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Risk Analysis of Investment Costs in PPP Projects Using Monte Carlo Simulation

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Abstract. *Infrastructure project investment is a substantial urgency in line with the vision of President Jokowi's administration of developing infrastructure in Indonesia. The Government and Private Sector partnership (PPP) becomes feasible alternative to cover the financial deficit in the provision of infrastructure. The Southern Jakarta-Cikampek II Toll Road Project has been determined to be operated under the PPP scheme. The identification, allocation, and appropriate risk mitigation of the projects are the important success keys to provide clarity and benefits for among the parties. The purpose of this study is to analyze 27 risk variables from PT PII guidelines qualitatively and quantitatively with probabilistic principles using Monte Carlo simulations, by then accurately to estimate the values of the effect of each risk on the project investment value. The research was carried out by collecting project data, identifying risk variables, questionnaires to experts, risk quantification, Monte Carlo simulation, calculating the effect and value of risk, as well as analysis of risk allocation and mitigation based on the Pareto Principle. The study shows that of 26 influential risk categories and one (1) risk does not affect the investment component of the project. There are 12 Risks could be allocated to the Government and 14 Risks could be allocated to Private Sector. The total value of the amount of risk cost is Rp16,424,331,645,796 (21% of total risk investment value). Based on Pareto, 30% risk categories (equal to 8 risks) are the dominant factors of which equal to 70% of the total value of risk. Hence the mitigation may focus to reduce the dominant factors to lower risk by then decrease the value of risk Rp9,885,627,136,618 that equal to 60% become Rp6.538.704.509.178 (equal to 40% of risk value)*

Keywords: dominant influential risks, monte carlo simulation, PPP, risk allocation, risk mitigation.

1. INTRODUCTION

Financing is a substancial hindrance in massive road projects in Indonesia. Directorate General of Infrastructure Financing, Ministry of PUPR calculates that the budget needed to build 1,500 kilometers of toll roads in the period of 2020-2024 period is around IDR 2,000 trillion, while the state budget for PUPR can only meet IDR 623 trillion where the budget must be shared with the development of other important sectors [1]. So that non-state budget funding sources are needed through Public and Private Sector Partnerships (PPP) to meet the needs of the budget deficit. Based on Precidential Decree No. 38 in 2015, PPP is a collaboration in the provision of Infrastructure for the public which partially or completely using financing from Private Sector by paying attention to the sharing of risk between each parties [2]. PPP is a financing scheme as a way for the government to provide services and equitable economic development for all Indonesian people [3].

The important success key of a PPP scheme is the identification, allocation, and appropriate risk mitigation so that it can provide clarity and benefits based on the capacity and capability of each party in the division of roles of controlling the risk in providing infrastructure [4]–[6]. This becomes important for investors to participate in PPP projects in Indonesia [7].

The uncertainty of PPP Projects impacts the reluctance of investors to participate as the result of big risk value costs, long-term business interactions, and subject to rapidly changing environment [8], [9]. An in-depth risk analysis expected to give an apropiate risk sharing which provide benefits in terms of cost, quality, and time as

well as information about how much of the influence of each risk accurately on the investment value which will assist in providing investment decisions on the toll road PPP concession [10], [11]. As the many plans for toll road projects using PPP scheme, it is necessary to conduct an in-depth study of the project's investment costs that are affected by the influential risk identified.

Qualitative and quantitative risk analysis is required with probabilistic principles method using Monte Carlo simulation to be able to analyze and give the possibility of uncertainty that can occur in a project so it can estimate how much the effect of each identified risk on the investment value of the PPP project [12], [13]. Another advantage is Monte Carlo can eliminate uncertainty in reliability modeling because of the ability to stimulate the actual process and behavior of the system [14]. Thus, it is expected to provide an estimate of the allocation as well as risk mitigation with the lowest risk of costs for each parties of the PPP project.

