation, government support, market opportunities and improved capabilities, which will take effect in the long term. Thus, construction firms are encouraged to invest in EP to establish sustainable competitive advantages. Furthermore, the project team's knowledge and skills are critical enablers for EP implementation. The implementation of environmental practices relies on firms' internal competence. Construction firms do not necessarily have adequate capabilities to implement EP even if they are willing to follow green construction regulations. Hence, managers are recommended to improve the project team's knowledge, skills, and capabilities in order to promote EP in construction projects.

6. Conclusions

To conclude, this study investigates the relationships among two potential drivers, EP implementation, and performance outcomes through a questionnaire survey in the Chinese construction industry. The drivers include government regulations from the perspective of legitimacy theory and the project team's knowledge and skills from the perspective of RBV. Environmental and organizational performance are considered as the outcomes of EP implementation. Structural equation modelling was used to test the hypothesized relationships. The results confirm project team's knowledge and skills can promote EP implementation, and that EP implementation positively influences environmental and organizational performance. This study provides empirical evidence for environmental management research and managerial implications for government officials and managers.

However, there are also some limitations to this research. First, we used a non-probability convenience sampling method to collect data in order to increase the response rate and 159 usable responses were obtained. Although the sample was adequate for the PLS-SEM method adopted in this study, a probability sampling method could be applied in future studies to improve the sample representativeness. Second, the effectiveness of EP may be affected by contingencies. Not all companies can necessarily achieve their desired results through EP implementation. Therefore, future research should consider the moderating effects of project complexity or environmental uncertainty on the effectiveness of EP implementation. Third, only two drivers are included in this research. Actually, EP implementation in construction projects is always associated with many stakeholders and therefore requires the collaboration between these stakeholders. Further research is suggested to explore how stakeholder collaboration promotes EP implementation.

