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Research on Delay Risks of EPC Hydropower Construction Projects in Vietnam

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Abstract

In recent years, in Vietnam, economy has been developing rapidly. To ensure rapid and sustainable economic growth, strong support from the energy sector is required. Governments in Vietnam have invested in numerous hydropower projects, many of which employ the EPC (Engineering, Procurement and Construction) contract. However, the EPC general contractors are facing many difficulties, resulting in schedule delays and considerable losses. This research is conducted to highlight the main risk factors in the delays of hydropower construction projects in Vietnam. The research employs the method of statistical calculations and risk analysis to obtain feedback from experts participating in similar projects. The research outcomes are as follows: identifying the risks that can cause delays in EPC hydroelectric construction projects in Vietnam; calculating and classifying the degree of impact of each risk to the progress of the construction. The practical significance of this study is to ensure the timely completion of projects, benefits for the investors, and the EPC general contractors.

Keywords

Engineering, Procurement and Construction (EPC), Risk Research, EPC Hydropower Project, Construction Projects

1. Research Context and Proposed Research Orientation

1.1. Research Context

The EPC contract of the hydropower projects in Vietnam is facing many difficulties due to slow progress in construction and delay in time of completion. There are numerous factors leading to slow construction progress.

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To identify these factors, the author analyzes the characteristics of hydropower projects combined with the opinions of experienced experts with hydropower projects in Vietnam. On this basis, hypotheses about risk models are developed.

In recent years in the Vietnam, more attention has been given to risk management of hydropower projects. For instance, Zhao Juelong (2008) [1] studied cases of EPC hydropower projects in Vietnam, proposed risk factors, and suggested ways to minimize risks and proposed management measures. Li Wei (2012) [2], through the research of the Con River hydropower station in Vietnam, showed risks in project procurement, contract construction, material purchases, risks of delays in the project, and the increased expenses in construction, Jixin Wei and Liujian Zhe, through the "The whole process of overseas engineering project risk management" [3] studied about project risks. The most general characteristics of hydropower projects following the EPC in Vietnam as follows: 1) The use of EPC in Vietnam is relatively new, and project management is poor; 2) At the construction sites, the people's culture standard is low, causing various difficulties; 3) Resettlement, land withdrawal and handover for the construction contractors are complex; 4) Hydropower equipment for the projects must be imported from abroad with complex procedures, difficult shipment, and slow assembly; 5) In Vietnam currently keep high inflation rates, which affect the purchase of required materials, machines, and equipment; 6) Natural conditions such as climate, hydrology, topography, and geological conditions lead to further complications; 7) The sub-contractors' construction capacity is poor; the domestic construction technology has low productivity, and is not up to standard; 8) The infrastructure and traffic facilities for transport are poor; machine and equipment transportation encounter many difficulties, leading to delays, etc.

In the above mentioned literature, the author finds that research on risks in hydropower projects in Vietnam is still limited. With the reality of tardy construction projects and progress delays, the author deems it urgent to conduct research on risks involved in delaying the construction progress of the hydropower project using EPC in Vietnam.

The research employs the method of statistical calculations and risk analysis to obtain feedback from experts participating in similar projects. The research outcomes as follows: identifying the risks that can cause delays in EPC hydroelectric construction projects in Vietnam; calculating and classifying the degree of impact of each risk to the progress of the construction.

1.2. Proposal for Project Orientation

1.2.1. Project Orientation

Using the public information on the Internet, television, newspapers and other documents, the author carried out on-site interviews with experts and officers participating in EPC projects. On the basis of these opinions, the author hypothesized the risk factors, and calculated statistical with SPSS and AMOS software to analyze and complete the objective: research on delay risks of EPC hydropower construction projects in Vietnam.

1.2.2. Research Structure

The structure of this research includes three main parts: 1) The risk hypothesis and the impacts of risks on construction schedule; 2) Calculation and inspection of risk; 3) Controlling and limiting risks.

2. Risk Variables and Risk Model Selection

2.1. Risk Variables

Through the analysis of information and consultation of experts' opinions, we summarize the characteristics of the hidden risks leading to delays in the construction progress of the hydropower projects. Based on these characteristics, the main reasons leading to the construction progress delays can be divided into the following groups: Risk from contracts (B1), Risk from politics and law (B2), Risk from technology (B3), Risk from natural conditions and social environment (B4), Risk from economy (B5), Risk from management (B6), Risks from EPC general contractors (B7). **Table 1** is systematic table of risk factors.