Based on the Toll Road Concession Agreement (PPJT) by the Ministry of PUPR in 2017, one of the toll road projects carried out with the PPP scheme is the Southern Jakarta-Cikampek II Toll Road Project which is one of the National Strategic Projects (PSN) with a track length of 64 km. The project, which is still under construction, is estimated to require an investment of Rp 14 trillion. Therefore, the research objectives is to determine which risks really influential in PPP Project of Southern Jakarta-Cikampek II Toll Road Project using Monte Carlo Simulation then to measure the value of influential risks as well as risk responses based on Pareto Principles to give an effective allocation and mitigation of each risks.

2. METHODS

1. Data Collection and Initial Risk Identification

   At this stage, PPP project agreement data and project investment data are collected, while risk variable data are collected based on the PPP project risk guidelines by PT PII and Financial Management Guidance, by Australian Government [15]. These datas will be used in conducting risk analysis in the next stage.

2. Expert Questionnaire Survey

   The Questionnaire Survey was conducted by purposive expert sampling method on nine (9) PPP experts who were familiar with the Southern Jakarta-Cikampek II Toll Road project. The questionnaire aims to reduce risk variables that have no effect on investment, find out how much is the estimated effect of the risk (impact and frequency of risk), as well as risk allocation that must be carried out on the influential risk variable.

3. Qualitative Risk Analysis

   Qualitative Risk Analysis was carried out by categorizing the frequency value and risk impact of the questionnaire results based on PMBOK Guide Sixth Edition (2017) [16].

4. Risk Quantification and Monte Carlo Analysis

   Risk quantification is carried out based on the mode of likelihood and the consequences of each risk identified. Then it is converted into a numerical indicator based on the risk assessment index in the PMBOK Guide Sixth Edition (2017) [16]. Quantitative analysis was carried out using Monte Carlo Simulation with Palisade Decision Tools @Risk software on the Microsoft Excel add-ins spreadsheet program. Monte Carlo simulation is done by simulating each impact and frequency risk value.

Likelihood	Consequences				
Very High 0,9	Moderate 0,05	Moderate 0,09	High 0,18	High 0,36	TerHigh 0,72
High 0,7	Low 0,04	Moderate 0,07	Moderate 0,14	High 0,28	TerHigh 0,56
Moderate 0,5	Low 0,03	Moderate 0,05	Moderate 0,1	High 0,2	High 0,4
Low 0,3	Low 0,02	Low 0,03	Moderate 0,06	Moderate 0,12	High 0,24
Very Low 0,1	Low 0,01	Low 0,01	Low 0,02	Moderate 0,04	Moderate 0,08
	0,05 Insignificant	0,1 Minor	0,2 Moderate	0,4 Major	0,8 Severe

Figure 1. Consequences and Likelihood Risk Assessment
Source: PMBOK Guide Sixth Edition (2017) [16]

5. Calculation of the Effect and the Amount of Risk on Project Investment Costs

   The results of the monte carlo simulation are then used to calculate risk factors to determine the risk rating category for risk response analysis. Each risk is identified its value and risk reference based on agreement data and the project investment value which is then used to calculate the effect of risk on investment costs based on the Toll Road Investment Risk Analysis Guidelines Pd T-01-2005-B of the Ministry of PUPR [17]

6. Risk Response Analysis

Risk response analysis consists of risk allocation and mitigation. The foundation for the analysis of this stage is the classification of risks that have been identified based on the ranking of the tornado diagrams which then will be analyzed the value of the effect of risk using the Pareto law principle which rank risks from highest to lowest based on cumulative values which aims to determine the dominant problem that has the greatest influence on the entire project and the greatest potential for improvement [18], [19]. Risk Allocation and Risk Mitigation are formulated based on Guidelines from the Ministry of PUPR, PT PII, PMBOK, and Financial Management Guidance, Australian Government.

