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Critical Behavioral Risk Factors among Principal Participants in the Chinese Construction Industry

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Abstract: The main participants in construction projects are the client, contractors, material suppliers, and consultants such as the project supervisor. They play the most important roles in implementing construction projects, and their behavior has a significant impact on the project's performance. Because each participant has their own particular interests, by virtue of proprietary information advantage, each individual participant is driven to achieve maximum benefit, which can result in improper behavior with respect to each other. The risk of this resulting in moral hazard and adverse selection based on information asymmetry is called behavioral risk among principal construction participants. Behavior is affected by various risk factors; successful implementation of construction projects depends on effective management of the key risk factors. This paper identifies and ranks the critical behavioral risk factors from the perspective of principal construction participants in the Chinese construction industry. The data used for analysis is based on an interview and questionnaire survey. Factor analysis is conducted with the assistance of SPSS17.0. Forty-one potential behavioral risk factors are identified, with 30 of those being critical, including "client changes project objective or investment direction", "designer uses technological capability advantage to obtain profit", and others. These findings contribute to the understanding of risk management in the construction industry in China. They also serve as a useful reference for further studies on the subject.

Keywords: behavioral risk factors; participants of construction project; risk management; life cycle; Chinese construction industry

1. Introduction

Construction project participants include the client, contractors, material suppliers, the supervisor, and so on, with these representing the most active roles in construction projects. Project participants' behavior will have a significant impact on project performance [1]. While each participant has their own particular interests, each individual participant is driven by achieving maximum benefit, which can result in improper behavior towards each other. Barnes pointed out that human risk factors in project management should be taken seriously, and behavioral factors in project management play an increasingly important role [2]. For human risk factors, some of these are due to the objective conditions or capability of participants caused by information asymmetry, such as "contractor's poor technical capability" or "poor management capability"; for the rest of them, due to inconsistency with regard to the target of maximizing benefit between the owner (the principal) and the contractor and supervisor (agents), in order to achieve maximum benefit, the agents would be willing to take action that is not of benefit to the principal, leading to loss of profits by virtue of their proprietary information advantage, such as "client changes project objection or invest direction", "designer uses technological capabilities advantage to obtain profit", and so on. The risk of moral hazard and adverse selection based on information asymmetry can be considered behavioral risks for principal participants [3].

Therefore, human risk can be divided into non-malicious factors and malicious factors. Non-malicious factors are mainly caused by non-subjective intention of participants, meaning that the risks result from limitations in terms of capability, resources or hardware of humans, rather than malicious intent. Malicious factors are caused by improper actions taken by participants in order to maximize their own interests. The behavioral risk of principal participants in this article was defined as malicious action taken by project participants [4]. Behavioral risk of principal participants is a component of basic risk, and exists in the behavior of the project participants; and the risk results directly affect the whole project subject group. Therefore, studying and reducing the behavioral risk factors of the principal participants is a prerequisite to achieving a "win-win" or "multi-win" situation [5]. Although there is a lot of research on human risk in construction projects, non-malicious and malicious factors are often considered synthetically, or only a certain kind of malicious factor is studied. There is no systematic identification and analysis of malicious factors, making it unable to provide effective guidance for engineering practice.

This research takes China as an example in order to systematically identify the behavioral risks of the principal participants in construction projects and effectively address this gap in knowledge. Due to the particularity of China's existing institutional environment, China is in the stage of high-speed development exhibited by developing countries; the Chinese construction market is not yet perfect. Additionally, the educational backgrounds of participants and the overall quality of their contribution is uneven. In fact, the percentage of construction participants in China having a bachelor's degree or higher is very low [6,7]. Hence, the probability of the behavioral risk among principal construction participants in China is very high. To the best of the authors' knowledge, little effort has been devoted in research or practice to systematically identifying and managing behavioral risk in the Chinese construction industry, and construction activities in China are exposed to many risks which may be partly—if not completely—neglected, and without proper management. The Chinese construction industry is an important component of the global construction market. Furthermore, the Chinese market is in a special phase of rapid development, which makes it different in many respects, including with regard to participants' poor education and the uneven level of quality, as well as the imperfection of laws and regulations. Improper behavior by principal participants has become the primary reason for the failure of construction projects. Thus, it is both meaningful and necessary to conduct research on the Chinese construction market, and this will be of benefit to the global construction industry.

To ensure the implementation of construction projects, the identification of risk factors is the first and the most important target. The purpose of this paper is to identify and explore the various components of behavioral risk factors of principal participants in the Chinese construction industry using a factor-analysis approach. The approach was designed to identify the risk factors that affect the completion of the project with regard to its time, its cost, and its specifications. Once the critical behavioral risk factors of principal participants in the Chinese construction industry have been identified, the following steps of evaluation and assessment of risks can be undertaken, and the research findings can be of benefit to risk management in construction project. Therefore, the identification of critical behavioral risk factors of principal participants is not only of theoretical significance, but also has important practical value.

2. A Review on the Existing Study for Behavioral Risk

2.1. Human Risk in the Construction Industry

Risk is defined as "the potential for unwanted or negative consequences of an event or activity" [8], a combination of hazard and exposure. To ensure the implementation of a construction project, identifying risk factors is the first and the most important target. Research on risk of construction projects has a long history, and there have been many useful research methods for analyzing construction project risks, the findings of which can offer good guidance and make important contributions to the Chinese construction industry [9–12]. However, most of the risk analysis is limited to analyzing non-human factors. Research on human risks appears little in existing studies. In construction projects, in practice, most project losses are due to human risks, which affects risk analysis and evaluation and risk control. Identifying human risk is an important role in construction project risk management. In recent years, scholars have transferred the research focus to human risk factors [2,13–15].

Many scholars believe that a large proportion of human risk is dependent on the attitudes of people. Teo and Loosemore suggested that attitudes, subjective norms and perceived behavior control influence behavioral intentions, which in turn determine the likelihood of behavior occurring [16]. The attitude is based on an individual's positive or negative evaluation of the consequences of a particular type of behavior, as well as personal beliefs or knowledge about those consequences. Therefore, even identical situations, a variety of risk attitudes could be adopted, and these would lead to different actual behavior and consequences. Shen proved that factors influencing the formation of risk perception include educational background, practical experience, an individual's cognitive characteristics, the availability of information, peer group influence, etc. [17]. These factors will indirectly change the behavior of the principal participants through their risk attitude, and they will ultimately affect the efficiency of construction projects. Therefore, human risk plays an important role in the risk management of construction projects.

Table 1 summarizes the identification of human risks in construction projects based on some existing studies. From the table, it can be seen that human risk in construction projects can be divided into three levels, namely, individual factors, project team factors and organizational factors [15]. The individual's ability, knowledge, skills and other factors, as well as the level of project management, will directly affect the construction project, and the rules and regulations of the organization will form constraints on individuals and the project team. Construction projects include government, owners, contractors, designers, consultants and many other participants; their risk attitudes and behaviors will have an impact on the project [17,18]. In addition, construction projects also involve human risk in the phases of design, implementation and operation, as well as human risk with respect to safety management, quality management, time management and so on [19–22]. However, these human risk factors include non-malicious factors, such as personal abilities, rules and regulations, as well as malicious factors, such as delaying the construction period and arbitrarily changing the design. At present, no scholars have identified malicious human risks.

Table 1. Human risk list for construction projects.

