Sensitivity analysis of risk from stakeholders’ perception
Case study: Semarang-Solo highway project section I
(Tembalang-Gedawang)

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Abstract

Risks at construction are borned by some parties. Each party carries the risks in accordance to their respective and responsibilities in the project. In Semarang-Solo Highway Project Section 1 (Tembalang-Gedawang), which was built in 2010 until 2011, the risks are borned by each stakeholder in the project, such as contractor, owner, consultant of planning, supervisory consultant, and society around the area of the project. Probability and impact of risk in the project can be estimated by risk analysis for defining the priority of risk. The risks of each stakeholder may change dynamically as changes in the stakeholder, such as policy changes because of internal or external factors. These changes can be predicted by sensitivity analysis that predicts the changes of risk priority in a decisional hierarchy structure because of the changes in each stakeholder. The aims of this paper are to analyze all risks at the project and to analyze the sensitivity of risk at Semarang-Solo Highway Project Section 1 (Tembalang-Gedawang). Primary data were taken through the interview, then analyzed using AHP (Analythical Hierarchy Process) method. The respondents were the decision maker on related projects. Sensitivity analysis uses weight changes simulations at hierarchical structure with Analythical Hierarchy Process. This paper assessed the risk sensitivity analysis on the project Semarang-Solo Highway Project section I-Gedawang Tembalang, and it’s found that the contractor, consultant of planning, and supervisory consultant, are sensitive to changes in some weight changes simulations. While the owner and the society are not sensitive to changes that occur.

Keywords: risk management; sensitivity analysis; analythical hierarchy process.

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1. Preliminary

Semarang-Solo Highway Project is a part of Trans Java Highway projects along 652 km, started from Cikampek West Java and finished at Gempol East Java. Semarang-Solo highway was planned along 76 km with the cost more than Rp 6.8 trillion. The Semarang-Solo highway perhaps can develop the economic at Java.

At construction project there must be risks. Risk is a consequence of the uncertainty conditions. In construction projects, the risk can’t be predicted as well because there are a lot of uncertainty to predict problems. Risks in construction projects are borned by some parties in the project. Usually, the risks in the project is only identified from the owner’s and the contractor’s sides, eventhough many parties also involve in the project, such as supervisory consultant, consultant of planning, and the society around the project. It is important to know the risk from all stakeholders’ perception. Assessing the risk from one’s perception of stakeholders will cause some tendency problems of the one stakeholder.

Risks on construction project from all stakeholders’ perception are calculated from all points of stakeholders’ perception. In some cases, the risk priority of the project may change due to some conditions, either because of internal factors or external factors. This condition was called a risk sensitivity. It means that the risk on the project can change because it is sensitive to decisional changes that occur by stakeholders.

The aims of this paper are to analyze all risks from stakeholders’ perception and to analyze the sensitivity of risk at Semarang-Solo Highway Project Section 1 (Tembalang-Gedawang). In risk sensitivity analysis, it will be known the changes of risk level form the changes of stakeholders policy.

2. Literature Review

2.1. Risk Management

According to Soemarmo (2007), risks of the project can be defined as an elaboration of unfortunate consequences, both of finance and structure of project, as a result of decisions taken or due to environmental conditions on the project location. Risks in construction projects are the matter that can not be eliminated, but their impact can be minimized.

In the developing countries, the risk of project must be managed properly for not only produce good and safe jobs for stakeholders, also produce benefits for the stakeholders in the project (Wang, et al, 2004). The effectiveness of managing the risk is to correctly identify the important risks and allocated the risk of the contract (Andi, 2006).

Abednego and Ogunlana (2006) classified the risk categories on highway projects from the owner perception in seven categories as follows:

- Political risks; such as policy changes, tax increases, inappropriate tariff, improper rate increase, and changes in government structure.
- Construction risks; such as the improper design, land acquisition, project delays, the conditions of the ground, and construction failures.
- Operate and maintenance risks; such as network conditions of expressway, incompetence of toll operators, and quality of construction.
- Legal and contractual risks; such as inconsistencies in the document of contract.
- Risk of income; such as inaccurate estimation of the traffic volume, inaccurate estimation of the tariff, etc.
- Financial risks; such as inflation, devaluation, interest rates, changes in monetary policy, and capital.
- The risk of force majeure; such as weather conditions, and war.

2.2. Sensitivity Analysis

Sensitivity analysis can be performed to predicts conditions that will occur if a significant change happens, such as change in weight due to changing priorities. It will generate change of priority, and there should be assigned the actions needed for these changes.
Sensitivity analysis is a dynamic element of a hierarchy. Assessment of the first maintain is carried out for a certain period of time and the change of policy is done with sensitivity analysis to see the effects that occur (Mora, 2009).

2.3. Analytical Hierarchy Process Method

Analytical Hierarchy Process is one of some methods in decision-making (Decision Support Systems) that developed by Thomas L. Saaty. This decision support system can elaborate a multi-factor or multi-criteria problem into a hierarchy. Hierarchy is defined as a representation of a complex problem in a multi-level structure. By hierarchy, a complex problem can be decomposed into their groups then arranged into a form of hierarchy so that problem would appear more structured and systematic.