3. RESULTS AND DISCUSSION

3.1 Evaluation of Influential Risk for the Investment Cost

Based on the preliminary study and the results of the expert questionnaire, from 27 potential risk factors, it was found that Utility Risk had no influent on the investment cost of the PPP project. These findings showed differences from the previous study from [20] which showed only 13 risks had an influent on investment cost. The higher number of influential risks on investment cost illustrates that recently there is a lot of uncertainty and trust in PPP projects both for the public and private sectors. The other 26 risks were then analyzed to determine their risk allocation, risk factor category, cost references, and risk value as shown in Table 1.

Table 1. Conclusions of Risk Allocation, Simulation Results, Reference for the Effect of Risk on Investment Cost Components, and Value of Risk of 26 identified risk

Risk Variables	Risk Alloca-tion	Consequences Value after Simulation	Likelihood Value after Simulation	Risk Factor Category	Cost References	Investme-nt Cost	Risk Value
Construction Completion Risk	Private Sector	0,431	0,559	High	Construction Cost	8.984.000	2.167.929
Delays Due to Force Majeuer Risk	Goverm-ent	0,480	0,478	High	Construction Cost	8.984.000	2.058.741
Risk of Sponsor	Private Sector	0,431	0,515	High	Value of Loans to Lenders	8.043.764	1.786.786
Maintenance Risk	Private Sector	0,380	0,507	Mode-rate	Maintenance Cost - O&M	7.393.362	1.424.160
Risk of Hidden Defects	Private Sector	0,376	0,470	Mode-rate	Maintenance Cost - O&M	7.393.362	1.307.327
Risk of Demands that Lower than Estimation	Private Sector	0,411	0,507	High	General Administration Cost and Toll Collecting-O&M	4.488.827	936.373
Risk of Tariff Didn't Go As Planned	Goverm-ent	0,419	0,493	High	General Administration Cost and Toll Collecting-O&M	4.488.827	925.413
Risk of Development Network	Goverm-ent	0,398	0,507	High	General Administration Cost and Toll Collecting-O&M	4.488.827	906.848
Assets ownership risk	Private Sector	0,406	0,478	Mode-rate	General Administration Cost + Toll Collecting-O&M and Project Financial Cost	4.649.702	900.952
Risk of Connectivity	Private Sector	0,381	0,522	High	General Administration	4.488.827	894.256

with existing network					Cost and Toll Collecting-O&M		
Incompatibility of land location	Goverm-ent	0,443	0,530	High	Land Acquisition Cost	3.069.701	719.569
Risk of asset take over	Goverm-ent	0,433	0,463	Mode-rate	General Administration Cost (O&M) and Project's Financial Cost	2.537.313	509.029
Risk of Cost Increase	Private Sector	0,465	0,581	High	Project's Escalation Value	972.410	262.824
Risk of regulations and laws changes	Goverm-ent	0,456	0,507	High	Project's Escalation Value	972.410	224.775
Industrial Relations Risk	Private Sector	0,339	0,478	Mode-rate	Toll Road Service Cost - O&M	1.320.243	213.765
Financial Parameters Risk	Goverm-ent	0,398	0,537	High	Project's Escalation Value	972.410	207.921
Inequality of Work Quality	Private Sector	0,400	0,500	Mode-rate	Project's Escalation Value	972.410	194.482
Risk of Permission	Goverm-ent	0,394	0,500	Mode-rate	Project's Escalation Value	972.410	191.781
Developer failure in carrying out its contractual obligations	Private Sector	0,428	0,493	High	Administration Cost	856.086	180.395
Risk of Changes in Tax Rates	Goverm-ent	0,380	0,470	Mode-rate	Project's Escalation Value	972.410	173.640
Planning Risk	Goverm-ent	0,424	0,537	High	Contingency Cost	550.423	125.355
Financial Structure Risk	Private Sector	0,435	0,537	High	Financial Cost	160.875	37.598
Technology Risk	Private Sector	0,372	0,463	Mode-rate	Toll Road Equipment Cost	179.680	30.963
Design Risk	Private Sector	0,424	0,507	High	Desain Cost	89.840	19.332
Land Acquisition Risk	Goverm-ent	0,506	0,596	High	Overhead Construction Cost	44.920	13.542
Sub-sovereign or parastatal risk	Goverm-ent	0,457	0,515	High	Overhead Construction Cost	44.920	10.578

