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External Risk Factors Affecting Construction Costs

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Abstract. Some risk factors can have impacts on the cost, time, and performance. Results of previous studies indicated that the external conditions are among the factors which give effect to the contractor in the completion of the project. The analysis in the study carried out by considering the conditions of the project in the last 15 years in Aceh province, divided into military conflict phase (2000-2004), post tsunami disaster rehabilitation and reconstruction phase (2005-2009), and post-rehabilitation and reconstruction phase (2010-present). This study intended to analyze the impact of external risk factors, primarily related to the impact on project costs and to investigate the influence of the risk factors and construction phases impacted the project cost. Data was collected by using a questionnaire distributed in 15 large companies qualification contractors in Aceh province. Factors analyzed consisted of socio-political, government policies, natural disasters, and monetary conditions. Data were analyzed using statistical application of severity index to measure the level of risk impact. The analysis results presented the tendency of impact on cost can generally be classified as low. There is only one variable classified as high-impact, variable 'fuel price increases', which appear on the military conflict and post tsunami disaster rehabilitation and reconstruction periods. The risk impact on costs from the factors and variables classified with high intensity needs a serious attention, especially when the high level impact is followed by the high frequency of occurrences.

INTRODUCTION

Project risk management is aimed at increasing the likelihood and positive impact of an activity while reducing the likelihood and negative impact of the activity [1]. Thus through risk management will be known the right method to avoid/reduce the amount of losses due to risks that occur. Directly good risk management can avoid as much as possible from the costs incurred due to the occurrence of an adverse event and support the increase in business profits [2].

Risk can be defined as anything that may or may not happen, which, if it does, have an impact on the project [2, 3]. Risks are related to the concept of opportunity, so risk will see opportunities for unexpected conditions and possible consequences that may lead to project failure [4]. Therefore, in general the risks to a project are a condition of the project that arises because of uncertainty with a certain chance of occurrence can have unfortunate consequences for the achievement of the project objectives, in this case related to the cost, time, and performance of the project [5].

The risks to a construction project may come from both internal and external projects. Internal risk is a risk that comes from activities within the project itself, involving the parties within the project. While external risks are sourced from outside the project and not related to project activities, they can have an impact on the achievement of project objectives. The type of risk events occurring in projects does vary based on project classification [6].

Associated with external risks, there are a number of factors associated with those risks. First, socio-political factors, which are risks derived from social and political activities and potentially alter or stop the flow of the project [7]. Second, the government's regulation factor, generally in the form of decisions or policies made systematically by the government with a specific purpose that concerns the public interest. The policies made can be profitable or even make big losses [8]. Third, the factor of natural disasters is a nature occurrence that has a major impact on the

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human population. Natural events can include floods, earthquakes, and extreme weather [7]. Fourth, monetary factors, related to macro control of economic conditions through regulation of the amount of money in circulation in order to stabilize the price and inflation [7, 9].

In relation to regional conditions, particularly in Aceh Province in the past 15 years, a number of risk variables from external factors have been the most frequent source of risk for contractors in project implementation [10]. Socio-political factors are dominant factors related to social/environmental issues. The condition emerged during the period of military conflict (2000-2005). The conditions for the two subsequent review periods (2005-2009 and 2010-present) generally show a decrease in the frequency of risks arising from external factors. Furthermore, the results of this study also indicate that there is a significant effect of external risk factors and the three periods of the study on the possibility of risks arising for the project implementing contractor.

Nevertheless, the study has not explained how much impact the contractor has had. Further studies are needed to provide more detailed information related to impacts. Therefore, this study attempts to assess the extent to which risks are likely to occur when associated with external risk factors. This study discusses the specific amount of the impact on project implementation costs. Furthermore, this study also examines the impact of external risk factors related to frequency of occurrence from those factors.

METHODOLOGY

Data Collection

The data accomplished by using questionnaire instruments that were returned from 15 companies out of to 20 local companies, classified as large companies that established before year 2000 [11]. The questionnaire contains a number of questions related to the characteristics of the respondent/company and the impact on the construction costs. The questioner variables grouped into four external risk factors as validated by experts which have professional experience in construction projects. External factors reviewed include socio-political factors (7 variables), government regulation factors (5 variables), natural disaster factors (9 variables), and monetary factors (5 variables). The impact measured by using Likert scale with the criteria stated in Table 1. The scope of risk impact assessment on construction costs is limited to 3 (three) periods of analysis, i.e. periods of military conflict (2000-2004), rehabilitation and reconstruction period post tsunami disaster (2005-2009), and post-rehabilitation and reconstruction period (2010-present).