Reference	Categories	Factors
[15]	Individual factors	Capability; Knowledge and skills; Stress; Motivation; Emotional and cultural factors
	Project team factors	Management; Communication and coordination; Task and supervision
	Organizational factors	Systems and procedures; Policies and standards
[16]	Attitudes	Few incentives; Skepticism of waste reduction; Poor knowledge; Belief that waste is inevitable
	Subjective Norms	Culture; Sense of unfairness/inequity; Inconsistent industry standards; Unclear waste objectives; Low management commitment; Unclear/absent policies; Poor consultation
	Perceived Behavioral Control	Time pressures; Cost pressures; Poorly design work processes

Table 1. *Cont.*

[17]	Government-related risks	Inadequate approved project budgets; Delays in obtaining permissions; Changes in Government regulations and laws; Lack of project controls; Administrative interference
	Client-related risks	Variations in project specifications; Delays in the settlement of contractor's claims; Lack of project control
	Design-related risks	Inadequate soil investigation; Delays in design; Ambiguities and inconsistencies in design and design changes
	Contractor-related risks	Inadequate estimates; Financial difficulties; Lack of experience; Poor management; Difficult in controlling nominated subcontractors
	Consultant-related risks	Lack of experience; Performance delays; Poor communication with other project parties
[18]	—	Education background; Engineering experience; Social experience; Professional knowledge; Completeness of project information; Interest in the engineering; Sensitivity to external information; Desire for decision objectives; Consequences of decision making; Judgment ability;
[19]	Contractual and legal risk	Delay in solving contractual issues; Delay in solving disputes; Delay payment on contract and extras; Change order negotiation
	Subcontractors-related risk	Subcontractor failure; Coordination of subcontractor; Financial failure of subcontractor
	Operational risk	Treatment of material removed from site
	Design risk	Inadequate specification; Conflict of document; Design change
	Delay risk	Third party delays
[20]	Design	Detail, precision and appropriateness of specifications; Design risks arising from surveys, investigations; Interaction of design with method of construction
	Logistics	Loss or damage in the transportation of materials and equipment; Organizational interfaces
	Financial	Adequate provision of cash flow; Losses due to default of contractors, suppliers
	Legal	Liability for acts of others, direct liabilities; Local law, legal differences between home country contractors, designers
	Construction	Feasibility of construction methods, safety; Quality and availability of management and supervision
	Operational	Fluctuations in market demand for product or service; Maintenance needs
[21]	Attitude towards general site safety	Everyone has responsibility in safety; Attitude in reporting risk; Safety versus site progress; Conflict with the senior relating safety; Attitude to follow safety
	Attitude towards Factories and Industrial Undertakings	Familiarity with F&IU; Effectiveness in reducing accidents
	Attitude towards regulation: Supervision Plan	Familiarity with SP; Effectiveness in reducing accidents; Legal liability makes SP more effective
	Attitude towards current company policy	Fully comply with F&IU; Fully comply with SP; Provide sufficient safety information; Safety meetings improve safety
	Attitude towards senior management commitment	Attitude of senior management towards safety
	Attitude towards site safety training	Provision of sufficient training; Awareness of basic training; Upgrade safety standard reduces accidents
[22]	—	Low/no safety education/training; Lack of poor crisis preparedness emergency plans; Low hazard awareness from upper management

2.2. Behavioral Risk in the Construction Industry

For human risk factors, a part of them are due to the objective conditions or capabilities of participants caused by information symmetry, such as the contractor's technical capability; however, a part of risk factors is still caused by information asymmetry, and could lead to moral hazard and adverse selection in order to obtain more benefit. The risk factors based on information asymmetry are referred to as the behavioral risk of the principal participants [23–25].

Yang is the first person to have proposed the concept of the behavioral risk factors of principal participants. He divided construction risk into objective event risk and subjective behavioral risk, and analyzed the importance and necessity of research on the behavior risk of principal participants; this finding brought fresh impetus to project risk research [5]. However, Yang's study did not identify the specific behavioral risks for project participants or describe how to prevent such risks.

Sha et al. analyzed the principal-agent relationship and problems between participating subjects from the perspective of information economics, and postulated that the main reason for project risk was the fact that information asymmetry induces the opportunism behavior; namely, that adverse selection and moral hazard are the causes of the anomie of project participants' subjective behavior [13]. Ren et al. analyzed the behavior of participants in projects and analyzed agency relationships between project participants and existing problems from an information economics perspective. They believed that opportunistic behavior was induced by information asymmetry [14]. That is to say, adverse selection and moral hazard are the reasons for project participants' misconduct, leading to project risk. Their research gave an economic explanation for the behavior risk of a project's principal participants.

Adams pointed out that traditional project risk management research generally implies the assumption of the completeness of information; that is to say, that no problems related to information asymmetry exist between principal participants. In fact, information asymmetry between principal participants is a common phenomenon in the real construction market. With respect to the competitive bidding process for projects [26], Adams further proposed the risk of adverse selection faced by the owner due to the bidders' cheating actions. After the owner has determined the contractor, he faces behavior risk in terms of the contractor potentially making use of their information advantage to harm the owner's interests. In response to Adams' research, with regard to the problem of asymmetric information in projects, some scholars introduced principal agent theory into the analysis of principal participants' behavior risk. Au and Chan discussed the relationship between contractors' risk perceptions, attitudes and behaviors, concluding that risk behaviors of principal participants in construction projects have a high degree of correlation with their risk perception and risk attitude [27]. Winch analyzed the reasons for leading moral risks in projects and suggested relevant measures based on principal agent theory, including designing an incentive mechanism in contracts, price adjustment mechanisms, conflict resolution mechanisms, and so on [28].

Xiang and Kong used the Delphi expert interview method to extract 10 behavioral risk factors for principal participants, classified into client, contractor and supervisor, the 10 discussed risk factors were "Lack of management ability", "Poor funding ability", "Incomplete project plan", and "Default leading to cannot complete the contract" with respect to the client; "Poor management ability", "Poor technological ability", and "Poor goodwill" with respect to contractors; and "Poor management and technological ability", "Poor ethics" and "Poor sense of service" with respect to the supervisor. However, these behavior risks mainly refer to the participants' ability and their management skill. They do not reflect the participants' moral behavior [4].

Shi investigated risk allocation and moral hazard in construction contracts driven by the owners, as well as the contractors. It was shown that the moral hazard produced by the owner, when the excessive cost overruns caused by the owner's indulgence are transferred to the contractor, may trigger moral hazard in the contractor, and they suggested an optimal risk allocation scheme between the owner and the contractor in developing countries, which could obviate the double moral hazard issue and enhance project efficiency [29]. Jian (2010) pointed out that both project owners and contractors probably have moral hazard during the period of project construction, establishing a bilateral moral hazard model while applying the principal agent theory. The model analysis shows that when information is asymmetrical, applying a linear contract mechanism of cost plus incentive fee is efficient, but that risk-neutral owners and contractors will only implement their second-best level of effort [30]. Liu found that the single low-price competition in the construction tender market leads to serious adverse selection and moral hazard behavior in bidding firms, and they systematically analyzed the evaluation method of the lowest-price-wins bidding policy, which is the fundamental cause of adverse selection and moral hazard problems in the Chinese construction market [31].

From the above discussion, it appears that little study exists on the behavior risks of the principal participants in Chinese construction. Nevertheless, the Chinese construction industry is a major construction market globally. Furthermore, the Chinese construction market is different from other construction industries in many respects, including the participants' poor education and their uneven level of quality, as well as the imperfection of the laws and regulations [32–35]. Thus, it is both important and necessary to extract the behavioral risks among principal participants in Chinese construction.