According to Tabel 1, it can be seen the differences from the result of Monte Carlo Simulation of Consequence and Likelihood value than the original number from PMBOK. Those factors are then used to determine the risk value of each 26 influential risks. Based on the analysis, it was found that the total risk value of the project is Rp 16.424.331.645.796 where the risk with the highest value is the Construction Completion Risk

and the lowest is the Risk of Sub-sovereign or Parastatal. By using the data from the expert questionnaire, 12 Risks could be allocated to the Government or with a risk value of Rp. 6,067,190,251 (37%) and 14 Risks are allocated to Private Sector or with a risk value of Rp. 10,357,141,394 (63%). Based on the risk allocation, it is found that Public Sector got a higher risk value allocated than the government, at the other words, goverments can get assistance in the allocation of the budget burden in terms of the amount of risk borne and the risk-sharing with the PPP scheme. This can be used as a way for the government to use the PPP scheme in implementing infrastructure development in Indonesia so that it can improve services, growth, and economic benefit for all Indonesian people. On the other hand, the private sector also gets investment assurance in terms of investment returns and a clear risk sharing between the government and private sector.

The results of the risk factor analysis are shown in Table 1 where it is obtained that the allocation of the average risk factor value for the public sector is high risk (0.7224) while the average factor value for private sector is a moderate risk (0.6735). The overall of 26 risks have a high-risk factor value (0.7080) so that risk factor reduction must be carried out to a lower level to give a better benefit for every sector in term of risk value.