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References

1. Zhao, X.; Zuo, J.; Wu, G.; Huang, C. A bibliometric review of green building research 2000–2016. *Archit. Sci. Rev.* **2018**, *52*, 1–15. [CrossRef]
2. Zhao, X.; Hwang, B.G.; Hong, N.L. Identifying critical leadership styles of project managers for green building projects. *Int. J. Constr. Manag.* **2016**, *16*, 150–160. [CrossRef]
3. Zuo, J.; Zhao, Z. Green building research—Current status and future agenda: A review. *Renew Sustain. Energy Rev.* **2014**, *30*, 271–281. [CrossRef]
4. WorldGBC. *The Business Case for Green Building: A Review of the Costs and Benefits for Developers, Investors and Occupants*; World Green Building Council: London, UK, 2013.
5. Shanmugam, S.; Sun, C.; Zeng, X.; Wu, Y.R. High-efficient production of biobutanol by a novel *Clostridium* sp. strain WST with uncontrolled pH strategy. *Bioresour. Technol.* **2018**, *256*, 543–547. [CrossRef] [PubMed]
6. Qi, G.Y.; Shen, L.Y.; Zeng, S.X.; Jorge, O.J. The drivers for contractors' green innovation: An industry perspective. *J. Clean. Prod.* **2010**, *18*, 1358–1365. [CrossRef]
7. Hwang, B.; Ng, W.J. Project management knowledge and skills for green construction: Overcoming challenges. *Int. J. Proj. Manag.* **2013**, *31*, 272–284. [CrossRef]
8. Shi, Q.; Zuo, J.; Huang, R.; Huang, J.; Pullen, S. Identifying the critical factors for green construction—An empirical study in China. *Habitat Int.* **2013**, *40*, 1–8. [CrossRef]
9. Zhang, X.; Shen, L.; Zhang, L. Life cycle assessment of the air emissions during building construction process: A case study in Hong Kong. *Renew Sustain. Energy Rev.* **2013**, *17*, 160–169. [CrossRef]
10. Wu, G.; Qiang, G.; Zuo, J.; Zhao, X.; Chang, R. What are the Key Indicators of Mega Sustainable Construction Projects?—A Stakeholder-Network Perspective. *Sustainability* **2018**, *10*, 2939. [CrossRef]
11. Yang, X.; Zhang, J.; Zhao, X. Factors affecting green residential building development: Social network analysis. *Sustainability* **2018**, *10*, 1389. [CrossRef]
12. Hwang, B.G.; Tan, J.S. Green building project management: Obstacles and solutions for sustainable development. *Sustain. Dev.* **2012**, *20*, 335–349. [CrossRef]
13. Li, Y.Y.; Chen, P.H.; Chew, D.A.S.; Teo, C.C.; Ding, R.G. Critical project management factors of AEC firms for delivering green building projects in Singapore. *J. Constr. Eng. Manag.* **2011**, *137*, 1153–1163. [CrossRef]
14. Wong, J.K.W.; Chan, J.K.S.; Wadu, M.J. Facilitating effective green procurement in construction projects: An empirical study of the enablers. *J. Clean. Prod.* **2016**, *135*, 859–871. [CrossRef]
15. Yusof, N.A.; Awang, H.; Iranmanesh, M. Determinants and outcomes of environmental practices in Malaysian construction projects. *J. Clean. Prod.* **2017**, *156*, 345–354. [CrossRef]
16. Banihashemi, S.; Hosseini, M.R.; Golizadeh, H.; Sankaran, S. Critical success factors (CSFs) for integration of sustainability into construction project management practices in developing countries. *Int. J. Proj. Manag.* **2017**, *35*, 1103–1119. [CrossRef]
17. Aarseth, W.; Ahola, T.; Aaltonen, K.; Økland, A.; Andersen, B. Project sustainability strategies: A systematic literature review. *Int. J. Proj. Manag.* **2016**, *35*, 1071–1083. [CrossRef]
18. Lu, Y.; Cui, Q.; Le, Y. Turning green to gold in the construction industry: Fable or fact? *J. Constr. Eng. Manag.* **2013**, *139*, 1026–1036. [CrossRef]
19. Jiang, P.; Dong, W.; Kung, Y.H.; Geng, Y. Analysing co-benefits of the energy conservation and carbon reduction in China's large commercial buildings. *J. Clean. Prod.* **2013**, *58*, 112–120. [CrossRef]
20. Carvalho, M.M.; Jr, R.R. Can project sustainability management impact project success? An empirical study applying a contingent approach. *Int. J. Proj. Manag.* **2017**, *35*, 1120–1132. [CrossRef]
21. Bortree, D.S. The impact of green initiatives on environmental legitimacy and admiration of the organization. *Public Relat. Rev.* **2009**, *35*, 133–135. [CrossRef]