2.2. Selection of Variables for Risk Calculation Models

Based on the above hypothesis of risks, the author summarized and proposed the hypothesis of the risk model affecting progress in **Figure 1**.

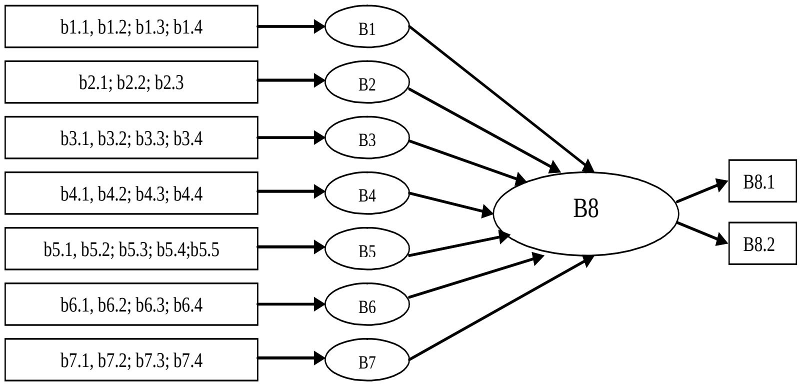

Figure 1. Specifies the assumptions of the risk system model affecting the progress.

Table 1. Hypothesis of risk group.

Objective for evaluation	Risk group level 1 (Hidden risk cause variables)	Risks level 2 (Hypothesized risk variables)
	Risk from contracts (B1)	Unfair contract terms (b1.1) Uncertain and unclear contract terms (b1.2) Fixing the EPC contract price (b1.3) Second language contracts with misleading clauses (b1.4)
	Risk from politics and law (B2)	The relationship of investor, general contractor with the authority and relevant departments (b2.1) Regional political change (b2.2) Laws and regulations of the management agencies (b2.3)
	Risk from technology (B3)	Technical design (b3.1) Negative survey data (b3.2) Construction drawings (b3.3) Inspection of technical and drawings design (3.4)
Delaying the construction progress	Risk from natural conditions and social environment (B4)	Geology, topography, and hydrography (b4.1) Ethnic groups and religions (b4.2) Transportation outside of the construction site (b4.3) Safety and security (b4.4)
	Risk from economy (B5)	Finances of the investor (b5.1) Interest rate fluctuations (b5.2) Inflation (b5.3) Financial capacity of EPC general contractors (b5.4)
	Risk from management (B6)	Poor progress management (b6.1) Construction projects monitoring team (b6.2) Poor quality work requiring repair (b6.3) Construction safety (b6.4) Inharmonious management among the EPC general contractors (b6.5)
	Risk from EPC general contractors (B7)	Purchasing materials, supplies, equipment and machines (b7.1) Difficulties with subcontractors (b7.2) Equipment installation and commissioning (b7.3) Poor construction from the EPC general contractors (b7.4)
	Consequences of the risk factors (B8)	Prolong the construction progress (b8.1) Increase in construction costs (b8.2)

3. Calculation and Verification of the Hypothesis Model

3.1. Data and Supporting Software

From the hypothesis of risks in Table 2, the author did an investigation using slips with 5 levels of risk assessment as follows.

Table 2. Investigation using slips with 5 levels of risk assessment.

1) Risk factors and risk consequences	Impact level of construction progress delays				
	Low (1)	Rather low (2)	Medium (3)	High (4)	Very high (5)
Risk factors of risk group at level 2					
2) Consequences of risk factors	<10%	10% - 20%	20% - 30%	30% - 40%	>40%
Prolong the construction progress. Increase in construction costs					

3.2. Verification Results

3.2.1. Calculate the Cronbach's Alpha Reliability Coefficient

The Cronbach's Alpha coefficient value (α) in the interval from 0 - 1, if $\alpha < 0.6$ is insufficient reliability. In the survey data for research, we can use $\alpha > 0.6$ achieved reliability, can use for analysis, (Hair J F, Anderson R E 1998) [4]; (Slater 1995) [5]. Using SPSS software to conduct the calculations and testing, the author eliminated the variables with "Corrected Item-Total Correlation" <0.3) [4]-[12] (eliminated the variables: b1.1, b1.4, b2.2, b4.2, b5.2, b6.3, b6.4, b6.5, b7.4). The Cronbach's Alpha was then calculated, results in **Table 3**.

