Revenue Risk Modelling and Assessment on BOT Highway Project

T Novianti¹, H Y Setyawant²

¹ Department of Industrial Engineering, University of Trunojoyo Madura, Jl. Raya Telang, Kamal, Bangkalan, Madura 69162 Indonesia
² Department of Agroindustrial Technology, University of Brawijaya, Malang, Indonesia
Email : viahaditomo@gmail.com

Abstract. The infrastructure project which is considered as a public-private partnership approach under BOT (Build-Operate-Transfer) arrangement, such as a highway, is risky. Therefore, assessment on risk factors is essential as the project have a concession period and is influenced by macroeconomic factors and consensus period. In this study, pre-construction risks of a highway were examined by using a Delphi method to create a space for offline expert discussions; a fault tree analysis to map intuition of experts and to create a model from the underlying risk events; a fuzzy logic to interpret the linguistic data of risk models. The loss of revenue for risk tariff, traffic volume, force majeure, and income were then measured. The results showed that the loss of revenue caused by the risk tariff was 10.5% of the normal total revenue. The loss of revenue caused by the risk of traffic volume was 21.0% of total revenue. The loss of revenue caused by the force majeure was 12.2% of the normal income. The loss of income caused by the non-revenue events was 6.9% of the normal revenue. It was also found that the volume of traffic was the major risk of a highway project because it related to customer preferences.

1. Introduction

The Indonesia government has a limited reserve for infrastructure development. One of the approaches to overcome this issue is through a Public Private Partnership (PPP). Suseno [1] stated this partnership uses a concession period, a period where the private partner can collect the benefit from the infrastructure projects - through tariff. Once the concession time expired, the projects are returned to the government and the community can freely use them. Askari [2] stated the viability of an infrastructure project is important due to the mega project characteristics include high capital outlays, long-term investment, and the volatility of macro economics. Especially for PPP project, feasibility study of a project is essential to ensure the equal sharing of benefits, costs, and risks. Also, each infrastructure project is unique as it developed at particular environmental condition and time. Thus, the risks of these projects are high and are greatly affected by government intervention and macroeconomics factors.

Risk can be defined as a factor, event, or an occurring effect which has to be handled carefully to finish a project which is limited by time, cost and quality. Burkhanov [3] stated a fundamental principle of PPP is that risks have to be processed by the competent parties. This research discusses
highway infrastructure projects which focused on risk analysis for revenue containing the causes of risk variables which identified by a risk analysis for revenue model of highway projects.

Auriol [4] stated development of infrastructure projects with PPP and BOT scheme are limited by concession period, in which management of costs and risks are essential to maximize revenue. Risks as a factor in the feasibility study and risk management were investigated as pre-negotiation data. Risk analysis methods include Delphi, fault tree analysis, fuzzy logic and scenario analysis were used to obtain risk value from probability value and predicted risks. Kang [5] stated it should initial outlook consensus does not meet the minimum variance. This minimum variance should be applied in Delphi method. The conceptual model of Fault Tree Analysis which validated through Delphi is as follow:

2. Experimental Method

2.1. Risk identification

The risk of revenue was the identified and analyzed risk, which was started by mapping of variables of revenue risk. The mapping of this variable was done using fault tree analysis tool which is validated by respondent. Respondents in the present research were infrastructure experts with the qualification of a 10-years experience in highway projects and 15-20-year experience in road and bridge infrastructures projects.

2.2. Risk Assessment

After the variables that cause risk of revenue were identified and the proposed model was verified, calculation of probability and risk effects of those variables was done referring to expert judgment using Delphi to find consensus. Calculation of risk value for revenue was done using the fuzzy algorithm in Matlab. Li [6] stated the fuzzy logic programming, consisting of fuzzification, fuzzy rule evaluation, aggregation, defuzzification

3. Result and Discussion

As previously discussed, the PPP projects are timed projects. Therefore, the initial tariff is crucial. If the original tariff was too low, it could not be raised instantly, but gradually in two years based on regional inflation. If the tariff was too high, it was difficult to win the project bidding and is limited by the public ability to pay and willingness to pay in the area of the projects. The probability of membership function is as shown in Figure 1.