TABLE 1. Criteria and scale of severity index (*SI*) assessment [12]

Classification	Likert Scale	*SI* Scale	*Cost Impact [3]*
Very Low	1	$0.000 < SI \leq 0.125$	No impact
Low	2	$0.125 < SI \leq 0.375$	<10%
Medium	3	$0.375 < SI \leq 0.625$	10-20%
High	4	$0.625 < SI \leq 0.875$	20-40%
Very High	5	$0.875 < SI \leq 1.000$	> 40%

Testing Instruments

The testing is conducted to ensure the validity and reliable instrument used for data collecting to answer the research objectives. The research instrument was tested using two test procedures, which are by validity test and reliability test. Validity test is required to show the validity levels of an instrument. Validation test using Pearson product moment correlation (r) that is essentially a measure of linear association between two paired variables x and y for n number of respondents [13]. The significance of a correlation value tested using the *t-distribution* and then compared with critical values of the t-distribution with n-2 degrees of freedom. If $t_{count} > t_{table}$, then the question item is significantly correlated to the total score (declared valid), and otherwise will declared as invalid.

$$r = \frac{n(\sum xy) - (\sum x \sum y)}{\sqrt{\{n\sum x^2 - (\sum x)^2\}\{n\sum y^2 - (\sum y)^2\}}} \quad (1)$$

$$t_{count} = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} \quad (2)$$

The reliability test is performed to ensure reliability adequacy of the instrument used as a data collection tool. The test was performed by Cronbach's Alpha (*c-alpha*) analysis. The *c-alpha* coefficient (*r*) range from 0 to 1 and must be greater than 0.6 to accomplish reliable instruments. The significance level for the statistical test used is 5%. The tests performed using Eq. 3 [14].

$$r = \frac{k}{(k-1)}\left[1 - \frac{\sigma^2 b}{\sigma^2 1}\right] \quad (3)$$

With k = number of items, $\sigma^2{}_b$ = variance of items, and $\sigma^2{}_1$ = variance of total score.

Analysis

The impact assessment on construction costs are presented in the form of *Severity Index (SI)*. The index is an indicator of the impact scale of each risk factor being reviewed. The impact classified in 5 scales range from 0 (very low/no impact) to 1 (very high or affecting construction cost > 40%) as described in Table 1. The index analyzed by using Eq. 4 [12].

$$Severity\,Index(SI) = \frac{\sum_{1=1}^{5} a_i n_i}{5N} \quad (4)$$

With i = index of response, a_1 = weight associated with value of i response, n_1 = frequency of respondent i as percentage of total respondent for each factor, and N = total number of respondents.

DISCUSSION AND RESULTS

Characteristics of Respondents

Characteristics of respondents describe the situations of personnel and company. The characteristics of personnel indicate the background of the position and experience of the personnel, and the characteristic of the company describes the number, type, and value of projects handled. Characteristics for 15 respondents involved are shown in Table 2.

The respondents involved in the study were almost entirely the middle and top management elements of the company with sufficient experience on the construction projects. The number of projects handled by respondent companies is generally less than 6 projects during the period of military conflict. However, in the next observation period, the number of projects handled by the company increased by more than 6 projects per year, and even 40% of companies are capable of handling more than 10 projects per year. This situation is in line with the better conditions of the study area and the increasing activity of infrastructure projects. The types of projects carried out were mostly the projects of building construction and transportation infrastructure with the value of contract above IDR 10 billion.

