Risk analysis of toll road construction project by using soft system methodology (SSM) – a case study of sumatera trans toll road terpeka section 1 (Terbanggi Besar – Menggala)

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Abstract. Toll Constructing a toll road project always deals with various technical and non-technical problems. Those problems are considered as the risk of construction projects. These risks will definitely affect the project function and result in losses both in terms of cost, quality, and time, which determine the success of a project. Therefore, the purpose of this research was to identify and to analyze the risks using qualitative-quantitative research with the Soft System Methodology (SSM) on Sumatra Trans Toll Road Project Section I in Terbanggi besar – Kayu Agung. Collecting data, this research used purpose sampling techniques from respondents. In addition, data analysis methods used in this study are Probability Risk Test, Consequences Risk Test, and Soft System Methodology (SSM)

1. Introduction
The development of the Trans Sumatra Toll Road (Terbanggi besar – Pematang Panggang) project by Hutama Karya along the 189.2 kilometers (km) is still being accelerated. By the end of 2019, it is estimated that 365 kilometers of toll road will be built and operated to be used by public. The construction process of Trans Sumatra Toll Road is done quite different from the latest technology experience. For the first time, in Indonesia, the Ministry of PUPR collaborated with Hutama Karya to apply the use of advanced technology called VCM to accelerate the construction of Trans-Sumatra Toll Road. The toll road construction in this project has also never been away from various technical and non-technical problems. These problems are known as construction project risks. These risks will definitely affect the project function and result in losses both in terms of cost, quality, and time, which determine the success of a project which determine the success of a project (Kangari, 1995). In the end, risks can arise both in expected and unexpected way (Smith, 1992). These risks can be managed by identifying quantifying the risks that might occur in a project. The analysis can be done with qualitative and quantitative analysis. This analysis was conducted to determine the opportunities and impacts of a project.

Formulation of the problem
Based on the background of the problems above, the problems can be formulated as follows:
1. What risks might occur in the project case study?
2. What were the level of opportunity and impact of the risk in the project?

1.1. Research Purposes
The objectives of this study are
1. Identifying and analyzing risks that might occur in project case study qualitatively.
2. Quantifying the risks that might occur using the SSM method.

1.2. Limit Problems
The limitations of this research are
Examining the risks occur at the construction stage in the project case study.
Determining the level of risk based on the results of identification and risk analysis.
Identifying risks based on secondary data, namely document reviews in project case study.
Analyzing risks using the SSM method.

1.3. Research Contribution
The result of this research is expected to give significant contribution, those are:
1. Being the initial recommendation in managing risks that may occur in the construction
2. Providing an overview of the SSM application framework in terms of construction risk management on toll road.
2. Literature review

2.1. Project Management
PMBOK (Project Management Body of Knowledge) defines project management as the application of knowledge, skills, tools, and techniques in the project activities to reach the project needs. Project management is considered to be successful if it can achieve the desired goals by fulfilling the following requirements:

a. Time allocation
b. Budget
c. The performance or certain specification
d. Customers’ approval
e. Changes in the minimum agreed scope of work
f. No disruption from the main work flow of the organization
g. No changes on the company’s (positive) culture

2.2. Definition of Risk Management
According to PMBOK Guide 5th Edition describes project risk management as a process of planning, identifying, analyzing, planning handling and controlling risks in a project. The purpose of risk management is to increase the chance (probability) of positive influences and reduce negative effects (threat). In this research, risk management is intended to analyze the risks that may occur in project case study.

2.3. Risks During Toll Road Construction
According to the Construction and Building Guidelines (Pd T-01-2005-B) issued by the Department of Public Works, the class and elements of toll road risks are divided into three stages consisting of:

Table 1. Class and element of toll risk

| step | risk |
|------|------|
| 1. Pre construction | licensing tender process dokumen contract  
feasibility study Data used assumptions taken  
Design Standard misinterpretation  
Land acquisition Land availability compensation process |
| 2. Construction | Financing Continuity of sources of funds interest during  
Development Filed condition, weather, material, supply, theft, specification, strike  
Equipment Import the performance  
Force majeur Disaster nationalization revolution |
| 3. Post construction | Operation and maintenance operation and maintenance system, poor building construction, estimated operating and maintenance costs, inflation of operating and maintenance costs, vandalism, accident rate, security conditions and public order  
Toll acceptance estimated traffic volume initial tariff and tariff adjustment  
Toll obligation competition inefficiency (corruption, collusion and nepotism)  
Force majeure during operation Exchange rate interest  
Revolution Disaster nationalization revolution |