The Cronbach's Alpha coefficient $\alpha > 0.6$, which holds enough reliability to permit the use of the survey results [4] [5]. After eliminating the unqualified variables, the results are as shown in **Table 3**.

3.2.2. Calculate and Analyze the Discovery Factors

Before performing the SEM model simulation, it is necessary to conduct the calculation and analysis of the discovery factors, investigate the main factors, including the observation variables (survey questions), and test the reliability as shown in **Table 4**. In the factor analysis of SPSS, the factor deduction method "Principal Axis Factoring" and the horizontal rotation method, Promax, were used.

The results are required to obtain a KMO ≥ 0.5 (Hair *et al.*, 2006) [6], testing coefficient with the statistical meaning Bartlett (Sig < 0.05) (Hair *et al.*, 2006) [6].

The results shown in Table 4, the KMO test coefficient features the value of 0.705 (>0.5), and the coefficient with the Bartlett statistical meaning of (Sig < 0.05). This proves the survey results have reliability; the question hypotheses are reasonable; the survey data is proper, and objective. The data is sufficient for conducting analysis in the following steps. Additionally, each variable features the factor loading coefficient larger than 0.5; Jabnoun & Al-Tamimi (2003) [7] providing that the factor loading coefficient of the variables is not less than 0.3, Gerbing & Anderson (1988) [8] clarifies the percentage of variance higher than 50%. Initially, the author used 18 variables, based on the standard of the factor loading coefficient larger than 0.5. The author gradually deleted the variables b3.2, then the factors analysis was conducted. Seven factors were chosen, B1, B2, B3, B4, B5, B6, B7, whose percentage of variance reached 56.5%, higher than the standard value of 50%, as shown in **Table 5**.

3.2.3. Calculate and Analyze the Factors

Analyze and verify the combination of factors

The author used the AMOS20.0 software for 8 assumption factors and 19 assumption risk variables to calculate the standardized factor loading coefficient of the 19 assumption risk variables in the interval of 0.501 to 1.038 (**Table 6**). In accordance with the standard factor loading coefficient >0.5, which shows the assumption risk variables for the groups of combined factors in a close relationship; the hypothesized risk variables have the largest effect on the factors group, as pointed out in the model.

Calculate verify the efficiency of the factors

The reliability value of the CR combination of the minimum factor is 0.75. All values are larger than the standard coefficient of 0.5 [4], proving that the assumption variables compared with the assumption variables models is highly consistent. The author calculated the Average Variance Extracted, AVE, found the abnormal average values, and conducted the confirmation of convergence of assumption variables in the model. The result showed the AVE value is 0.51 to 0.74, All values are larger than the standard coefficient of 0.5 [9], proving the assumption variables compared with the factors with good convergence.

Verify the proposed model

Shown in **Figure 2** and from the following **Table 7**, it is possible to conclude that the assessment result is