2.3. Method of Identifying Risk Factors

The method used for risk identification has a significant impact on the accuracy of the risk identification results. Choosing the right identification method helps us to correctly understand the behavioral risks of the main participants in a construction project. The general methods for risk identification in construction projects include Delphi, brainstorming, checklist, fault tree, flow chart, SWOT, WBS-RBS, questionnaire survey, literature research, expert interview, and so on [36–44]. Table 2 shows the general methods commonly used for risk identification in construction projects. Literature research is the most common method of risk identification in construction projects; however, limited by the research data, the identification results often have very obvious limitations. Therefore, this paper will use the literature research method and the expert interview method to identify the behavior risk factors of the main participants of construction projects.

Table 2. General risk identification methods in construction projects.

Reference	Method	Purpose
[36]	Delphi	A two-round Delphi method was applied by asking 10 experts to specify the importance of each risk interaction.
[37]	Literature review	Literature review was used to identify risks associated with stakeholders in construction projects.
[38]	Checklist	A risk checklist for public-private partnerships was developed and could be adopted for further empirical studies.
[39]	Brainstorming	Brainstorming sessions were conducted with the workers to identify why certain hazards remained unrecognized.
[40]	Fault tree	A fault tree method was applied in order to identify the main causes of events and incidents.
[41]	Flow chart	This study built a risk identification feedback chart and risk flow chart to comprehensively identify investment risks that projects in China may face.
[42]	SWOT	Seventeen risk agents with 17 risk events were identified based on SWOT analysis through the process of planning.
[43]	WBS-RBS	The WBS-RBS was used to identify the possible risks that may arise in project implementation and then considered those risks for the estimation process.
[44]	Questionnaire survey	A questionnaire survey was conducted totaling 50 questions, of which 47 questions were related to risk and three questions were related to personal details and risks faced on the work site.

Determining weights is an important step in identifying risk factors. At present, the methods for determining the weighting of risk factors for construction projects can be roughly divided into two categories: subjective empowerment and objective empowerment. The subjective empowerment method is based on the experience of experts to judge the relative importance of each risk factor relative to the purpose of evaluation, for example, the AHP method and the Delphi method. The objective weighting method is an automatic weighting method for risk factors based on certain rules, such as principal component analysis, factor analysis and the entropy weight method. The weighting coefficient of the risk factor is determined by the subjective weighting method, which reflects the intentions of the decision-maker, but the decision or evaluation result is highly subjective. The results when using objective empowerment methods to determine the weighting coefficient of risk factors have a strong mathematical basis, but do not consider the intentions of decision-makers [45–49]. Table 3 shows the general weighting determination methods in construction projects. This paper will use principal component analysis to determine the weighting of each behavioral risk factor, because principal component analysis can eliminate the correlation between risk factors. In addition, the weighting of the principal components reflects the amount of the original data in the total amount of information, and the weighting is objective and reasonable [50,51].

Table 3. General weighting determination methods in the construction project.

Reference	Method	Purpose
[45]	Delphi	To explore how the risks should be allocated, three rounds of a Delphi questionnaire survey was conducted.
[46]	AHP	AHP was used to identify typical risks associated with PPP projects in the Chinese water supply sector.
[47]	Principal component analysis	Principal component factor analysis methods were adopted to evaluate and classify the critical risk factors.
[48]	Entropy weight method	Shannon Entropy and statistical methods of calculating and ranking analysis were implemented for modelling the integrated risks of a power construction project.
[49]	Factor analysis	Critical risk factors obtained through factor analysis were assessed to gain a better understanding of their importance and impact on project management.

3. Methodology

This paper aims to identify the behavioral risk factors of the Chinese construction industry. A questionnaire survey method was used in the research. The questionnaire was designed on the basis of comprehensive literature research and expert interviews, and was distributed to 200 Chinese construction industry practitioners from 10 provinces, including officials from government departments, professionals from design institutes, construction clients, building companies, supervision units, and research institutes. A statistical analysis of the effective survey data from the 150 returned questionnaires was conducted, and 30 critical behavioral risk factors were identified.

After a comprehensive literature review and expert interview, a questionnaire including a total of 41 potential behavioral risk factors related to principal participants in construction projects was compiled, with the behavioral risk factors matched to different principal participants and different project stages. The construction project life cycle was divided into four stages—the investment decision stage, the tendering and bidding stage, the construction stage and the completion and acceptance stage—and the magnitude of each potential risk factor was evaluated using a 5-point scale. Then, the questionnaire was distributed, and survey data was collected. With the assistance of SPSS17.0, 32 risk factors were extracted on the basis of principal component analysis, but 2 of them were rejected by convergent validity. Finally, 30 critical behavioral risk factors of principal participants were identified and ranked in importance.

4. Research Process

4.1. Questionnaire Design

4.1.1. Literature Research to Identify Potential Risk Factors

Based on the examination of the existing studies [17,19,20,52], 22 behavioral risk factors of principal participants are listed in Table 4.

Table 4. Potential behavioral risk factors of principal participants based on literature research.

Construction Project Stage	Principal Participants	Behavioral Risk Factors
(A) Investment decision stage	(A) Client	(AA1) Change project objective or investment direction
		(AA2) Default payment for design fee
		(AA3) Choose the worse designer because of tacit collusion
	(B) Designer	(AB1) Evil intention to sub package
		(AB2) Arbitrary intent to make a design change against the client's intention
(B) Tendering and bidding stage	(C) Consultant	(BC1) Expert is unfair
		(BC2) Expert takes bribes
		(BC3) Malfeasance of conduct department
(C) Construction stage	(A) Client	(CA1) Change project objective or investment direction
		(CA2) Error guidance and nonprogrammed interference with instruction
		(CA3) Defaulting and rejection of compensation
		(CA4) Evil failure to supply equipment and raw material in time
		(CA5) Defaulting in payment of project settlement amount
	(D) Contractor	(CD1) Arbitrary intent to construct against intended design
		(CD2) Evil intention to require design change
	(E) Supplier	(CE1) Evil intention to raise price of equipment and raw materials
		(CE2) Evil lag in supplying equipment and raw material
	(F) Supervisor	(CF1) Error guidance and nonprogrammed interference with instructions
		(CF2) Intent to make trouble for suppliers, contractors, and so on
		(CF3) Go places without notice
(D) Completion and acceptance stage	(A) Client	(DA1) Default paying project settlement amount
		(DA2) Delay acceptance time

4.1.2. Expert Interview to Identify Potential Risk Factors

On the basis of the 22 summarized risk factors identified in the literature review, 10 interview discussions were conducted with relevant personnel with rich backgrounds of work experience, and top experts in this field. The 15 experts consisted of the following: professors who have done research on construction project risk for many years from universities belonging to Project 985 in China; project managers with a rich experience from the China National Building Corporation and its subsidiaries, and China National Railway Corporation and its subsidiaries (which are in range of word 500 top corporations); and engineers from famous real estate development companies ranked in the top 10 in China, as well as some supervisor companies. The experts first listed all of the possible or existing behavioral risk factors of principal participants in construction projects, and then the collected risk factors were discussed by all the experts. Each time that new risk factors were determined on the basis of the discussion, the new factors would be discussed again. Eventually, after several rounds of discussion, 19 risk factors were added to the above 22 behavioral risk factors. The 19 risk factors are listed in Table 5.

Table 5. Potential behavioral risk factors of principal participants based on expert interview.