Figure 1. Conceptual risk assessment model using Fault Tree Analysis

Figure 2. Membership function of probability of event
Development of fuzzy reasoning, as follow

Figure 2. Shows the schematic diagram of calculation of probability fault tree analysis using fuzzy logic:

\[ E = P(\text{route } C1-E \ OR \ \text{route } C2-E) = P(\text{route } C1-E) + P(\text{route } C2-E) - \{P(\text{route } C1-E) \times P(\text{route } C2-E)\} \]

Table 1. The variance of risks in the development of three scenarios

| Event | Risk Assessment (%) | Variance of 3 Scenarios (%) | Variance of 3 Scenarios |
|-------|---------------------|-----------------------------|-------------------------|
|       | Optimistic | Most Likely | Pessimistic |                         |                         |
| A     | 20,1831 | 38,03662 | 50          | 24,70                    | 0,25                    |
| B     | 40      | 44,29918 | 47,1831     | 1,43                     | 0,01                    |
| C     | 30      | 46,01728 | 60,0864     | 25,14                    | 0,25                    |
| D     | 20,1831 | 26,08512 | 30,0297     | 2,69                     | 0,03                    |

The variance of the three scenarios showed that the variance was adequate ≤0.25.

Table 2. Risk value for revenue

| Event | Probability | Risk value for revenue (D) (%) | Expected Value of risk | Risk value (%): \((G) = (B) \times (F)\) |
|-------|-------------|-------------------------------|-------------------------|------------------------------------------|
|       | O | ML | P |                           |                                         |
| {A}   | 0,28582 | 20,1831 | 38,03662 | 50 | 37,0549 | 10,5910 |
| {B}   | 0,47768 | 40 | 44,29918 | 47,1831 | 44,0633 | 21,0482 |
| {C}   | 0,26748 | 30 | 46,01728 | 60,0864 | 45,6926 | 12,2219 |
| {D}   | 0,27112 | 20,1831 | 26,08512 | 30,0297 | 25,7589 | 6,9837 |
Based on the calculation above, the risk value for revenue is as follow:

**Table 3. Risk value for revenue of each event**

| Code | Event Name                                      | Risk assessment (defined as % of normal revenue per total income) |
|------|------------------------------------------------|---------------------------------------------------------------|
| A    | Loss of revenue caused by tariff risks          | 10,5910                                                      |
| B    | Loss of revenue caused by low traffic volume    | 21,0482                                                      |
| C    | Loss of revenue caused by force majeure         | 12,2219                                                      |
| D    | Loss of revenue caused by incidental events     | 6,9837                                                       |

### 3.1 Loss of revenue caused by tariff risks

Table 3 shows that the ranking of this risk is placed third. This is because there have been legal improvements to protect the investor, especially the legal certainty about periodical tariff increase every two years (according to the inflation of the location of the construction of the toll road). Consideration of uncertainty in investment decisions becomes very important with the complexity of a project, especially infrastructure projects. The shareholders manage the costs, profits, and the risks of a project. Siemiatycki [7] and Huang [8] stated the feasibility study at the beginning of the project is essential in determining the toll tariff, that is, to generate an adequate return, Internal Rate of Return (IRR) exceeds MARR and Net Present Value (NPV) more than zero. Tariffs cannot be raised because of the low volume of the traffic and can not be lowered when it increases. Indonesia embraces a price cap system where tariff increases are adjusted to the inflation rate, which states that the evaluation and adjustment of toll tariffs are conducted every two years by BPJT based on the old tariff adjusted for the effect of inflation. The investor can not freely determine initial toll rates. This is related to the Willingness to Pay (WTP) of the targeted community. Ability to Pay (ATP) can be used as a benchmark of WTP. ATP is the ability of a person to pay for the services he or she receives based on the income that is considered ideal. In other words, ATP is the ability of the community to pay for the cost of travel, while the WTP is the willingness of users to issue rewards for services obtained.

ATP is the maximum rate that can be collected by investors. If the tariff was above ATP, the government must subsidize the tariff charged to the user. The zone between the ATP and the WTP is the tariff zone but the investor must either improve the service level or must comply with the applicable quality service standards. Under the WTP zone, investors do not have to improve the level of service, because the tariff setting charged to the user is at a very cheap level and the user will use the service without taking into account the quality of service.