TABLE 2. Characteristics of respondents

Characteristics of Respondents	Category of Measurement	Quantity	(%)
Personnel positions	Director	5	33.30
	Manager	7	46.67
	Others	3	20.00
Working experience of personnel	>2-4 years	1	6.67
	>4-7 years	1	6.67
	>7 years	13	86.67
Number of projects handled by the company	Period of military conflict		
	1-3 project	3	20.00
	>3-6 project	5	33.33
	>6-10 project	4	26.67
	>10 project	3	20.00
	Period of rehab/recon		
	1-3 project	1	6.67
	>3-6 project	5	33.33
	>6-10 project	3	20.00
	>10 project	6	40.00
	Period of post rehab/recon		
	1-3 project	2	13.33
	>3-6 project	2	13.33
	>6-10 project	5	33.33
	>10 project	6	40.00
Types of projects ever handled by the companies	Building	11	73.33
	Roads and bridges	14	93.33
	Water constr.	9	60.00
Average yearly project value (in IDR)	< 10 billion	2	13.33
	10 billion to 50 billion	8	53.33
	> 50 billion	2	13.33

Result of Validity and Reliability Test

Validity test in this research was conducted by taking 15 respondents. With the value of t_{table} 0.514 for 5% significant level, the test for all questions (26 variables) indicated that $t_{count} \geq t_{table}$, so that the instrument can be declared valid. For the reliability, the test results indicate that the *c-alpha* coefficients for all external risk factors analyzed are greater than 0.6. The results of the validity and reliability test are summarized in Table 3.

TABLE 3. Result of tests

Risk Factor	Validity Test			Reliability Test		
	Range of t_{count} Per Period			C-Alpha Per Period		
	Military Conflict	Rehab/Recon	Post Rehab/ Recon	Military Conflict	Rehab/ Recon	Post Rehab/ Recon
Social Politics	0.768-0.966	0.862-0.971	0.895-0.982	0.86	0.89	0.90
Government Regulation	0.571-0.907	0.669-0.928	0.745-0.945	0.73	0.73	0.77
Natural Disasters	0.629-0.964	0.614-0.959	0.601-0.982	0.81	0.90	0.92
Monetary	0.530-0.933	0.709-0.942	0.844-0.952	0.68	0.73	0.79

The Impact on Cost of External Risk Factors

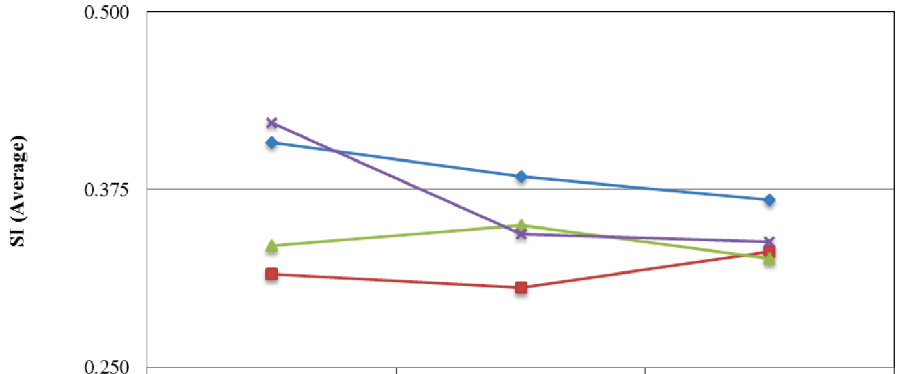
The impact assessment on the cost of construction implementation is based on the SI index value. The index values are in the range of 0 to 1. SI values for external risk factors are in the range of 0.125-0.875 or are in *low* to *high* of impact categories. For more detail, the SI value for 4 external risk factors and 26 variables are shown in Table 4.