22. Barney, J.B. Is the resource-based "view" a useful perspective for strategic management research? Yes. *Acad. Manag. Rev.* **2001**, *26*, 41–56.
23. Cui, L.; Chan, H.K.; Zhou, Y.; Dai, J.; Jia, J.L. Exploring critical factors of green business failure based on Grey-Decision Making Trial and Evaluation Laboratory (DEMATEL). *J. Bus. Res.* **2018**. [CrossRef]
24. Marcelino-Sádaba, S.; González-Jaen, L.F.; Pérez-Ezcurdia, A. Using project management as a way to sustainability. From a comprehensive review to a framework definition. *J. Clean. Prod.* **2015**, *99*, 1–16. [CrossRef]
25. Brones, F.; de Carvalho, M.M.; de Senzi Zancul, E. Ecodesign in project management: A missing link for the integration of sustainability in product development? *J. Clean. Prod.* **2014**, *80*, 106–118. [CrossRef]
26. Green Jr, K.W.; Zelbst, P.J.; Meacham, J.; Bhadauria, V.S. Green supply chain management practices: Impact on performance. *Supply Chain Manag.* **2012**, *17*, 290–305. [CrossRef]
27. Bossink, B.A.G. A Dutch public-private strategy for innovation in sustainable construction. *Constr. Manag. Econ.* **2002**, *20*, 633–642. [CrossRef]
28. Hwang, B.; Zhu, L.; Wang, Y.; Cheong, X. Green building construction projects in Singapore: Cost premiums and cost performance. *Proj. Manag. J.* **2017**, *48*, 67–79. [CrossRef]
29. Chandramohan, A. Cost and time overrun analysis for green construction projects. *Int. J. Green Econ.* **2012**, *6*, 167–177. [CrossRef]
30. Kubba, S. *Green Construction Project Management and Cost Oversight*; Architectural Press: London, UK, 2010.
31. Horváthová, E. Does environmental performance affect financial performance? A meta-analysis. *Ecol. Econ.* **2010**, *70*, 52–59. [CrossRef]
32. Yang, L.R.; Huang, C.F.; Hsu, T.J. Knowledge leadership to improve project and organizational performance. *Int. J. Proj. Manag.* **2014**, *32*, 40–53. [CrossRef]
33. Richard, P.J.; Devinney, T.M.; Yip, G.S.; Johnson, G. Measuring organizational performance: Towards methodological best practice. *J. Manag.* **2009**, *35*, 718–804. [CrossRef]
34. Zhang, X.; Shen, L.; Wu, Y. Green strategy for gaining competitive advantage in housing development: A China study. *J. Clean. Prod.* **2011**, *19*, 157–167. [CrossRef]
35. Zeng, S.X.; Meng, X.H.; Zeng, R.C.; Tam, C.M.; Tam, V.W.Y.; Jin, T. How environmental management driving forces affect environmental and economic performance of SMEs: A study in the Northern China district. *J. Clean. Prod.* **2011**, *19*, 1426–1437. [CrossRef]
36. Sarkis, J.; Dijkshoorn, J. Relationships between solid waste management performance and environmental practice adoption in Welsh small and medium-sized enterprises (SMEs). *Int. J. Prod. Res.* **2007**, *45*, 4989–5015. [CrossRef]
37. Suchman, M.C. Managing legitimacy: Strategic and institutional approaches. *Acad. Manag. Rev.* **1995**, *20*, 571–610. [CrossRef]
38. Liu, J.Y.; Sui, P.L.; He, X. Green practices in the Chinese building industry: Drivers and impediments. *J. Technol. Manag. China* **2012**, *7*, 50–63.
39. Wu, C.L.; Fang, D.P.; Liao, P.C.; Xue, J.W.; Li, Y.; Wang, T. Perception of corporate social responsibility: The case of Chinese international contractors. *J. Clean. Prod.* **2015**, *107*, 185–194. [CrossRef]
40. Armstrong, J.S.; Overton, T.S. Estimating nonresponse bias in mail surveys. *J. Mark. Res.* **1977**, *14*, 396–402. [CrossRef]
41. Lam, P.T.I.; Chan, E.H.W.; Poon, C.S.; Chau, C.K.; Chun, K.P. Factors affecting the implementation of green specifications in construction. *J. Environ. Manag.* **2010**, *91*, 654–661. [CrossRef]
42. Robichaud, L.B.; Anantatmula, V.S. Greening project management practices for sustainable construction. *J. Manag. Eng.* **2011**, *27*, 48–57. [CrossRef]
43. Zhang, X.; Wu, Y.; Shen, L. Embedding "green" in project-based organizations: The way ahead in the construction industry? *J. Clean. Prod.* **2015**, *107*, 420–427. [CrossRef]
44. Zhu, Q. Green supply chain management in China: Pressures, practices and performance. *Int. J. Oper. Prod. Manag.* **2012**, *25*, 449–468. [CrossRef]
45. Zhao, X.; Singhaputtangkul, N. Effects of firm characteristics on enterprise risk management: Case study of Chinese construction firms operating in Singapore. *J. Manag. Eng.* **2016**, *32*, 5016008. [CrossRef]
46. Zhao, X.; Hwang, B.; Pheng Low, S.; Wu, P. Reducing hindrances to enterprise risk management implementation in construction firms. *J. Constr. Eng. Manag.* **2014**, *141*, 4014083. [CrossRef]

