International Journal of Engineering & Technology, 7 (4.33) (2018) 71-73

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Macroeconomic Risk Factor in Fuzzy Present Value of Highway Development

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Abstract

Highway developments are the backbone for the society and economic growth. It is part of the capital investment in infrastructure developments that require high spending, long term commitment and prognosticated with numbers of risks. This is because the investment is associated with uncertainty and vagueness due to long term duration of construction and operation of the project. Hence, the valuation of the investment requires accommodated model to present more accurate estimation of the project. This study proposed to evaluate fuzzy present value of a highway project with anticipated risk assessment in its valuation using fuzzy present value. The risk assessment is part of the estimation of fuzzy cash flow to represent better present value of the project. The results show an estimated value comprise with risk assessment of macroeconomic factor to portray better estimation that can assist decision maker to make decision towards the project.

Keywords: *Fuzzy cash flow; Fuzzy number; Fuzzy present value; Risk assessment.*

1. Introduction

Capital investment is the backbone for social and economic development. However, this kind of investment requires high spending, long term commitment and anticipated with various numbers of risks. In year 2001-2005, Malaysia spent approximately RM 64.12 billion in capital investment mainly in infrastructure development [1]. Roads development is one of infrastructure development that demand large amount of financial allocation. As total amount spent in year 2001-2005, RM 180 million needed for roads development alone. Due to high financial commitment, many countries including Malaysia adopted the built-operate-transfer (BOT) scheme for roads development. BOT is an agreement between public and private sectors where the private sector is required to finance, design, build, operate and maintain the facility. In this agreement, private sector can collect reasonable profit from users for a certain period called concession period. After a specified concession period, the facility is handed over to the government [2].

Studies showed that roads developments are associated with numbers of risks [3-4]. Hence, risk assessment is extremely important to the success implementation of BOT project. The purpose of risk assessment is to quantify the common risks occurred. Risk assessment will help to determine the severity impact and compose the most significant factor that affect the project [5]. In risk assessment, each risk involved in BOT project will be identified to determine most common risk anticipated during construction and operation of the project. Next, the risk will be ranked and assessed to ascertain value of the risk to the valuation of the project. This study proposes to estimate fuzzy present value with macroeconomic risk factor assessment. The identified and assesses risk will be comprised to the valuation of the project to prevail the project estimation.

2. Risk Assessment

The purpose of risk assessment is to identify and quantify the most common risks occurred in the project. Risk assessment help to determine the severity impact of each risk involve, which ultimately strike the project's valuation [5]. Table 1 presented most commonly risk occurred in infrastructure development in Malaysia.

This study adopted model used by [6], to determine the weightage of each risk identified in Table 1. This model presented better judgement of severity impact of the risk in the project. The severity impact was normalized [0,1] which signify greater impact for risk that has value closer to 1 and less impact for risk close to 0. Model (1) is used.

$$W_i = \frac{M_i}{\sum_{i=1}^{n} M_i} \quad (1)$$

where

W_i : weightage of each risk group

M_i : mean of particular risk group

$\sum_{i=1}^{n} M_i$: summation of mean of all risks groups

There were seven risks identified and ranked to show significant anticipation on highway development. Operation and maintenance risk signify the highest risk in the development. According to [7], there are few factors contributed to higher maintenance in BOT project in Malaysia, namely over-loaded freight transportation, change of road networks and traffic congestion. Macroeconomic factor is the forth in the row. Microeconomic risk considered risky due to fluctuation of interest and inflation rate.

Table 1: Risk Severity Impact

	Risk Severity Impact	
	Risk Identified	Weightage
1.	Operation and maintenance	0.57
2.	Construction	0.21
3.	Staffing	019
4.	Macroeconomic	0.17
5.	Political	0.17
6.	Market risk	0.15
7.	Natural	0.13

3. Macroeconomic Risk in Fuzzy Present Value

Fuzzy in financial mathematics started around 1987, proposed by [8], to estimate present value for long time period project. In this study, the present value is said to represent the real value of the project due to its consideration of other extraneous factor that happen during the operation of the project. One of the factor that changes in time is the macroeconomic factor.

Model proposed by [8] have been extended in many studies. It has been widely used for projects valuation to evaluate big scale and long duration project investment [9-11].

Fuzzy element colligates to net present value model capable to extend the given result in the range that will give flexible judgement to the decision maker in making the decisions.

The classical net present value model presented by net cash flow and the annual interest rate [12].

$$\mathrm{NPV} = -\mathrm{C}_0 + \sum_{\mathrm{i}=1}^{\mathrm{n}} \frac{\mathrm{CF}_\mathrm{i}}{(1+\mathrm{r})^\mathrm{i}} \tag{2}$$

This study divided 26 years of toll collection into seven sub-periods. The divisions into seven sub-periods of GDP growth illustrated the fluctuation in toll collection based on the economic scenario. Each sub-period represents single triangular fuzzy number.

Fuzz number allows crisp value of annual cash flows of the project to the triangular fuzzy number with various degrees of membership. Fuzzy number is an element of Fuzzy Set theory developed by [13].

Definition 1.