TABLE 4. Assessments of the impact on construction costs

Risk Factors	Variables	Conflict		Rehab/Recon		Post Rehab/Recon	
		SI	Impact	SI	Impact	SI	Impact
Social Politic	The occurrence of unrest	0.35	Low	0.35	Low	0.37	Low
	The existence of sabotage of facilities/ materials	0.28	Low	0.29	Low	0.33	Low
	Demonstration at the project site	0.27	Low	0.27	Low	0.31	Low
	Cultural conditions and customs of the community at the project site	0.37	Low	0.31	Low	0.31	Low
	Social issues (surrounding environment)	0.35	Low	0.32	Low	0.36	Low
	Conflict with project stakeholders	0.28	Low	0.29	Low	0.31	Low
	Religious holidays/other holidays	0.31	Low	0.31	Low	0.33	Low
Government Regulation	Government policy changes/updates lead to cessation of the project	0.36	Low	0.31	Low	0.33	Low
	Changes in government regulations	0.33	Low	0.31	Low	0.29	Low
	Late permissions and licenses	0.36	Low	0.33	Low	0.33	Low
	Rise in fuel prices	0.63	High	0.64	High	0.53	High
	Project cancellation by government	0.36	Low	0.33	Low	0.36	Low
Natural Disaster	Uncertain weather conditions	0.45	Medium	0.51	Medium	0.43	Medium
	Uncertainty of conditions in the field	0.32	Low	0.33	Low	0.33	Low
	War	0.37	Low	0.28	Low	0.29	Low
	Revolution	0.31	Low	0.28	Low	0.28	Low
	Fire	0.32	Low	0.33	Low	0.32	Low
	Environmental pollution	0.29	Low	0.31	Low	0.31	Low
	Epidemic of a disease	0.32	Low	0.31	Low	0.32	Low
	Flooding	0.33	Low	0.39	Medium	0.37	Low
	The occurrence of an earthquake	0.31	Low	0.41	Medium	0.29	Low
Monetary	Monetary instability	0.32	Low	0.29	Low	0.29	Low
	Fluctuations in loan interest rates in banks	0.46	Medium	0.37	Low	0.39	Medium
	Inflation, deflation and devaluation	0.36	Low	0.32	Low	0.33	Low
	Fluctuation of currency value	0.37	Low	0.35	Low	0.37	Low
	Economy Crisis	0.60	Medium	0.39	Medium	0.31	Low

Assessment of impacts based on risk factors indicates that the impact with high intensity is seen only in government regulation factor, namely for the variable 'rise in fuel prices'. Impacts with such intensity appear in all three observed periods. This condition illustrates that for these variables, the level of the impact on costs is not affected by the observed period. In other words, if the risk variables appear under any circumstances then the cost can be high. The impact on costs with medium intensity appeared only in several variables for natural disaster factor (3 variables) and monetary factor (2 variables). For these variables, impacts with medium intensity generally appear only in one or two observed periods. This condition indicates the influence of the study period on the scale of the impact that may occur for these variables and risk factors. Risk factors and variables with low intensity impacts are seen in all factors (20 variables) and periods reviewed. The impact with such low intensity can be said not to be affected by the observed periods.

Based on the average of SI values, the patterns of impact occurred in two forms related to intensity of impact over three period observed (Fig. 1). Firstly, the tendency of impact decreasing arises in two external risk factors that are on the monetary factor and the government regulation factor. The average SI scores for both factors indicate impacts on project costs at medium levels during the military conflict period (2000-2004) and decreased to low levels in the two subsequent observation periods (rehab/recon and post-rehab/recon). Secondly, the pattern of impacts with trends relatively constant as seen on factors of natural disasters and social politic. In both of these factors, differences in province situations for the three observation periods do not provide significant change in impacts for project costs.



	1	2	3
Social Politic	0.316	0.306	0.331
Government Regulation	0.408	0.384	0.368
Natural Disaster	0.336	0.350	0.327
Monetary	0.422	0.344	0.338

FIGURE 1. Typical of average SI value for external risk factors

Assessment the impact of a risk factor can be attributed to the probability of occurrence of the risk. Studies related to the probability of risk occurrence have been prepared previously [10]. The occurrence pattern of risk and the intensity of the impact on costs described in Table 6.

Factor Social-Politic

The frequency of risk occurrence for a number of variables on this factor appears high in the initial period of observation and decreases in the next period of observation. Variables with fixed frequencies for all three periods are seen only in the variables 'social issues (surrounding environment)' and 'religious holidays/other holidays'. Associated with the impact, the high to low frequency of occurrence of the entire risk variable only contributes to the impact with low intensity. These conditions illustrate that the frequency of occurrence of a risk variable, will not have a significant effect on the impacts of project costs. Thus, the project implementation costs escalation is probably below 10% of the contract value of the project.

Factor Government Regulation

The five variables reviewed on this factor indicate that the occurrence of the variables tends to be at a medium level position, and there are only a variable specified in high frequency, namely 'rise in fuel prices'. For contractors, this variable requires a particular consideration, as these variables indicate the frequency of high-level events and simultaneously impacts with high intensity to increase the cost of project implementation. The problem of fuel price increase is closely related to the availability of fuel for the operation of a number of project equipment. In the two initial periods of observation, the period of military conflict and rehab/recon, the condition of scarcity is commonly occurred. High intensity impacts may contribute to an increase in project costs by 20-40% of contract value. For variables with medium frequencies, the impact on costs that the project may experience is entirely in low intensity.