3.3 Reduction of Risk Value on Dominant Risks

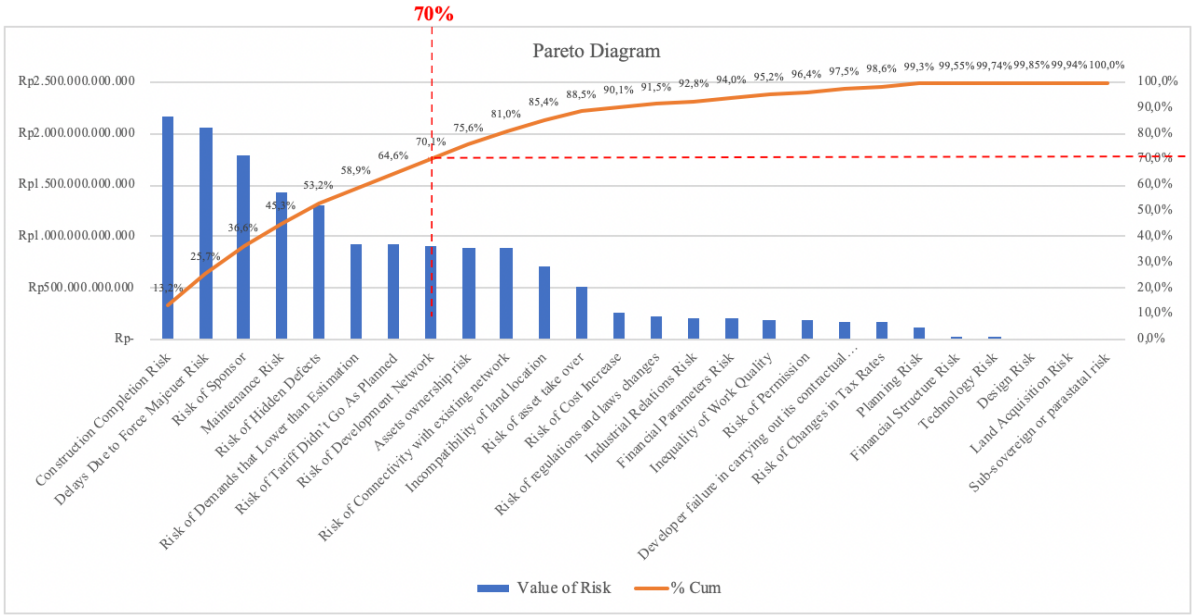

Figure 2. Dominant Risks based on Pareto Diagram

According to Figure 2**,** the 26 risks then sorted based on risk value from the highest to the lowest which is then analyzed further using a Pareto Principle so that it is found 30% of risks equal to eight risks are the dominant cause of 70% of the total value of the risk value in this project. The Eight Dominant Risks are: (1) Construction Completion Risk; (2) Delays Due to Force Majeure Risk; (3) Risk of Sponsors; (4) Maintenance Risk; (5) Risk of Hidden Defects; (6) Risk of Demands that Lower than Estimation; (7) Risk of Toll Road Tariff Didn't Go As Planned; (8) Risk of Development Network.

The 8 dominant risks then will be the focused analysis to reduce the risk factor values into a lower risk category. The analysis done by testing the consequence and likelihood values of each risk using Monte Carlo simulations and standard values so that the following results were obtained in Table 2 used to re-calculate the value of the risk and its reduction. The consequences and likelihood values in trial 2 with standard number deliver the lowest risk factor.

Table 2. Risk Factor Value Reduction Among Eight Dominant Risks

Trial	Consequences	Likelihood	Risk Factor	Conclussion
Real	0.4135	0.5130	0.7080	High Risk
		Monte Carlo		
Tial 1	0.3500	0.4333	0.6317	Moderate Risk
Tial 2	0.3167	0.4	0.59	Moderate Risk
Tial 3	0.3000	0.3667	0.5567	Moderate Risk
		Standar		
Tial 1	0.2	0.3	0.44	Moderate Risk
Tial 2	0.1	0.3	0.37	Low Risk

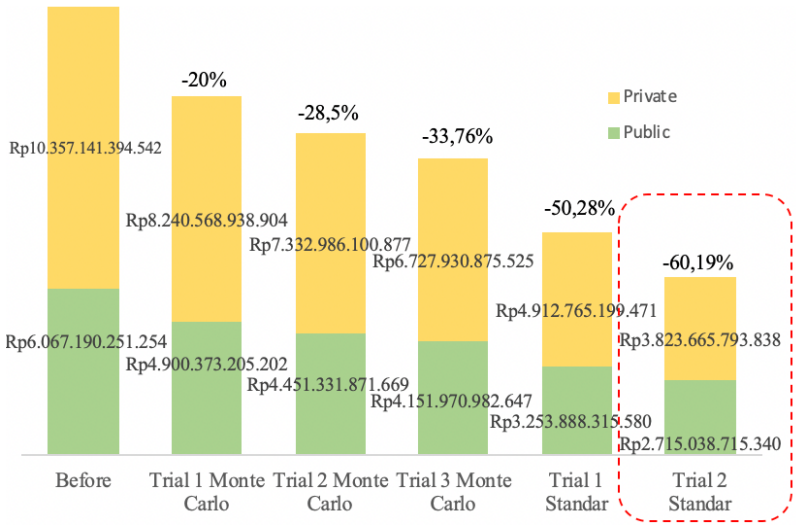

Figure 3. Result of Risk Category Reduction for Risk Value of Investment Cost

Figure 3 is the result of re-calculation data of risk value in graphical form. It can be seen the risk value of 8 dominant risks for 5 reduction attemps of consequence and likelihood value could bring 60% of risk value reduction (equal to Rp 11.242.251.308.178). The risk value reduction for trial 2 with standard number meet the lowest category. It is showed if effective strategies for risk allocation and migitation applied for those dominant risks could bring benefits in PPP Project for Southern Jakarta-Cikampek II Toll Road regarding risk value reduction for both the public and private sector.

3.3 Risk Allocation and Mitigation Strategies

Based on the re-calculation of risk value reduction, it showed if the there are focused strategy on risk mitigation and allocation for 8 dominant risks it could deliver reduction up to 60% of the total 26 risk value. Thus, the eight risks were then analyzed for risk allocation and mitigation as shown below in Table 3.