![Fig.1 The hierarchy structure](image)

2.4. Sensitivity Analysis Using Analytical Hierarchy Method

Sensitivity analysis on the decision criteria may occur due to the changes even on the additional information made by decision maker. The change of criteria can cause the change of alternative priority, which is obtained from the calculation using Analytical Hierarchy Process method. The sensitivity analysis calculations are written in the steps as follows:
1. Determine global priorities
Global priority matrix is obtained by multiplying the weight of each criteria and the weight of each alternative decision.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>K1</th>
<th>K2</th>
<th>K3</th>
<th>K4</th>
<th>Global Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>x₁</td>
<td>x₂</td>
<td>x₃</td>
<td>x₄</td>
<td>X</td>
</tr>
<tr>
<td>A</td>
<td>a₁</td>
<td>a₂</td>
<td>a₃</td>
<td>a₄</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>b₁</td>
<td>b₂</td>
<td>b₃</td>
<td>b₄</td>
<td>Y</td>
</tr>
<tr>
<td>C</td>
<td>c₁</td>
<td>c₂</td>
<td>c₃</td>
<td>c₄</td>
<td>Z</td>
</tr>
</tbody>
</table>

Where:
- A, B, C = Alternative of decision
- K1, K2, K3, K4 = Criteria
- x₁, x₂, x₃, x₄ = The weight of each criteria
- X = Global Priority of alternative A
- Y = Global Priority of alternative B
- Z = Global Priority of alternative C
From the table of global priority matrix, the global priority can be calculated by the formula:

\[ X = a_1 \cdot x_1 + a_2 \cdot x_2 + a_3 \cdot x_3 + a_4 \cdot x_4 \]  
\[ Y = b_1 \cdot x_1 + b_2 \cdot x_2 + b_3 \cdot x_3 + b_4 \cdot x_4 \]  
\[ Z = c_1 \cdot x_1 + c_2 \cdot x_2 + c_3 \cdot x_3 + c_4 \cdot x_4 \]

(1) 
(2) 
(3)

2. Change the value of weight criteria

The changes of weight criteria \((x_1)\), will make the changes of priority. This changes of priority can be seen in the changing of global priority values \((X, Y, \text{ and } Z)\). The weight of the criteria can be changed to be smaller or larger than the previous. The same step is also performed on the criteria \(x_2, x_3, \text{ and } x_4\). Then it will be known the sensitivity changes from each criteria.

3. Research Method

Primary data were taken through the interview, then analyzed using AHP (Analythical Hierarchy Process) method. Respondents were the decision maker on related projects. By this analysis will be known the priority of risk at the project. Sensitivity analysis is calculated using weight changing simulations at hierarchical structure with Analythical Hierarchy Process.

4. Data analysis and discussion

The hierarchy structure of risk from the stakeholders’ perception is described as follows.

![Risk Hierarchy Structure at Semarang-Solo Highway Project Section I Tembalang-Gedawang](image)

Based on the hierarchy structure, the comparisons models between elements are made by the effect of the elements on the upper level. This pair comparisons are solved using Analytical Hierarchy Process method. The weights that calculated are the element at level two and three. The second level will obtained the weight for each stakeholder, there are contractor, owner, society, consultant of planning, and the supervisory consultant. While on the third level it will be obtained the weight for each risk category, there are construction risk; political, legal and contracts risk; and economic risks of each stakeholder.

The weight was obtained from questionnaires of several respondents in project management (Expert Team) and stakeholders at Semarang-Solo highway project. The Expert Team are respondents outside of related projects, and respondents from each stakeholders, there are contractor, owner, society, consultant of planning and supervisory consultant.
4.1. Calculation of Global Priorities

The first step of sensitivity analysis is to calculate weight level of risk from each stakeholder based on a hierarchical structure. From the questionnaire that filled up by respondents, the weight of risk level among stakeholders are shown as follows.

<table>
<thead>
<tr>
<th>RISK</th>
<th>Contractor</th>
<th>Owner</th>
<th>Society</th>
<th>Consultant of Planning</th>
<th>Supervisory Consultant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Risk</td>
<td>0.48</td>
<td>0.19</td>
<td>0.04</td>
<td>0.11</td>
<td>0.19</td>
</tr>
<tr>
<td>Political, Legal And Contracts Risk</td>
<td>0.28</td>
<td>0.69</td>
<td>0.35</td>
<td>0.25</td>
<td>0.65</td>
</tr>
<tr>
<td>Economic Risk</td>
<td>0.60</td>
<td>0.18</td>
<td>0.35</td>
<td>0.09</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>0.12</td>
<td>0.13</td>
<td>0.30</td>
<td>0.66</td>
<td>0.25</td>
</tr>
</tbody>
</table>

(Source: Analysis, 2011)

The final step of sensitivity analysis is to calculate global priorities of weight that was calculated previously. This global priority is obtained by multiply the matrix between weight of risk in each category and risk level from each stakeholders.