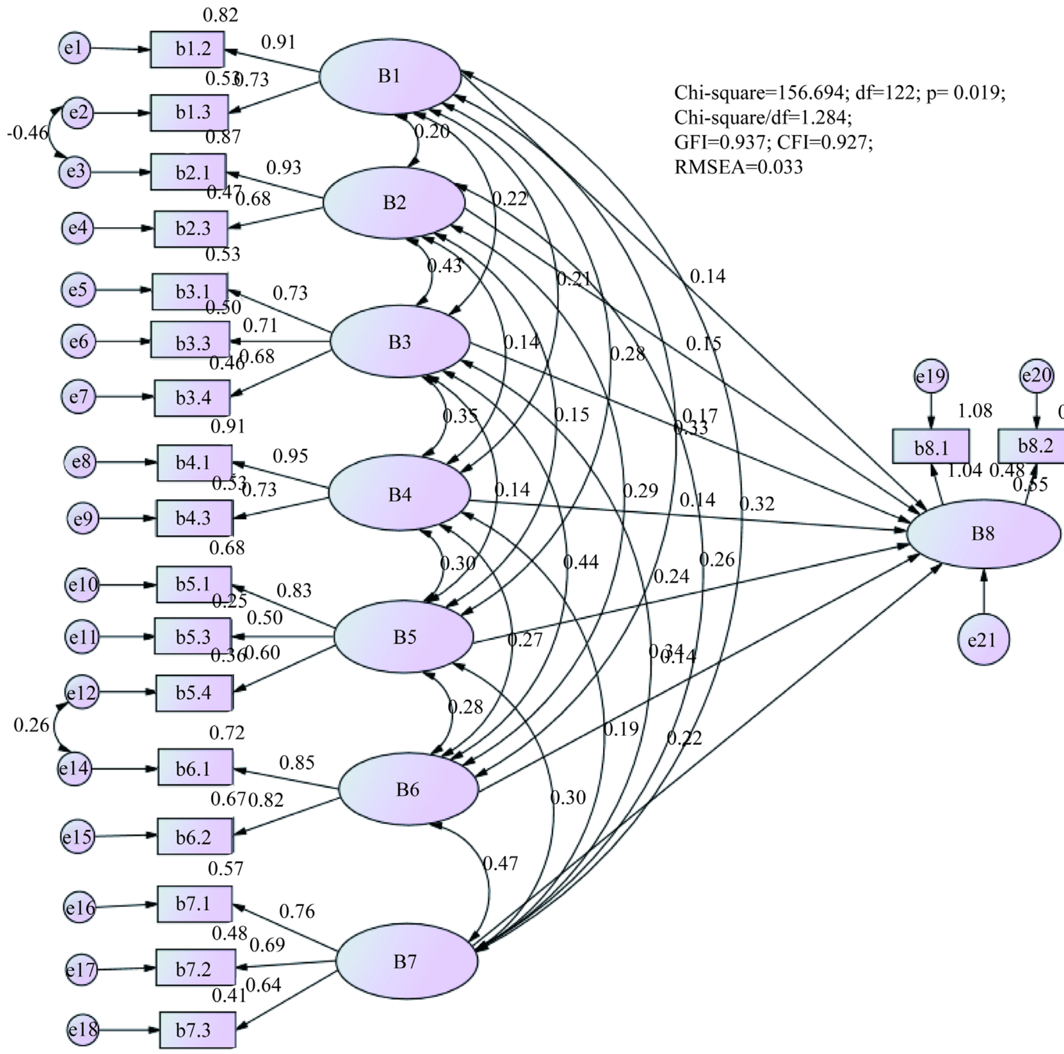

Figure 2. The structure of SEM model and assessment result.

Table 3. Cronbach's Alpha.

Group of hidden cause variables	B1 (b1.2; b1.3)	B2 (b2.1; b2.3)	B3 (b3.1; b3.2; b3.3; b3.4)	B4 (b4.1; b4.3)	B5 (b5.1; b5.3; b5.4)	B6 (b6.1; b6.2)	B7 (b7.1; b7.2; b7.3)	B8 (b8.1; b8.2)	Sum of the variables
Cronbach's Alpha	0.799	0.719	0.726	0.812	0.663	0.805	0.684	0.69	0.78

Table 4. KMO and Bartlett's Test, total variance explained.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.705
	Sig.	0.000

extremely ideal; and further indicates the proposed model for the survey data is of reasonable design.

Review the parameters of the model

According to the parameters of the regression model given in **Table 8**, the values (p) of the assumption items are also less than 0.05, which explains the reliability level of over 95%. The risk factors strongly affected the extension of the construction progress.

Table 5. Pattern Matrixa.

	Factor						
	1	2	3	4	5	6	7
b1.2	0.713						
b1.3	0.922						
b2.1		0.911					
b2.3		0.651					
b3.1			0.855				
b3.3			0.528				
b3.4			0.611				
b4.1				0.813			
b4.3				0.861			
b5.1					0.547		
b5.3					0.655		
b5.4					0.681		
b6.1						0.775	
b6.2						0.893	
b7.1							0.511
b7.2							0.743
b7.3							0.691

Table 6. Average variance extracted and AVE values.