As mentioned before, the researcher will only analyze toll road risks during the construction phase.
2.4. Risk Management Process

Risk Management Process is a systematic process of planning, identifying, analyzing, responding, and monitoring project risks. It aims to increase the opportunities and impacts of positive events and reduce the opportunities and impacts of negative events. The process will be explained in detail in the following stages:

1. Plan Risk Management

Risk Management Planning is the process of determining how to carry out risk management activities in a project. It can be concluded that the Risk Management Planning explains how to manage risk into a structured project.

2. Risk Identification

As a series of processes, risk identification begins with understanding what is actually called by a risk. Risk identification can be done by analyzing the source of risk and analyzing the problem.

Table 2 Risk Identification

| Input                                    | Technique                      | Output                        |
|------------------------------------------|--------------------------------|-------------------------------|
| Environmental factor                     | Documentation review           | Risk register:                |
| Organizational process assets            | Brainstorming                  | List of identified risks      |
| Project scope statement                  | Delphi Technique               | List of potential responses   |
|                                          | Interview                      | Risk of root causes           |
| Project management plan                  | SWOT Analysis                  |                               |
|                                          | Checklist Analysis             |                               |

In this study, the researcher identified the risks by using Information gathering techniques from the Interview method conducted with experts in project case study. The outputs or results of the identification above are re-analyzed by using the Fishbone Diagram to make a list of risks that occur in the project case study.

3. Qualitative Risk and Quantitative Risk

a. Qualitative risk

According to PMBOK® Guide-2000 Edition, p.193, a qualitative risk analysis is a method of prioritizing the list of identified risks in subsequent treatment. This process is carried out by arranging risks based on their impact on project objectives. It also prioritizes risks based on their probabilities and impacts. Qualitative risk analysis can be done with the help of tools and technique, including:

- Risk Probability and Impact Assessment

This technique is an investigation of the possibilities of each Specific risk will occur such as potential impacts on project performance such as time, cost, scope and quality and also negative impacts and opportunities.

- Probability and Impact Matrix

Risk can be prioritized for further quantitative analysis and action (responses) based on the size (rating) of risk. Measures are taken of risks based on opportunities and their impact. Risk data quality analysis is a technique for evaluating the usefulness of data in risk management.

- Risk Data Quality Assessment

Risk data quality analysis is a technique for evaluating the usefulness of data in risk management

- Risk Categorization

Project risks can be categorized by source of risk, risk impact, and phases (engineering, procurement, and construction) to determine the project area affected.

- Risk Urgency Assessment

Risks that require immediate action may be categorized as the urgent thing to be analyzed. In this study, the authors quantify the risk by Probability and Impact Matrix using the Soft System Methodology (SSM) method. The understanding of SSM, as follows:

**Soft System Methodology (SSM)**

The development of the system model is carried out by exploring unstructured problems, discussing intensively with related parties, comparing the concept of the thinking
system with the real world, and solving problems together. The application of this SSM can be seen in the picture below:

Table 3. The Application SSM

| Organizational design | Performance evaluation |
|-----------------------|------------------------|
| - Restructuring of role | - Performance indicators |
| - Create new organization culture | - Quality assurance |
| Information Systems | - Monitoring an organization |
| - Defining information needs | Education |
| - Creating is strategy | - Defining training needs |
| - Knowledge acquisition | - Course design |
| - Initial scoping/players | - Causes of truancy |
| - Evaluate impact of computerization | - Analysis of language teaching |
| General Problem solving | Miscellaneous |
| - Understanding complex situation | Project management |
| - Initial problem clarification | - Business strategy |

Source: John Mingers, 1992

b. Quantitative Risk

Quantitative risk analysis is the process of analyzing the impact of risk events occurs and provides a ranking of numbers on the list of risks. The techniques used for quantitative risk analysis and techniques are as follows:-

- Sensitivity Analysis
- Expected Monetary Value Analysis
- Decision Tree Analysis
- Monte Carlo Modeling and Simulation

4. Planning Risk Responses

The process of developing options and actions to increase opportunities and reduce threats to the objectives of the project case study. Project table the planning process the risk:

Table 4. Planning Risk Responses

| Input | Technique | Output |
|-------|-----------|--------|
| Risk management planning | Strategies for negative risks/Risk list update | Performance evaluation/impact analysis |
| Opportunity | - Strategies for positive risk/management | - Performance indicators |
| Threats | - Risk-related contractual agreements | - Quality assurance |
| Risk List | - Continuous response strategy | - Monitoring an organization |

6. Measurement of risk assessment.

Table 6. opportunities going on risk:

| Opportunities for Risk | Scale | Criteria |
|------------------------|-------|----------|
| - Very High | 5 | The frequency or percentage of events is very high at more than 80% |
| - High | 4 | The frequency or percentage of events High > 60% up to 80% |
| - Medium | 3 | The frequency or percentage of events that is 40% to 60% |
| - Small | 2 | The frequency or percentage of occurrence is not too high ie. > 20% to 40% |
| - Very Small | 1 | The frequency or percentage of events did not significant that is up to 20% |
Table 7. The impact of risk

| Objective Project | Cost | Schedule | Scop | Quality |
|-------------------|------|----------|------|---------|
| Very Small        | Cost increase is not significant | Schedule slip is not significant | Reduced insignificant scope | Insignificant quality degradation |
| Small             | <5% Cost Increase | <5% schedule slip | Skopel area which is quite large | Quality degradation needs approval |
| Medium            | 5-10% Cost Increase | 5-10% schedule slip | Skopel area which is quite | Quality degradation needs approval |
| High              | 10-20% Cost Increase | 10-20% schedule slip | Reduced Scop is not acceptable | Quality degradation is not acceptable |
| Very High         | >20% Cost Increase | >20% schedule slip | Final item the project is not useful | Project items cannot be used effectively |

Table 8. Matrix risk

| Risk Probability | Very Low | Low | Moderate | High | Very High |
|------------------|----------|-----|----------|------|-----------|
| Very High        | High     | High| Moderate| High | Extreme   |
| High             | Moderate| High| High    | Extreme| Extreme  |
| Medium           | Low      | Moderate| High| Extreme| Extreme |
| Small            | Low      | Low | Moderate| High | Extreme  |
| Very Small       | Low      | Low | Low     | High | High      |

In this study, assessment and measurement of aims to understand how big levels opportunities risk if there is.

3. Research Methodology

3.1. Case Study
Methods used in the research are a method of descriptive with:
1. Case study
Case study research is research on the status of research subjects with regard to a specific or typical phase of the whole personality. The purpose of the case study is to provide a detailed description of the background, characteristics, and characteristics of a particular case and then the characteristics of the above will be made a general thing.
2. Risk Identification
In detail, interview method is used to obtain primary data by conducting interviews with PT. PPI (Persero) Tbk as the contractor. The purpose of this risk identification is to get a list of risks that will be analyzed using a fishbone diagram.
3. Qualitative
After obtaining a list of risks with a fishbone diagram, the next process is to quantify the data to obtain opportunities and the impact of risks that may occur using the SSM method.

3.2. Types of data on
1. Secondary data.
   Secondary data was obtained from project case studies such as project documents, etc.
2. The primary data.
   Primary data was obtained through opinion surveys using a questionnaire.
3.3. Research procedures
Research procedures is follow:

Fig.1. Research procedures

Fig.2. SSM Method
4. Conclusion

In the implementation of project management, each project is always limited by constraints (risks) that are interdependent and commonly referred as the project constraint triangle, namely cost, time, and quality. The balance of the three constraints will determine the quality of a project. Balancing it, risk management is needed to increase the opportunity (Probability) of positive influences and reduce negative effects (Threat). In the management process, risk comes from several stages namely planning, identification, qualitative and quantitative analysis, response planning, risk monitoring, and risk control. In this study, the researcher quantifies quality risks by using the SSM method. SSM consists of several stages where the output of this method is a result table in the form of risk opportunities that are likely to occur in a project case study.

Hypothesis

1. What is the highest-risk occurred on the Trans Sumatra Bakauheni-Kalianda Toll Road by using the Soft System Methodology (SSM)?
2. Is it better to analyze the high risks to clear them out?
3. Are the Soft System Methodology (SSM) risks similar to those faced by the Trans Sumatra Terpeka Section 1 toll road project?
4. Can the research results be compared to the toll road object in the rest area where research?
5. Does it have the same order as the previous research?

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