TABLE 6. The relationship between the frequency occurrence and impact on costs of external risk factors

Risk Factors	Variables	Conflict		Rehab/Recon		Post Rehab/Recon	
		Freq. [10]	Impact	Freq. [10]	Impact	Freq. [10]	Impact
Social Politic	The occurrence of unrest	High	Low	Low	Low	Low	Low
	The existence of sabotage of facilities / materials	Low	Low	Low	Low	Low	Low
	Demonstration at the project site	Low	Low	Low	Low	Low	Low
	Cultural conditions and customs of the community at the project site	High	Low	Medium	Low	Low	Low
	Social issues (surrounding environment)	High	Low	High	Low	High	Low
	Conflict with project stakeholders	Low	Low	Low	Low	Low	Low
	Religious holidays / other holidays	Medium	Low	Medium	Low	Medium	Low
Government Regulation	Government policy changes / updates lead to cessation of the project	Medium	Low	Medium	Low	Medium	Low
	Changes in government regulations	Medium	Low	Medium	Low	Medium	Low
	Late permissions and licenses	Medium	Low	Medium	Low	Medium	Low
	Rise in fuel prices	High	High	High	High	High	Medium
	Project cancellation by government	Low	Low	Medium	Low	Low	Low
Natural Disaster	Uncertain weather conditions	High	Medium	High	Medium	High	Medium
	Uncertainty of conditions in the field	Medium	Low	Low	Low	Low	Low
	War	High	Low	Low	Low	Low	Low
	Revolution	Low	Low	Low	Low	Low	Low
	Fire	Low	Low	Low	Low	Low	Low
	Environmental pollution	Low	Low	Low	Low	Low	Low
	Epidemic of a disease	Low	Low	Low	Low	Low	Low
	Flooding	Medium	Low	Medium	Medium	High	Low
	The occurrence of an earthquake	Low	Low	Medium	Medium	Low	Low
Monetary	Monetary instability	Low	Low	Low	Low	Low	Low
	Fluctuations in loan interest rates in banks	Medium	Medium	Medium	Low	Medium	Medium
	Inflation, deflation and devaluation	Medium	Low	Medium	Low	Medium	Low
	Fluctuation of currency value	Medium	Low	Medium	Low	Medium	Low
	Economy crisis	High	Medium	Low	Medium	Medium	Low

Factor Natural Disaster

The frequency of the occurrence of a number of risk variables on natural disaster factor tends to be determined by the observation period. The variables of 'uncertainty of conditions in the field', and 'war' with medium and high frequencies only appeared during the period of military conflict (2000-2004), while the flooding variables appeared

with medium frequencies in the two initial observation periods and increased to high frequencies In the third observation period. Almost all of these variables have an impact with low intensity on the cost of project implementation. This is made possible by the accommodation of most of the variables on natural disaster factors in construction work contracts, so that the risks are not borne by the contractor. However, for the uncertain weather conditions variable needs to be noticed because of the medium intensity impact that may be caused by this factor. These floating variables affected the increase in construction costs in the range of 10-20% of the value of contracted project.

Factor Monetary

Variables in monetary factors are generally likely to appear with medium frequency. However, it should be noted that the probability of occurrence of variables on this factor is strongly determined by the state monetary conditions rather than by the observation period in this study. The high frequency of occurrence in each observation period is largely determined by the general monetary condition of the country in that period. In monetary factors, the most likely adverse impacts occur in the variables 'fluctuations in loan interest rates in banks' and 'economy crisis' with medium intensity. However, these variables only occur in certain observation periods.

CONCLUSIONS

The external risk factors impacts on construction cost are generally in low intensity level for three period of observation. The level of the impact on costs then concludes that is not affected by the observed period.

The contractor firms need to pay attention for several risk variables that contribute impact with high and medium level, because those levels will contribute the additional construction cost in range of 10% to 40% from the value of contracted work.

Related to the relationship between the frequency of occurrence and the magnitude of the impact that may arise, the contracting firm should consider the possible risks of government regulatory and monetary factors. A number of variables on both these factors are potentially appearing with medium and high frequencies, as well as having high-intensity impact (1 variable) and medium (5 variables).

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