A fuzzy set $\tilde{\mathrm{A}}$ in X is a set of ordered pairs,

$$\tilde{\mathrm{A}} = \left\{ \mathrm{x},\, \mu_{\tilde{\mathrm{A}}}(\mathrm{x}) \middle| \mathrm{x} \in \mathrm{X} \right\} \tag{3}$$

where $\mu_{\tilde{\mathrm{A}}}(\mathrm{x})$: degree of membership function of x in $\tilde{\mathrm{A}}$. The membership function is in the closed interval $[0, 1]$ and $\tilde{\mathrm{A}}$ is a normal fuzzy set.

Definition 2.

Present value of projects' valuation

$$\mathrm{PV} = \sum_{\mathrm{t}=1}^{7} \frac{\mathrm{CF}_\mathrm{i}}{(1+\mathrm{r}_\mathrm{i})^\mathrm{i}} \tag{4}$$

where

PV : Present value

$\mathrm{CF_i}$: Cash flows

$\mathrm{r_i}$: real interest rate

The model used is based on the work of [14].

$$\mathrm{FPV} = \left(\overline{\mathrm{PV}}^{\alpha}, \underline{\mathrm{PV}}^{\alpha} \right) = \frac{\left(\mathrm{pv}_1^{\mathrm{l}(\alpha)}, \mathrm{pv}_1^{\mathrm{r}(\alpha)} \right)}{(1+\mathrm{r}_1)} + \frac{\left(\mathrm{pv}_2^{\mathrm{l}(\alpha)}, \mathrm{pv}_2^{\mathrm{r}(\alpha)} \right)}{(1+\mathrm{r}_1)(1+\mathrm{r}_2)} + \ldots + \frac{\left(\mathrm{pv}_7^{\mathrm{l}(\alpha)}, \mathrm{pv}_7^{\mathrm{r}(\alpha)} \right)}{(1+\mathrm{r}_1)(1+\mathrm{r}_2)\ldots(1+\mathrm{r}_7)} \tag{5}$$

where

FPV : Fuzzy present value

$\left(\overline{\mathrm{PV}}^{\alpha}, \underline{\mathrm{PV}}^{\alpha} \right)$: alpha-cut representation of present value

$\mathrm{r}_1, \mathrm{r}_2, \ldots, \mathrm{r}_7$: interest rate of each sub-period.

Using the mean and standard deviation of each sub-period, each fuzzy number is formed using proposed work by [15].

$$P\left(X \in \left\lfloor x^{mean} - k\sigma, x^{mean} + k\sigma \right\rfloor \right) \geq 1 - 1/k^2 \tag{6}$$

for $k \geq 1$

4. Results and Discussion

This study portrayed one of the highway developments in Malaysia. The operation period is 26 years, divided into seven sub-periods agreeing to the fluctuation of Malaysian GDP aligned with operation period. Only toll collection is considered, even so the parameter takes into consideration of risk of macroeconomic factor as stated in table 1.

Table 2 illustrates mean and standard deviation of toll collection in seven sub-periods and the average real interest rate of each particular sub-periods. Here, real interest rate is considered as discount rate for the fuzzy present value model.

Table 2: Mean and Standard Deviation of Toll Collection and Real Interest Rate for Each Sub-periods

	Toll Collection		Int. Rate (avg.)
	Mean	Std. Deviation	
1.	79958654	9118778	5.21
2.	78600630	5378469	5.43
3.	83217463	538926	5.43
4.	86225442	2931698	1.24
5.	90507411	3815439	3.94
6.	103017375	2681248	1.40
7.	112003404	2960607	2.98

Table 3 presents mean and standard deviation of toll collection into left-right presentation of triangular fuzzy number. The values also present macroeconomic risk that has comprised to observe the effect of the risk in the present value of toll collection.

Table 3: LR-presentation of Fuzzy Number

	Toll Collection		
	Left	Mean	Right
1.	11727008	15192144	18657280
2.	12890301	14934120	16977938
3.	15606526	15811318	16016110
4.	15268789	16382834	17496879
5.	15746541	17196408	18646275
6.	18554427	19573301	20592176
7.	20155616	21280647	22405678

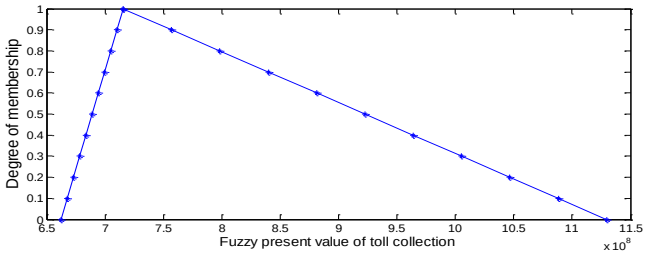

Fig. 1: Fuzzy present valuation of toll collection for 26 years operation period.

Figure 1 depicted fuzzy present value for 26 years of operation of the highway. Based on the result given, present value of the highway is in the range of $[6.6240 \text{x} 10^8,\ 1.1295 \text{x} 10^9]$. However, the most plausible present value of the highway estimated to be $7.0494 \text{x} 10^8$. The estimated value also comprises macroeconomic risk that ascertains to anticipate in the highway development. The range of the estimated value will give sensible thought for the decision maker to make decision making based of the range given by the fuzzy present value of the project.

5. Conclusion

There are various numbers of risks associated with infrastructure development particularly in highway development. This study focuses on the impact of macroeconomic risk which particularly has significant impact to the toll highway collection. The estimated present value given can be employ by the decision maker to estimate the lucrative amount of profit from the development.

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