Table 3. Mitigation and Allocation Strategy Among 8 Dominant Risks

1. Construction Completion Risk
a. Handling Plans : Reducing Risk to a Lower Level
b. Risk Categories and Risk Events :
1. Bad Performances from Contractors;
2. Failure of Provide Civil Works from Contractor;
3. Failing to maintain security and safety during work;
c. Risk Descpription : [Construction Stage]
1. Contractor is unable to carry out the work according to the contract
2. Contractor failed to complete the contract due to its internal management & financial factors
3. High accident rate during construction
d. Risk Mitigation Strategies :
1. Apply a Penalty in the process of selecting a credible construction works provider
2. Good application of procedures (K3) with Zero Accident, an experienced and reliable EPC, including a penalty clause for K3 violations in the contract;
3. Periodic supervision and communication is required from the owner and PJPK representatives for each work progress
2. Delays Due to Force Majeure Risk
a. Handling Plans : Reducing Risk to a Lower Level
b. Risk Categories and Risk Events :
1. Natural Disasters
2. Political *Force Majeur*
3. Extreme Weather
c. Risk Descpription : [All Stages]
1. A natural disaster occurred so that the Toll Road could not operate normally.
2. War events, riots, public security disturbances.
3. Due to climate change or other factors.

d. Risk Mitigation Strategies : Insurance and guarantee
e. Specific Conditions :
What is meant by being shared is that the risk is borne by the Private Sector as long as there is insurance covering these events. The part that is not covered by insurance is taken over by the government. Natural disasters can be in the form of force majeure events such as earthquakes, and others that are national, especially for now that affect is Covid-19 Pandemic.

3. Risiko of Sponsors

a. Handling Plans : Reducing Risk to a Lower Level
b. Risk Categories and Risk Events :
1. Private Sector Failure,
2. Project's Sponsors Failure,
3. Project's Lenders Failure,
4. Financial risk leads to failure to achieve financial close
5. Risk of late support from the government in the form of (incentives, subsidies, etc.) (Financial Risk)
c. Risk Descpription :
1. Private Sector failure leading to contract termination or step-in by the financier [All Stages].
2. Failure of the sponsor (or consortium member) [All stages after financial close].
3. Failure on the part of financial/banking institutions (or syndications) due to changes in policy/trust towards BU or due to internal lender issues [All Stages after financial close],
4. Financial close was not achieved due to the non-optimal project capital structure and uncertain market conditions [Pre-Construction Stage]
5. Construction and/or project operations are disrupted due to government support not being on time as promised [Construction & Operation Stage]
d. Risk Mitigation Strategies :
1. The consortium is supported by credible and solid sponsors.
2. Pre-qualification process is carried out to get a credible sponsor.
3. Selection of lenders according to credible requirements so that Private Sector can carry out the contract,
4. Coordination and consortium with potential and qualified lenders with good credibility.
5. Ensure timely fund budgeting process; The government ensures that the tender process runs according to schedule, including the implementation of tenders before the budget is set (conditional auction); Providing bailout funds managed by the Public Service Agency Unit
e. Specific Conditions :
Could be the precedent conditions are not met the criteria

4. Maintenance Risk

a. Handling Plans : Corrective steps or changes are needed within a certain period of time
b. Risk Categories and Risk Events :
1. Increase in O&M Costs,
2. Error Estimating the business plan or financial cycle
3. Project Management Failure
c. Risk Descpription : [Operation Stage]
1. Due to an error in the estimation of O&M costs or other unexpected increase in costs.
2. Failure to obtain fixed and current prices from suppliers, causing errors in cost estimation.
3. Private Sectors's failure or inability to manage the operation of the PPP Projects.
d. Risk Mitigation Strategies :
1. Choosing a reliable Toll Road Operator; considering the escalation factor in the contract.
2. Carry out agreements or contracts as early as possible with *suppliers*
3. Prepare operational management plans that are carried out professionally
e. Specific Conditions :
Asset maintenance is becoming more frequent than planned.