Construction Project Stage	Principal Participants	Behavioral Risk Factors
(A) Investment decision stage	(A) Client	(AA4) Evil intention to make unreasonable requests
	(B) Designer	(AB3) Use technological capability advantage to obtain profit
(B) Tendering and bidding stage	(A) Client	(BA1) Establish an obstruction to reject others (BA2) Disclose project information because of tacit collusion
	(D) Contractor	(BD1) Bidders ring (BD2) Bidding with fraudulent qualifications (BD3) Collude to tender or bid (BD4) Bribes to experts
(C) Construction stage	(A) Client	(CA6) Evil intention to make unreasonable construction requests (CA7) Collude with other participants to modify the design proposal
	(D) Contractor	(CD3) Collude with other participants to modify the design proposal (CD4) Illegal subcontracting (CD5) Unreasonable claims (CD6) Malicious withholding of wages, leading to project interruption
	(E) Supplier	(CE3) Supplying shoddy equipment and material instead of good ones
	(F) Supervisor	(CF4) Obtain unreasonable profit because of collusion with contractors
(D) Completion and acceptance stage	(A) Client	(DA3) Increase the workload of the contractor
	(D) Contractor	(DD1) Malicious claims
	(F) Supervisor	(DF1) Obtain unreasonable profit because of collusion with contractors

It should be noted that the risk "use technological capability advantage to obtain profit", related to the designer, refers to the fact that when participants are familiar with their business and have years of rich work experience, there exists an information asymmetry between different stakeholders, such that they can obtain unfair advantage with the help of their own information superiority.

4.1.3. Questionnaire Design

In this paper, each different behavioral risk of principal participants was identified in accordance with the project life cycle. The project life cycle was divided into four stages: the investment decision stage, the tendering and bidding stage, the construction stage, and the completion and acceptance stage. For the principal participants of construction projects, we mainly discussed risks from the client, construction contractor and supervisor; in the investment decision stage, we also discussed risks from designer, who is an important participant in the first stage; in the tendering and bidding stage, we also discussed potential risks from the reviewing experts and third parties; in the construction stage, we also took risks from material and equipment suppliers into account; thus, a behavioral risk factors table covering 41 risk factors was concluded.

After the potential 41 behavioral risk factors were listed, a questionnaire was administered. The questionnaire consisted of two sections: Section 1 solicited general information about the respondents, and Section 2 contained a total of 41 behavioral risks associated with the principal participants in construction projects.

The total of 41 risk factors consists of the sum of Tables 1 and 2, these risk factors are categorized into 4 parts in terms of the project life cycle, with 7 related to the investment decision stage, 9 related to the tendering and bidding stage, 20 related to the construction stage, and 5 related to the completion and acceptance stage. On the other hand, the 41 risks could be categorized into 5 parts, on the basis of their relevant principal participants, with 16 related to the client, 11 related to the construction contractor, 5 related to the supervisor, 3 related to third parties, 3 related to the designer and 3 related to suppliers.

All 41 risk factors included in the questionnaire were set on a five-point scale (5 = extremely important, 4 = very important, 3 = important, 2 = somewhat important, 1 = not important), and these scales were used to conduct factor analysis.

4.2. Sample Size

Although it is difficult to know the exact population size, it is still necessary to determine the sample size in order to ensure the validity of the survey results. Cochran suggested a formula to calculate the appropriate sample size when the data collection takes place on the basis of scaled or ordinal variables [53], as in this study. Accordingly, the minimum sample size required by this formula is 143.

Questionnaires were distributed to 200 construction practitioners in China from 10 provinces, including officials from government departments, professionals from design institutes, construction clients, building companies, supervision units, and research institutes. Of the 200 distributed questionnaires, 174 were returned, of which 150 were considered effective responses for analysis. The number of valid questionnaires meets the minimum sample size requirement. The recovery rate of the questionnaire was calculated to be 75%, which is acceptable according to the theory of Moser and Kalton [54].

4.3. Sample Composition

The respondents were practitioners in the Chinese construction industry. They had an average of 7.12 years' work experience in construction-related sectors; 32.67% of them worked in construction companies, and another 32.00% worked in building companies; all of them had received professional education. More details of the respondent profiles are presented in Table 6. The respondents' long work experience, solid educational background and multifaceted involvement in diverse construction-related units imply that the respondents have adequate knowledge of construction project management and the associated risks.

Table 6. Profiles of the survey respondents.

Respondent Profiles	**Categorization and Percentages**			
Type of unit worked in	Government department	3.33%	Design institute	6.67%
	Construction company	32.67%	Building company	32.00%
	Supervision company	8.00%	Research institute	17.33%
Years of work experience	Less than 2 years	12.67%	2–5 years	30.00%
	5–10 years	38.00%	10–15 years	16.67%
	More than 15 years	2.67%		

4.4. Questionnaire Analysis

4.4.1. Preliminary Analysis

Factor analysis was initially performed on all 41 variables related to risk factors. The Kaiser–Mayer–Olkin (KMO) test and Bartlett's test of sphericity were used to check suitability of the factor analysis. Acceptable values of the KMO test should be greater than 0.5, and determine the adequacy of the sample, while Bartlett's test of sphericity can ensure that the correlation matrix is an identity matrix [55]. The result of the KMO test was 0.835 and Bartlett's test of sphericity was high, at 2195.992 (associated with a probability value of 0.000), as shown in Table 7. Both tests showed that the variables were suitable for factor analysis.

Table 7. KMO and Bartlett's Test.

Statistical Test of Data		Results
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.801
Bartlett's Test of Sphericity	Approx. Chi-Square	2977.860
	df	820
	Sig.	0

4.4.2. Factor Extraction

Factor loadings are the correlations of the variables with the factor. High factor loading implies that the factors and variables are critical [56]. In the present study, a sample size of 150 subject to a minimum factor loading of 0.563 was used for factor analysis. To extract critical risk factors, both principal component analysis and correlation value between risk factors approach were used. For the principal component analysis, all of the factors extracted should account for at least 60% of total variance [57], Table 8 shows that the percentage of total variance explained by the 12 extracted components is 69.721%. With respect to our approach to the correlation value between risk factors, factors with relatively high absolute correlation values were retained, and those with relatively low absolute correlation values were ignored [58]. The criterion used in this paper was that for the first component, absolute values for a factor greater than 0.5 should be retained, and for the other 11 components, the maximum absolute value is retained. Table 9 shows that 32 variables were extracted under the above criteria (the extracted variables are marked with *).

Table 8. Total variance explained.