### 3.2 Loss of revenue caused by low traffic volume

Babatunde [9] stated this traffic volume risk is the main risk that must be considered by an investor as it related to the revenue. Revenue is obtained from tariffs collected from road users. This is related to the number of road users which is predicted from the beginning of the project. The more road users using toll road services, the higher the revenue. Lu [10] stated the decreasing or increasing the number of road users is influenced by many factors and the determination of toll road tariffs that are mainly influenced by government policies.

The risk of traffic volume is caused by the low Gross Regional Domestic Product (GDP). The growth of traffic volume is based on GDP growth. The high GDP in a region is one of the indicators of the economy of a region. The higher the GDP, the higher the economic turnover and the economic level of the community in the area, resulting in the potential number of toll users and future business development.
3.3 Loss of revenue caused by Force Majeure

The risks of force majeure are risks arising from specific events that are unpredictable and can not be controlled by the project manager and have a major impact on toll road projects. Force majeure can occur due to sociopolitical conditions, for example, there are wars, public demonstrations, government penalty, lack of AMDAL requirements, etc.

3.4 Loss of revenue caused by incident Non-revenue

This event may occur because the toll road is closed due to certain events, for example, due to construction failure or latent defect. Toll road users are exempted from the cost of using toll roads for a period due to certain considerations, resulting in loss of income. Malfunction from the toll road operator administration is resulting in a decrease in toll road project revenues, for example, loss of revenue due to the corruption of certain parties related to toll road management.

Conclusions

The results obtained through calculations through a fuzzy logic based on the variables that exist in the model Fault Tree Analysis are as follow: Loss of revenue caused by tariff risk has a risk value of 10.5910%. Income losses due to the potential for low traffic volume has a risk value of 21.0482%. Income losses caused by force majeure have a risk value of 12.2219%. Income loss resulting from non-revenue events has a risk value of 6.9837%. Fuzzy logic or ALARP (As Low As Reasonably Practicable) predicted the upper bound value. The highest risk is the risk of traffic volume, as it involves the prediction of the planned toll road users which possibly over/under predict. Regulations related to toll roads have been improved, especially regarding the increases of toll tariff. The increase of toll road tariff is aimed to return the investment financed by investors in the construction of the toll roads through tariff paid by toll road users.

References

[1] Suseno, Y H, Wibowo, M A and Setiadji, B.H., 2015. Risk analysis of BOT scheme on post-construction toll road. Procedia Engineering, 125, pp.117-123.
[2] Askari, M and Shokrizade, H R, 2014. An integrated method for ranking of risk in BOT projects. Procedia-Social and Behavioral Sciences, 109, pp.1390-1394.
[3] Burkhanov, U and Atamuradov, T, 2013. Problem of Mangement of Public-Private Partnership, 2013, Central Bohemia University, pp. 104-109.
[4] Auriol, E and Picard, P M , 2013. A theory of BOT concession contracts. Journal of Economic Behavior & Organization, 89, pp.187-209.
[5] Kang, C C, Feng, C M and Kuo, C Y, 2011. A royalty negotiation model for BOT (build–operate–transfer) projects: The operational revenue-based model. Mathematical and Computer Modelling, 54(9), pp.2338-2347.
[6] Li, Q, 2013. A novel Likert scale based on fuzzy sets theory. Expert Systems with Applications, 40(5), pp.1609-1618.
[7] Siemiatycki, M, 2010. Delivering Transportation Infrastructure Through Public-Private Partnerships. American Planning Association Journal of the American Planning Association, 76(1), pp. 43-58.
[8] Huang, Z, Zheng, P, Ma, Y, Li, X, Xu, W, & Zhu, W. 2016. A simulation study of the impact of the public-private partnership strategy on the performance of transport infrastructure. SpringerPlus, 5(1), 1-15.
[9] Babatunde, S O and Perera, S, 2017. Analysis of traffic revenue risk factors in BOT road projects in developing countries. Transport Policy, 56, pp.41-49.
[10] Lu, Z and Meng, Q, 2017. Analysis of optimal BOT highway capacity and economic toll adjustment provisions under traffic demand uncertainty. Transportation Research Part E: Logistics and Transportation Review, 100, pp.17-37.