On the matrix above it can be seen that the construction risk is the highest risk from stakeholders’ perception at Semarang-Solo Highway project with weight 0.428 or 42.8%, the second position of risk is political, legal and contract risks with weight 0.360 or 36%, and on the third position of risk is the economic risk with weight 0.212 or 21.2%. As of the risk from stakeholders (at second level from hierarchy structure), the most important stakeholders that carries risk into construction phase is contractor with weight of 0.48 or 48%. The second is owner and supervisory consultant that has same weight 0.19 or 19%. The risk by consultant of planning perception in the third ranking with weight 0.11, or 11%, and the fourth ranking is a society with weight 0.04 or 4%.

4.2. Sensitivity Analysis from Stakeholders Interest Rate

The calculation of sensitivity analysis can be calculated by the formula of global priorities as follows:

Construction Risk: $0.28 \times \text{I} + 0.69 \times \text{II} + 0.35 \times \text{III} + 0.25 \times \text{IV} + 0.65 \times \text{V}$

Political, Legal, And Contracts Risk: $0.60 \times \text{I} + 0.18 \times \text{II} + 0.35 \times \text{III} + 0.09 \times \text{IV} + 0.10 \times \text{V}$

Economic Risk: $0.12 \times \text{I} + 0.13 \times \text{II} + 0.30 \times \text{III} + 0.66 \times \text{IV} + 0.25 \times \text{V}$

Where:
- \text{I} = Risk level of Contractor
- \text{II} = Risk level of Owner
- \text{III} = Risk level of Society
- \text{IV} = Risk level of Consultant of Planning
- \text{V} = Risk level of Supervisory Consultant

The risk level of contractor, owner, society, consultant of planning, and supervisory consultant will be simulated by weight 0.1 to 1.0. This simulation is made to Construction Risk; Political, Legal, And Contracts Risk; and Economic Risk. From this simulation it will be known the weight change from risk category as follow:
Table 3 Results of Risk Sensitivity Analysis in Semarang-Solo Highway Project Section I Tembalang-Gedawang

<table>
<thead>
<tr>
<th>No</th>
<th>Stakeholders</th>
<th>Weight of Risk Level at Beginning</th>
<th>Weight of Risk Level When Changed</th>
<th>Risk Priority</th>
<th>Risk</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0.48</td>
<td>0.10</td>
<td>1</td>
<td>Construction Risk</td>
<td>0.321</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.70</td>
<td>2</td>
<td>Economic Risk</td>
<td>0.166</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>Political, Legal, And Contracts Risk</td>
<td>0.134</td>
</tr>
<tr>
<td></td>
<td>Contractor</td>
<td>0.19</td>
<td>-</td>
<td>1</td>
<td>Political, Legal, And Contracts Risk</td>
<td>0.491</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>Construction Risk</td>
<td>0.491</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>Economic Risk</td>
<td>0.239</td>
</tr>
<tr>
<td></td>
<td>Owner</td>
<td>0.19</td>
<td>-</td>
<td>1</td>
<td>Construction Risk</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>Political, Legal, And Contracts Risk</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>Economic Risk</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Planning Consultant</td>
<td>0.19</td>
<td>1.20</td>
<td>1</td>
<td>Construction Risk</td>
<td>1.086</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>Economic Risk</td>
<td>0.469</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>Political, Legal, And Contracts Risk</td>
<td>0.456</td>
</tr>
<tr>
<td></td>
<td>Supervisory Consultant</td>
<td>0.11</td>
<td>0.4</td>
<td>1</td>
<td>Construction Risk</td>
<td>0.502</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>Economic Risk</td>
<td>0.404</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>Political, Legal, And Contracts Risk</td>
<td>0.386</td>
</tr>
<tr>
<td></td>
<td>Society</td>
<td>0.04</td>
<td>-</td>
<td>1</td>
<td>Construction Risk</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>Political, Legal, And Contracts Risk</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>Economic Risk</td>
<td>-</td>
</tr>
</tbody>
</table>

From the sensitivity analysis shown at Table 3; from contractor, the priority of risk changed when the weight of risk level changed at 0.10 and 0.70. From supervisory consultant, the priority of risk changed when the weight of risk level changed at 1.20. From consultant of planning, the priority of risk changed when the weight of risk level changed at 0.40. Besides the owner and the society, the priority of risk has not changed in this simulation.

5. Conclusions And Recommendation

The conclusion that can be defined from this research are:
1. Risks at Semarang-Solo highway project section I Tembalang-Gedawang from stakeholders’ perception are Construction Risk (Rank 1), Political, Legal, And Contracts Risk (Rank 2), and Economic risk (Rank 3).
2. The risk at construction projects carried by many stakeholders can change dynamically according to the internal or external changes from each stakeholders. The change of priorities can be seen by simulating changes in weight to each stakeholder. In contractor, the priority of risk will change when the weight changed at 0.10 and 0.70. At supervisory consultant, the priority of risk will change when the weight changes at 1.20. In consultant of planning, the priority of risk will change when the weight changes at 0.40. Besides the owner and the society, the priority of risk has not changed in this simulation.

Recommendation of this research is for further development, the future research can observe risk analysis on the other stakeholders that has not been analyzed in this study, such as risk analysis from the sub-contractors, material suppliers, and banking.

References