Component	Initial Eigenvalues			Extraction of Load		
	Total	Variance Explained Percentage (%)	Cumulative Percentage (%)	Total	Variance Explained Percentage (%)	Cumulative Percentage (%)
1	10.489	25.584	25.584	10.489	25.584	25.584
2	2.657	6.48	32.064	2.657	6.48	32.064
3	2.533	6.177	38.241	2.533	6.177	38.241
4	2.049	4.998	43.239	2.049	4.998	43.239
5	1.761	4.295	47.535	1.761	4.295	47.535
6	1.543	3.763	51.297	1.543	3.763	51.297
7	1.452	3.542	54.839	1.452	3.542	54.839
8	1.348	3.288	58.128	1.348	3.288	58.128
9	1.342	3.274	61.402	1.342	3.274	61.402
10	1.235	3.011	64.413	1.235	3.011	64.413
11	1.1	2.683	67.095	1.1	2.683	67.095
12	1.077	2.626	69.721	1.077	2.626	69.721
13	0.957	2.335	72.056			
14	0.902	2.199	74.255			
15	0.795	1.94	76.195			
16	0.766	1.868	78.063			
17	0.698	1.703	79.766			
18	0.645	1.573	81.339			
19	0.622	1.516	82.855			
20	0.597	1.456	84.311			
21	0.563	1.374	85.685			
22	0.508	1.239	86.925			
23	0.474	1.156	88.081			
24	0.444	1.082	89.163			
25	0.432	1.053	90.217			
26	0.397	0.968	91.185			
27	0.388	0.947	92.131			
28	0.354	0.863	92.994			
29	0.35	0.854	93.848			
30	0.308	0.751	94.599			

Table 8. *Cont.*

Component	Initial Eigenvalues			Extraction of Load		
	Total	Variance Explained Percentage (%)	Cumulative Percentage (%)	Total	Variance Explained Percentage (%)	Cumulative Percentage (%)
31	0.301	0.733	95.332			
32	0.291	0.711	96.043			
33	0.256	0.624	96.667			
34	0.229	0.558	97.225			
35	0.222	0.542	97.767			
36	0.215	0.523	98.29			
37	0.177	0.433	98.723			
38	0.168	0.41	99.133			
39	0.135	0.329	99.462			
40	0.113	0.276	99.737			
41	0.108	0.263	100			

4.4.3. Internal Consistency Analysis

Internal consistency reliability is a statement of the stability of individual measurement items across replications from the same source of information. To ensure the reliability of each factor, Cronbach's coefficient alpha (α) was used to test the internal consistency among the items included in each factor. Nunnally has suggested that a minimum of 0.7 is sufficient [59]. Factor reliability was measured by calculating Cronbach's α for all factors. The results of factor analysis showed that the final 12 components accounted for 69.721% of total variance explained. Table 7 shows that α value for the 41 variables ranged from 0.918 to 0.923. The α values were at an acceptable level, indicating that all factors were reliable.

4.4.4. Content Validity

Content validity defines how representative and comprehensive the items were in presenting the hypothesis. It is assessed by examining the process that was used in generating the scale item [60]. As the questionnaire was designed based on a literature review and the opinions of interviewed experts, the content validity of the critical risk factors needs be proved. It is believed that the 41 risks listed in the survey were highly comprehensive in terms of representing almost all risks that might occur in construction projects in China.

4.4.5. Convergent Validity

In this study, we followed Straub's processes for validating instruments in order to test construct validity in terms of convergent and discriminate validity [61]. According to Peter, convergent validity is related to the extent to which different scale items that are assumed to represent a construct converge on the same construct [62]. Convergent validity is useful for measuring the agreement between multiple attempts to measure the same concepts. The item-to-total correlation indicates the correlation of each item to the sum of the remaining items, which can be used for convergent validity. Variables with an item-to-total correlation score lower than 0.4 were removed, as suggested by Park and Kim [63]. Table 10 shows that of the 32 extracted risk factors, 30 factors were retained, with item-to-total correlations ranging from 0.412 to 0.629. The other 2 variables ((CD6) Malicious withholding of wages, leading to the project interruption; and (DA3) Increase the workload of the contractor) were rejected because they had values lower than 0.4 (the retained variables are marked with *).

Table 9. Correlations between the risk factors.

Variables	Component											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
* (AA1) Change project objective or investment direction	0.313	−0.047	−0.318	0.301	0.094	0.093	0.041	−0.500	0.249	0.134	0.040	0.404 *
(AA2) Defaulting on payment for design fee	0.286	−0.124	0.003	−0.159	−0.352	0.414	0.197	−0.032	0.242	0.051	0.345	−0.065
* (AA3) Choose a worse designer because of tacit collusion	0.551 *	0.011	−0.383	−0.231	−0.127	0.397	0.169	−0.016	−0.187	−0.031	−0.107	−0.065
* (AA4) Evil intention to make unreasonable requests	0.480	−0.223	−0.255	−0.133	−0.158	0.506 *	0.056	0.176	−0.181	−0.014	0.053	−0.334
* (AB1) Evil intention to sub package	0.636*	−0.021	−0.273	0.172	0.052	−0.042	0.096	−0.263	−0.189	0.052	−0.028	0.179
* (AB2) Arbitrary intent to make a design change against client's intention	0.617 *	0.112	−0.452	0.126	−0.199	0.057	−0.090	−0.072	−0.028	0.023	0.105	−0.032
* (AB3) Use technological capability advantage to obtain profit	0.469	−0.110	−0.076	0.052	0.379	0.061	0.048	0.047	−0.368 *	0.413	0.102	−0.184
(BA1) Establish an obstruction to reject others	0.356	0.136	0.235	0.277	−0.285	−0.105	0.060	0.040	−0.321	−0.028	0.064	−0.124
* (BA2) Disclose project information because of tacit collusion	0.591 *	0.217	0.060	0.162	−0.221	0.127	0.214	−0.194	−0.289	−0.050	0.072	0.209
(BC1) Expert is unfair	0.294	0.411	0.342	−0.149	0.204	0.241	−0.143	−0.064	0.105	−0.047	0.172	0.034
(BC2) Expert takes bribes	0.338	−0.381	0.138	−0.032	0.185	0.173	0.081	0.164	0.247	−0.179	−0.288	−0.030
(BC3) Malfeasance of conduct department	0.329	0.316	0.110	−0.444	0.210	0.274	0.001	0.207	−0.120	−0.084	−0.110	0.226
* (BD1) Bidders ring	0.430	0.387	0.404 *	0.306	−0.033	0.050	−0.005	0.124	−0.176	−0.048	−0.106	0.042
* (BD2) Bidding with fraudulent qualifications	0.557 *	0.432	0.003	0.237	−0.101	0.110	−0.052	0.049	0.213	0.094	0.059	0.098
* (BD3) Collude to tender or bid	0.594 *	0.403	0.120	0.071	−0.125	−0.081	−0.100	−0.186	−0.179	0.114	0.117	0.171
(BD4) Bribes to experts	0.401	0.502	0.309	0.014	0.195	0.017	−0.196	0.138	−0.174	0.089	0.233	−0.074
* (CA1) Change project objective or investment direction	0.455	0.052	−0.223	0.482*	0.351	−0.234	0.192	−0.008	0.301	−0.074	0.119	0.002
* (CA2) Error guidance and nonprogrammed interference with instructions	0.608 *	−0.121	−0.261	0.206	0.049	−0.024	0.000	0.190	0.102	−0.180	−0.001	0.055
* (CA3) Defaulting and rejection to compensation	0.562 *	−0.362	0.111	0.223	−0.072	−0.012	−0.159	0.181	0.197	−0.207	−0.087	−0.102
* (CA4) Evil failure to supply equipment and raw materials in time	0.480	−0.382	0.068	0.048	0.018	0.013	−0.490 *	0.196	−0.132	0.009	−0.094	0.138
* (CA5) Defaulting on paying project settlement amount	0.494	0.593 *	0.323	0.037	0.119	0.120	0.068	−0.096	0.023	−0.265	0.063	0.207
(CA6) Evil intention to make unreasonable construction requests	0.271	−0.412	0.242	0.197	−0.007	0.140	0.175	0.338	−0.012	−0.197	0.255	0.257
* (CA7) Collude with other participants to modify the design proposal	0.204	−0.268	0.029	−0.044	0.124	−0.166	0.329	0.535 *	−0.018	0.359	0.109	0.256
* (CD1) Arbitrary intent to construct against design intention	0.682 *	0.045	−0.461	0.014	0.078	−0.065	−0.115	0.213	−0.072	−0.022	−0.056	−0.024
* (CD2) Evil intention to require design change	0.634 *	0.124	−0.419	−0.051	0.021	−0.084	−0.128	0.089	0.159	0.102	−0.163	0.044