5. Risk of Hidden Defects

a. Handling Plans : Corrective steps or changes are needed within a certain period of time
b. Risk Categories and Risk Events :
Failure in Project Control and Monitoring
c. Risk Descpription : [All Stages]
Business Entities and/or PJPKs fail to carry out supervision, causing undetected work irregularities
d. Risk Mitigation Strategies :
Develop a monitoring plan and periodic evaluation of the effectiveness of planning and implementation

6. Risk of Demands that Lower than Estimation

a. Handling Plans : Reducing Risk to a Lower Level

b. Risk Categories and Risk Events :
   1. Changes in traffic volume projection
   2. Error in demands estimation,
   3. Risks in the early stages of operational stages.

c. Risk Descpription :
   1. Resulting in debt loans due to a decrease in income for the Business Entity[Operation Stage].
   2. Model design error resulting in estimation deviation [Operation Stage].
   3. Lack of cash flow at the beginning of the operation resulted in the project being financially viable but not bankable [Operation Stage]

d. Risk Mitigation Strategies :
   1. Loans of funds or debts at the beginning of operations.
   2. Good traffic survey; Experienced Toll Road modeling consultant
   3. If the risk is allocated to the Government, a certain amount of funds can be provided if the income at the beginning of the operation is not sufficient
   4. Insuring risks or guarantees proposed by BU to the government through PT PII

e. Specific Conditions :
   For risks triggered by government actions (political policies and policy changes), guaranteeing a minimum demand can be considered at the beginning of the collaboration.

7. Risk of Toll Road Tariff Didn't Go as Planned

a. Handling Plans : Reducing Risk to a Lower Level

b. Risk Categories and Risk Events :
   1. Failure to apply for periodic tariff adjustments
   2. Periodic delays in tariff adjustments
   3. Tariff adjustment rate is lower than planned
   4. Tariff estimation error

c. Risk Descpription : [Operation Stage]
   1. As a result of BUJT not being able to meet the minimum service standard according to the PUPR Ministerial Regulation No. 15 of 2014
   2. Determination of the inflation rate on the indexation of rates so as to cause differences if there is a change, especially after indexation and tariff determination.
   3. Tariff estimation that is too optimistic or exceeds the results of the ATP/WTP survey.

d. Risk Mitigation Strategies :
   1. Good Toll Road operation performance;
   2. Ensure regulatory support that regulates the level and period of periodic tariff adjustments.
   3. Reliable traffic survey
   4. Experienced Toll Road fare modeling consultant.

e. Specific Conditions :
   Can consider minimum demand guarantee if there is an action triggered by the Government Supporting regulations from BPJT

8. Risk of Development Network

a. Handling Plans : Reducing Risk to a Lower Level

b. Risk Categories and Risk Events :
   Road and transportation network connectivity risks

c. Risk Descpription : [Operation Stage]
   Government or Developer failed to build and maintain the necessary infrastructure connectivity

d. Risk Mitigation Strategies :
   1. Good construction synchronization and contract understanding by the Government
   2. Private Sector plays an active role in developing networks in the form of connectivity and regional development

4. CONCLUSION

Based on the results of the analysis of 27 risks, it is obtained if Monte Carlo Simulation could show only 26 risks are influential to the investment cost and can estimate a risk value which is around Rp 16,424,331,645,796. The 26 risks were then classified into risk categories as shown in Table 1 which based on the Pareto principle resulted in 8 dominant risks. The focus of the mitigation strategy and allocation was carried out to reduce the 8 risks to a low category so as the risk value decreased became Rp6,538,704,509,178 or reduce the value of the risk amount to 60% of the initial risk.

This study can be a focus for both the government and the private sector to conduct studies and focus strategies of allocation and mitigation on the dominant risks that occurred in PPP Project. So it can provide good

benefits and a clear formulation of agreements for each party in carrying out PPP projects so that it is expected to increase the participation of the private sector in infrastructure development in Indonesia.

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