47. Lomax, R.G.; Schumacker, R.E. *A Beginner's Guide to Structural Equation Modeling*; Routledge: New York, NY, USA, 2012.
48. Hair, J.F.; Hult, G.T.M.; Ringle, C.M.; Sarstedt, M. *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*; Sage: Thousand Oaks, CA, USA, 2016.
49. Zhao, X.; Wu, P.; Wang, X. Risk paths in BIM adoption: Empirical study of China. *Eng. Constr. Archit. Manag.* **2018**, *25*, 1170–1187. [CrossRef]
50. Liu, J.; Zhao, X.; Li, Y. Exploring the factors inducing contractors' unethical behavior: Case of China. *J. Prof. Issues Eng. Educ. Pract.* **2016**, *143*, 4016023. [CrossRef]
51. Lim, B.T.H.; Loosemore, M. The effect of inter-organizational justice perceptions on organizational citizenship behaviors in construction projects. *Int. J. Proj. Manag.* **2017**, *35*, 95–106. [CrossRef]
52. Mojtahedi, M.; Oo, B.L. The impact of stakeholder attributes on performance of disaster recovery projects: The case of transport infrastructure. *Int. J. Proj. Manag.* **2017**, *35*, 841–852. [CrossRef]
53. Suprapto, M.; Bakker, H.L.M.; Mooi, H.G.; Hertogh, M.J.C.M. How do contract types and incentives matter to project performance? *Int. J. Proj. Manag.* **2016**, *34*, 1071–1087. [CrossRef]
54. Liu, J.; Zhao, X.; Yan, P. Risk paths in international construction projects: Case study from Chinese contractors. *J. Constr. Eng. Manag.* **2016**, *142*, 5016002. [CrossRef]
55. Zhao, X.; Feng, Y.; Pienaar, J.; O Brien, D. Modelling paths of risks associated with BIM implementation in architectural, engineering and construction projects. *Archit. Sci. Rev.* **2017**, *60*, 472–482. [CrossRef]
56. Lim, B.T.H.; Ling, F.Y.Y.; Ibbs, C.W.; Raphael, B.; Ofori, G. An Empirical Analysis of the Determinants of Organizational Flexibility in Construction Business. *J. Constr. Eng. Manag.* **2011**, *137*, 225–237. [CrossRef]
57. Comrey, A.L. A first course in factor analysis. *J. R. Stat. Soc.* **1973**, *43*, 332.
58. Anderson, J.C.; Gerbing, D.W. Structural equation modeling in practice: A review and recommended two-step approach. *Psychol. Bull.* **1988**, *103*, 411–423. [CrossRef]
59. Nunnally, J.C.; Bernstein, I.H.; Berge, J.M.T. *Psychometric Theory*; McGraw-Hill: New York, NY, USA, 1978.
60. Hair, J.; Anderson, R.; Tatham, R.; Black, W. *Multivariate Data Analysis with Readings*; Prentice Hall: Englewood Cliffs, NJ, USA, 1998.
61. Fornell, C.; Larcker, D.F. Evaluating structural equation models with unobservable variables and measurement error. *J. Mark. Res.* **1981**, *3*, 39–50. [CrossRef]
62. Henseler, J.; Sarstedt, M. Goodness-of-fit indices for partial least squares path modeling. *Comput. Stat.* **2013**, *28*, 565–580. [CrossRef]
63. Hwang, B.G.; Leong, L.P.; Huh, Y.K. Sustainable green construction management: Schedule performance and improvement. *Technol. Econ. Dev. Econ.* **2014**, *19*, S43–S57. [CrossRef]