Table 9. *Cont.*

Variables	Component											
	1	2	3	4	5	6	7	8	9	10	11	12
* (CD3) Collude with other participants to modify the design proposal	0.622 *	0.011	−0.256	0.213	0.366	−0.061	−0.040	0.029	0.019	−0.074	−0.078	−0.036
* (CD4) Illegal subcontracting	0.584 *	0.052	−0.174	−0.148	−0.275	−0.234	−0.056	−0.076	0.048	−0.329	0.250	−0.022
* (CD5) Unreasonable claims	0.497	−0.024	0.109	−0.255	−0.440 *	−0.177	−0.391	0.068	0.228	0.050	−0.001	0.168
* (CD6) Malicious withholding of wages, leading to the project interruption	0.418	0.015	0.216	−0.035	−0.054	−0.428	−0.115	0.023	0.048	0.000	0.469 *	−0.297
* (CE1) Evil intention to raise price of equipment and raw materials	0.589 *	−0.247	0.163	−0.204	0.204	0.014	−0.244	−0.254	−0.045	0.276	−0.021	0.114
* (CE2) Evil lag in supplying equipment and raw materials	0.612 *	−0.237	0.081	−0.280	0.189	0.022	−0.321	−0.130	−0.095	−0.040	−0.013	−0.082
(CE3) Supplying shoddy equipment and materials instead of good ones	0.357	−0.201	0.099	0.072	0.397	0.388	−0.167	−0.066	0.273	−0.022	0.205	−0.219
* (CF1) Error guidance and nonprogrammed interference with instruction	0.621 *	−0.120	−0.212	−0.093	−0.173	−0.176	0.100	0.073	−0.105	0.105	−0.081	−0.002
* (CF2) Intent to make trouble for suppliers, contractors and so on	0.559 *	0.116	0.071	−0.441	0.092	−0.192	0.375	−0.033	0.105	0.136	0.077	0.005
* (CF3) Go places without notice	0.550 *	0.022	0.173	−0.364	−0.065	−0.140	0.258	−0.016	0.258	0.252	−0.002	−0.070
* (CF4) Obtain unreasonable profit because of collusion with contractors	0.507 *	0.076	0.007	−0.155	0.273	−0.213	0.334	−0.060	−0.016	−0.401	−0.040	−0.125
* (DA1) Defaulting on paying project settlement amount	0.521 *	−0.382	0.465	0.020	0.013	0.029	0.167	−0.261	−0.042	−0.067	−0.220	0.015
(DA2) Delay acceptance time	0.386	−0.198	0.353	0.411	0.041	0.038	0.193	−0.056	0.028	0.129	−0.141	−0.346
* (DA3) Increase the workload of the contractor	0.361	0.133	0.133	0.333	−0.276	0.107	−0.020	0.180	0.363	0.308 *	−0.235	−0.084
* (DD1) Malicious claims	0.613 *	−0.177	0.355	−0.156	−0.184	−0.110	0.033	−0.149	0.062	0.129	−0.253	0.015
* (DF1) Obtain unreasonable profit because of collusion with contractors	0.667 *	0.008	0.071	−0.203	−0.221	−0.135	0.016	0.029	−0.114	−0.224	−0.229	−0.159

Table 10. Internal consistency analysis and convergent validity.

Variables	Scale Average Value if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Square of the Multi-Correlation	Cronbach's Alpha if Item Deleted
* (AA1) Change project objective or investment direction	141.17	425.314	0.410 *	0.421	0.923
(AA2) Defaulting on payment for design fee	141.82	428.710	0.267	0.492	0.922
* (AA3) Choose a worse designer because of tacit collusion	141.10	415.939	0.507 *	0.673	0.920
* (AA4) Evil intention to make unreasonable requests	141.50	419.945	0.435 *	0.590	0.920
* (AB1) Evil intention to sub package	140.93	415.496	0.589 *	0.652	0.919
* (AB2) Arbitrary intent to make a design change against client's intention	141.18	410.129	0.565 *	0.683	0.919

Table 10. *Cont.*

Variables	Scale Average Value if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Square of the Multi-Correlation	Cronbach's Alpha if Item Deleted
* (AB3) Use technological capability advantage to obtain profit	141.16	421.527	0.435 *	0.568	0.920
(BA1) Establish an obstruction to reject others	141.52	424.887	0.329	0.512	0.922
* (BA2) Disclose project information because of tacit collusion	141.06	414.433	0.563 *	0.586	0.919
(BC1) Expert is unfair	141.60	429.047	0.284	0.508	0.922
(BC2) Expert takes bribes	141.47	426.196	0.321	0.586	0.922
(BC3) Malfeasance of conduct department	141.35	427.444	0.302	0.543	0.922
* (BD1) Bidders ring	141.38	421.462	0.412 *	0.676	0.921
* (BD2) Bidding with fraudulent qualifications	141.36	414.948	0.534 *	0.643	0.919
* (BD3) Collude to tender or bid	141.09	416.250	0.558 *	0.669	0.919
(BD4) Bribes to experts	141.50	421.910	0.379	0.559	0.921
* (CA1) Change project objective or investment direction	140.96	420.333	0.419 *	0.473	0.921
* (CA2) Error guidance and nonprogrammed interference with instructions	141.12	417.681	0.563 *	0.603	0.919
* (CA3) Defaulting and rejection to compensation	141.18	419.462	0.526 *	0.610	0.920
* (CA4) Evil failure to supply equipment and raw materials in time	141.26	421.507	0.432 *	0.603	0.920
* (CA5) Defaulting on paying project settlement amount	141.31	418.695	0.459 *	0.574	0.920
(CA6) Evil intention to make unreasonable construction requests	141.40	431.250	0.258	0.453	0.922
* (CA7) Collude with other participants to modify the design proposal	141.27	432.500	0.408 *	0.368	0.923
* (CD1) Arbitrary intent to construct against design intention	141.02	411.392	0.629 *	0.774	0.918
* (CD2) Evil intention to require design change	141.22	413.838	0.580 *	0.658	0.919
* (CD3)Collude with other participants to modify the design proposal	141.13	416.085	0.581 *	0.680	0.919
* (CD4) Illegal subcontracting	141.00	417.734	0.526 *	0.580	0.919
* (CD5) Unreasonable claims	141.61	420.751	0.450 *	0.630	0.920
* (CD6) Malicious withholding of wages, leading to the project interruption	141.40	427.127	0.381	0.435	0.921
* (CE1) Evil intention to raise price of equipment and raw materials	141.28	417.725	0.543 *	0.669	0.919
* (CE2) Evil lag in supplying equipment and raw materials	141.14	417.580	0.562 *	0.660	0.919
(CE3) Supplying shoddy equipment and materials instead of good ones	141.50	425.303	0.337	0.457	0.921
* (CF1) Error guidance and nonprogrammed interference with instruction	141.24	415.920	0.570 *	0.658	0.919
* (CF2) Intent to make trouble for suppliers, contractors and so on	141.40	416.375	0.515 *	0.680	0.920
* (CF3) Go places without notice	141.82	419.918	0.511 *	0.639	0.920
* (CF4) Obtain unreasonable profit because of collusion with contractors	141.15	421.117	0.463 *	0.527	0.920
* (DA1) Defaulting on paying project settlement amount	141.12	418.440	0.484 *	0.699	0.920
(DA2) Delay acceptance time	141.56	424.967	0.365	0.494	0.921
* (DA3) Increase the workload of the contractor	141.48	425.574	0.341	0.461	0.921
* (DD1) Malicious claims	141.50	416.602	0.574 *	0.652	0.919
* (DF1) Obtain unreasonable profit because of collusion with contractors	141.45	412.127	0.611 *	0.665	0.918

5. Discussion of the Findings

The findings of the above analysis suggest that the behavior risks among the principal participants in the Chinese construction industry are largely concerned with participants' moral behaviors. Behavior risks have also been researched in other studies, but these have been more related to management skill and capability. This is well appreciated by Barnes [2].