The hypothesized variables	Factor loading coefficients	Errors of variables	CR	AVE
Risk from contracts (B1)			0.85	0.74
Uncertain and unclear contract terms (b1.2)	0.905	0.139		
Transportation outside the construction site (b1.3)	0.727	0.324		
Risk from politics and law (B2)			0.83	0.72
The relationship of investor and general contractor with the authority and relevant departments (b2.1)	0.933	0.141		
Laws and regulations of management agencies (b2.3)	0.683	0.384		
Risk from techniques (B3)			0.75	0.51
Technical design (b3.1)	0.727	0.467		
Construction drawings (b3.3)	0.705	0.493		
Inspection of technical and drawings design (b3.4)	0.682	0.502		
Risk from natural conditions and social environment (B4)			0.80	0.67
Geology, topography, and hydrography (b4.1)	0.952	0.110		
topography (b4.3)	0.731	0.591		
Risk from economy (B5)			0.77	0.53
Finances of the investor (b5.1)	0.827	0.215		
Inflation (b5.3)	0.501	0.458		
Financial capacity of the contractors (b5.4)	0.596	0.457		
Risk from management (B6)			0.84	0.72
Poor management of progress (b6.1)	0.850	0.264		
Construction items monitoring unit (b6.2)	0.816	0.283		
Risk from the EPC general contractors (B7)			0.79	0.56
Purchasing materials, equipment, and machines (b7.1)	0.756	0.287		
Sub-contractor (b7.2)	0.693	0.416		
Equipment installation and commissioning (b7.3)	0.636	0.423		
Consequences of the risk factors (B8)			0.79	0.68
Prolong the construction progress (b8.1)	1.038	0.063		
Increase construction costs (b8.2)	0.501	0.576		

Table 7. Absolute appropriate index and information index.

	Absolute appropriate index				
	Chi-square/df	GFI	TLI	CFI	RMSEA
Value	1.284	0.937	0.901	0.927	0.033
Assessment criteria	Hair *et al.*, 1998 [4] think that 1 < Chi-square/df < 3 is very good	Segar, Grover, 1993 [10] and Chin, Todd, think that >0.9 is very good.			Taylor, Sharland, Cronin, Bullard, 1993 [11] think that RMSEA <0.05 is very good

Table 8. The values: C.R., P, Standardized coefficients.

Assumption	Non-standardized coefficients	S.E.	C.R.	P	Standardized coefficients
Consequences of risks (Prolong the construction progress) ← Risk from contracts (B1)	0.211	0.087	2.416	0.016	0.136
Consequences of risks (Prolong the construction progress) ← Risk from the politics and law (B2)	0.236	0.093	2.528	0.011	0.146
Consequences of risks (Prolong the construction progress) ← Risk from techniques (B3)	0.236	0.105	2.245	0.025	0.167
Consequences of risks (Prolong the construction progress) ← Risk from natural conditions and social environment (B4)	0.162	0.064	2.532	0.011	0.143
Consequences of risks (Prolong the construction progress) ← Risk from economy (B5)	0.440	0.126	3.506	***	0.237
Consequences of risks (Prolong the construction progress) ← Risk from management (B6)	0.173	0.085	2.037	0.042	0.139
Consequences of risks (Prolong the construction pro.) ← Risk from the EPC general contractors (B7)	0.331	0.111	2.985	0.003	0.220

Note: ***Indicate the value less than 0.001.

4. Conclusions

The work achieved includes the following:

1) Recognizing the risks existing in the EPC hydropower projects in Vietnam, thereby establishing the risk factor model for projects in Vietnam.

2) Based on those risk models, calculating, analyzing and carefully evaluating the risks to determine the 17 the main reason causes leading to the delays of construction progress of the projects.

3) Discovering the levels of risk impacts to construction progress finds that the largest risk factor is Risk from the economy (B5), which can severely delay the construction progress. The remaining factors from high to low impact level are: Risk from the EPC general contractors (B7); Risk from techniques (B3); Risk from the politics and law (B2); Risk from natural conditions and social environment (B4); Risk from the management (B6); Risk from contracts (B1).

These efforts have achieved the goals set by the original thesis: research on the risk of delay in construction of hydropower projects, Procurement and Construction (EPC) in the Vietnam.

Research results show overall objective situation EPC hydropower projects in Vietnam. Based on the results of this thesis, recommendations have been proposed regarding the full understanding of the risk factors of EPC project constructions to enhance risk management, as follows: Firstly, it is necessary to reinforce the theory of risk management, and continuously summarize and accumulate the experiences in the actual construction process to manage the risks of all similar projects. Secondly, before the construction, it is essential to consider the characteristics and circumstances of each given project, and continue to determine and assess each stage of hidden risk factors that may occur in order to control and restrain them.

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