5.1. Ranking of the Critical Behavioral Risk Factors

To manage behavioral risk effectively, it is important to rank the importance of each risk factor; this is the premise of behavioral risk management. The relative significance among the 30 selected behavioral risks is analyzed by establishing a ranking list among them. The ranking list is generated by calculating the mean score (*MS*).

Chan and Kumaraswamy adopted the "mean score" method to establish the relative importance index of behavioral risk factors as perceived by the clients, contractors and supervisor, respectively [64]. The data collected from the current questionnaire survey was also analyzed using the same technique. A five-point Likert scale (1 = least important and 5 = most important) was used to calculate the mean score for each risk factor, which was then used to determine its relative ranking in descending order of importance. These rankings made it possible to triangulate the relative importance of the risk factors; the *MS* value refers to the importance index of the risk factors. The mean score (*MS*) for each risk factor was computed using the following formula:

$$MS = \frac{\sum (f \times s)}{N} \; (1 \leq MS \leq 5) \tag{1}$$

where s is the score given to each risk factor by the respondents, ranging from 1 to 5 (1 = least important and 5 = most important); f is the frequency of each rating (1–5) for each risk factor; and N is the total number of responses concerning a particular risk factor.

Table 11 presents the degree of importance (i.e., the *MS* value) assigned to the 30 critical risk factors for the overall project, extracted from the factor analysis.

The key risks related to project stakeholders are discussed to identify appropriate strategies that the stakeholders should take to manage their relevant risks, as elaborated below.

5.2. Discussion

5.2.1. Critical Behavioral Risk Related to the Client

The identified behavioral risks related to the client consist of 11 factors: (1) Change project objectives or investment direction (investment decision stage), ranked 14th with an *MS* value of 3.673; (2) Evil intention to make unreasonable requests, ranked 27th; (3) Choose a worse designer because of tacit collusion, ranked 7th; (4) Disclose project information because of tacit collusion, ranked 5th; (5) Change project objectives or investment direction (construction stage), ranked second in the list; (6) Error guidance and nonprogrammed interference with instructions, ranked 8th; (7) Defaulting and rejection of compensation, ranked 16th; (8) Evil failure to supply equipment and raw materials in time, ranked 19th; (9) Defaulting on paying project settlement amount, ranked 22th; (10) Collude with other participants to modify the design proposal, ranked 20th; (11) Defaulting on paying project settlement amount, ranked 9th.

Changing project objective or investment direction ranked second, with a high *MS* value of 3.88, meaning changes in planning and fund supply. The client is the leader and fund supplier of a construction project; any client's behavior risk is critical to the project. For most Chinese clients, time is money, and because of the high cost of capital, they expect to complete a project as quickly as possible and to realize profit as soon as possible, resulting in sudden changes in project objectives or investment direction during the implementation period. If that occurs, contractors and suppliers could suffer great loss. To solve this problem, contractors should assess a client's financial capacity and obtain relevant statements that guarantee the progress of payments.

Table 11. Ranking of the critical behavioral risk factors.

Construction Project Stage	Principal Participant	Behavioral Risk Factor	Total Number of Responses						*MS* Value	Ranking
			1	2	3	4	5	Total		
(A) Investment decision stage	(A) Client	(AA1) Change project objectives or investment direction	8	19	41	28	54	150	3.673	14
(A) Investment decision stage	(A) Client	(AA3) Choose a worse designer because of tacit collusion	8	13	34	50	45	150	3.740	7
(A) Investment decision stage	(A) Client	(AA4) Evil intention to make unreasonable requests	11	19	48	51	21	150	3.347	27
(A) Investment decision stage	(B) Designer	(AB1) Evil intention to sub package	5	8	29	61	47	150	3.913	1
(A) Investment decision stage	(B) Designer	(AB2) Arbitrary intent to make a design change against client's intention	10	22	27	40	51	150	3.667	15
(A) Investment decision stage	(B) Designer	(AB3) Use technological capability advantage to obtain profit	5	14	37	62	32	150	3.680	13
(B) Tendering and bidding stage	(A) Client	(BA2) Disclose project information because of tacit collusion	6	11	40	45	48	150	3.787	5
(B) Tendering and bidding stage	(D) Contractor	(BD1) Bidders ring	4	23	54	37	32	150	3.467	24
(B) Tendering and bidding stage	(D) Contractor	(BD2) Bidding with fraudulent qualifications	8	20	46	44	32	150	3.480	23
(B) Tendering and bidding stage	(D) Contractor	(BD3) Collude to tender or bid	4	12	42	51	41	150	3.753	6
(C) Construction stage	(A) Client	(CA1) Change project objective or investment direction	6	11	34	43	56	150	3.880	2
(C) Construction stage	(A) Client	(CA2) Error guidance and nonprogrammed interference with instructions	4	8	47	57	34	150	3.727	8
(C) Construction stage	(A) Client	(CA3) Defaulting and rejection of compensation	1	16	47	55	31	150	3.660	16
(C) Construction stage	(A) Client	(CA4) Evil failure to supply equipment and raw materials in time	2	22	45	49	32	150	3.580	19
(C) Construction stage	(A) Client	(CA5) Defaulting on paying project settlement amount	7	21	38	53	31	150	3.533	22
(C) Construction stage	(A) Client	(CA7) Collude with other participants to modify the design proposal	2	18	50	52	28	150	3.573	20
(C) Construction stage	(D) Contractor	(CD1) Arbitrary intent to construct against design intent	4	15	37	41	53	150	3.827	4
(C) Construction stage	(D) Contractor	(CD2) Evil intention to require design change	8	15	35	60	32	150	3.620	17
(C) Construction stage	(D) Contractor	(CD3) Collude with other participants to modify the design proposal	7	7	39	66	31	150	3.713	10
(C) Construction stage	(D) Contractor	(CD4) Illegal subcontracting	3	14	31	57	45	150	3.847	3
(C) Construction stage	(D) Contractor	(CD5) Unreasonable claims	7	25	63	36	19	150	3.233	29
(C) Construction stage	(E) Supplier	(CE1) Evil intention to raise the price of equipment and raw materials	1	23	46	51	29	150	3.560	21
(C) Construction stage	(E) Supplier	(CE2) Evil lag in supplying equipment and raw materials	5	7	48	58	32	150	3.701	11
(C) Construction stage	(F) Supervisor	(CF1) Error guidance and nonprogrammed interference with instruction	5	16	41	59	29	150	3.607	18
(C) Construction stage	(F) Supervisor	(CF4) Obtain unreasonable profit because of collusion with contractors	6	6	48	58	32	150	3.693	12
(C) Construction stage	(F) Supervisor	(CF2) Intend to make trouble for suppliers, contractors and so on	5	27	45	43	30	150	3.44	25
(C) Construction stage	(F) Supervisor	(CF3) Go places without notice	7	37	60	38	8	150	3.02	30
(D) Completion and acceptance stage	(A) Client	(DA1) Defaulting on paying project settlement amount	5	17	31	59	38	150	3.72	9
(D) Completion and acceptance stage	(D) Contractor	(DD1) Malicious claims	7	21	50	58	14	150	3.34	28
(D) Completion and acceptance stage	(F) Supervisor	(DF1) Obtain unreasonable profit because of collusion with contractors	8	27	35	58	22	150	3.393	26

5.2.2. Critical Behavioral Risk Related to Contractors

Behavioral risk related to contractor consists of 9 critical risk factors: (1) Bidders ring, ranked 24th; (2) Bidding with fraudulent qualifications, ranked 23th; (3) Collude to tender or bid, ranked 6th, (4) Arbitrary intent to construct against design intent, ranked 4th; (5) Collude with other participants to modify the design proposal, ranked 10th; (6) Evil intention to require design change, ranked 17th; (7) Illegal subcontracting, ranked the third, with an *MS* value of 3.847; (8) Unreasonable claims, ranked 29th; (9) Malicious claims, ranked 28th.

A majority of Chinese contractors are either labor or specialist contractors, and they generally lack the managerial skills to contract large projects, if not all types of projects. Hence, the necessary qualifications to bid for construction projects are difficult for them to achieve. This problem is often solved by means of a bidders ring, bidding with fraudulent qualifications, or collusion to tender or bid, which results in poor quality of buildings or even engineering accidents.

Contractor's illegal subcontracting is ranked third in the list. To save costs or time, multi-level contracting and illegal sub-contracting is chosen; if a subcontractor for any part of the project fails, this is a risk for the whole system. In the Chinese construction industry, contractor's illegal subcontracting often happens; for example, the main culprit of the heavy "11.15" fire accident in Shanghai, China was the contractor's illegal subcontracting.

5.2.3. Critical Behavioral Risk Related to the Designer

Behavioral risk related to the designer consists of 3 critical risk factors: (1) Use technological capability advantage to obtain profit, ranked 13th; (2) Evil intention to sub package, ranked the first, with the highest *MS* value of 3.913; (3) Arbitrary intent to make a design change against client's intention, ranked 10th.

In the Chinese construction industry, to obtain more profit or to save time in order to contract more work, designers are often driven to deliver sub packages to non-qualified subcontractors, or ask for rebate from the subcontractor. As the design is one of the most important guarantees for the safety of the project, this risk factor should be paid attention.

To obtain more illegal profits, the designer will collude with the contractor and make design changes without permission from the owner, meaning that their own interests are met, but at the expense of seriously damaging the interests of the owner. In the long run, designers will gradually lose more customers because of the credibility problem, and will eventually be eliminated by fierce market competition.

5.2.4. Critical Behavioral Risk Related to the Supervisor

Behavioral risk related to the supervisor consists of 5 critical risk factors: (1) Error guidance and nonprogrammed interference with instruction, ranked 18th; (2) Obtain unreasonable profit because of collusion with contractors, ranked 12th with an *MS* value of 3.693; (3) Intent to make trouble for suppliers, contractors and so on, ranked 25th; (4) Go places without notice, ranked 30th; (5) Obtain unreasonable profit because of collusion with contractors, ranked 26th.

The most common behavioral risk for supervisors is Obtain unreasonable profit because of collusion with contractors. If this risk happens, the supervisor will shelter contractors' unethical behavior, resulting in great loss to the project. However, in order to win the owner's favor, the developer may support the owner in an unprincipled way, negating and blaming contractors' claims and other reasonable requirements, causing contractor dissatisfaction and leading to many disputes. On the one hand, the contractors do not trust the developer and will not cooperate with their supervision work; on the other hand, this will affect the enthusiasm of the contractors. This is a big risk for both owners and developers.

5.2.5. Critical Behavioral Risk Related to Suppliers

Behavioral risk related to suppliers consists of 2 critical risk factors: (1) Evil intention to raise the price of equipment and raw materials, ranked 21th; (2) Evil lag in supplying equipment and raw materials, ranked 11th. The quality of suppliers has a direct impact on the duration, quality and cost of the project. Cost control is often a very important assessment index for construction projects, and the cost of materials is a large part of the cost of construction projects. In practice, suppliers deliberately delay the time and reduce the quality of materials in order to pursue their own interests, seriously damaging the interests of owners and contractors. For example, the contract promises that material will be supplied at a certain point; when that time arrives, in order to obtain more profit or pursue other own interests, the supplier would look for all sorts of reasons to delay supplying the material. Therefore, research on the selection and optimization of suppliers is very important.

5.3. Comparison between the Behavior Risks from the Perspective of Different Participants

There are two cases from China to illustrate the importance of critical behavioral risk in the Chinese construction industry.

The first one is the "11.15" heavy fire accident in Shanghai, resulting in the deaths of 58 people, and 71 injured, along with a direct economic loss of 158 million yuan.

The accident was due to participants' behavioral risk: firstly, the client disclosed project information because of tacit collusion; secondly, contractor bidding with fraudulent qualifications and a bidders ring; thirdly, the supervisor obtained unreasonable profit because of collusion with contractors.

The second case happened in 1999, a walking bridge (rainbow bridge) at Qi Jiang, Chong Qing collapsed completely and suddenly, leading to 40 people dead and great economic losses of about 6.31 million Yuan. The essential reason of the accident was collusion of government, designer, construction contractor and supervisor. There were 4 participants who took behavioral risk action leading to the occurrence of the accident: (1) related to the client (this project was a government project; thus, the government was the client): government chose a worse designer because of tacit collusion, and government disclosed project information because of tacit collusion; (2) related to the contractor: bidders ring, bidding with fraudulent qualifications, illegal subcontracting, arbitrary intent to construct against design intent; (3) related to the designer: evil intention to sub package; and (4) related to the supervisor: obtain unreasonable profit because of collusion with contractors.

6. Conclusions and Future

Construction project failure is influenced and determined by many behavioral factors by principal participants. It is neither practical nor necessary to identify and understand all the related factors in order to minimize their influence on construction project. It is a smarter way to identify some critical factors in order to reduce the risk of project failure.

In this paper, we identified 41 behavioral risk factors with the potential to affect successful completion of projects as a result of principal participants' behavior. Through principal component analysis, 32 factors were extracted based on a correlation value criterion. Finally, however, there were only 30 critical risk factors retained, with corrected item-total correlation values above 0.400, which were deemed to be critical in influencing principal participants' behavior in construction projects. Finally, those 30 critical factors were ranked by *MS* value. These findings enrich the theoretical research on risk management of construction projects in China, providing additional guidance for project managers with regard to risk management, not only identifying key points of risk management in construction projects for principal participants, but also serving as a useful reference for further studies on methods to manage these risks.

It is important to note that this paper provides only the critical behavioral risk factors of principal participants in construction projects. Further studies will need to explore how to respond to and manage them. Firstly, the behavioral risk should be assessed and evaluated; following that, further investigation should consider the interrelationships between the identified factors and the dynamic transfer process during the whole life cycle of a construction project; finally, combined with case studies in the Chinese construction industry, a burden-sharing model for the principal participants could be established, which would contribute to human-risk management in construction projects.

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