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Monte Carlo on Net Present Value for Capital Investment in Malaysia

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Abstract

Capital investment becomes crucial investment decision in uncertain economic environment need to be made. Two major pitfall of classical net present value are uncertainty and managerial flexibilities. These drawbacks lead to imprecise cash flows estimation. This study proposes the employment of the Monte Carlo method in the NPV model in order to achieve reliable cash flows estimation. Monte Carlo provides the risk analysis which can be adopted by investors in making capital budgeting decisions. Result of this study found that Monte Carlo is an appropriate tool to embed in NPV model.

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Keywords: Capital budgeting; cash flow estimation; Monte Carlo simulation; net present value; risk analysis

1. Introduction

Capital budgeting is a planning process of analysing investment to determine the value of a long term investment to a firm. Capital investment aims to maximize the wealth and value of the firm through the continuous profit obtained from that particular investment. For that reason, capital investment decisions are crucial for firm's survival and sustainability in the future.

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Various techniques have been developed and improved to assist in capital investment valuation. Early studies focused to the number of years needed to get back the cost of capital. Hence, the payback period technique which is simple and easy to understand is used by many firms and organizations (Singh, Jain, and Yadav 2012). However, this technique's major pitfall, it ignores the time value of money (Boyle and Guthrie 2006).

One of the powerful tools used in capital budgeting analysis is the net present value (NPV). It is considered as theoretically correct for it to adopt the difference for time value of money (Bennouna, Meredith, and Marchant 2010), and yet, net present value has two major discrepancies. First, the uncertainty of cash flows estimation from the investment. In this matter, cash flows for more distant future may be discounted at a higher rate for high risk project and consequently may lead to undervalue the project (Liao and Ho 2010; Ho and Liao 2011). Second is the managerial flexibilities that implies to the timing for the decision makers to make a decision to invest. This classical net present value assumed that the investment is irreversible and must be executed immediately until the end of the project's period. Despite the positive valuation from the model, the investment actually can be delayed for new information which reduce the downside risk and undesirable outcome (Liao and Ho 2010; Appadoo 2014; Wilkinson 2006).

The application of Monte Carlo simulation reserve wider context of cash flows estimation in capital investment valuation. Monte Carlo simulation is adopted to solve incomplete information and allows decision maker to better understand of risk and uncertainty in discounted cash flows estimation. The purpose of this paper is to present a preliminary study to evaluate public capital project using classical Monte Carlo simulation. The paper is organized as follows. Section 2 briefly reviews some previous studies on capital budgeting valuation. Section 3 describes the Monte Carlo net present approach used in this study. Section 4 illustrates project valuation using the proposed approach. Finally, Section 5 is the conclusion.

2. Motivation of the study

Payback period is widely employed by many firms (Verbeeten 2006; Leon, Isa, and Kester 2008; Drakota et al. 2011). This method is simple, require less cost, less commitment and easy to understand. This method is frequently used to determine how soon firm will be able to get back its cost of capital. Shorter payback period is preferable than longer period. The payback period of an investment will influence investors in decision making. Investors may ignore potential investment with later payoff stream (Shaari Isa 1994; Wambach 2000). Major pitfall of the payback period is that it does not consider discounted cash flow, thus long term investment fail to reflect the actual value of its return (Shaari 1994). Many later studies intended to improve the flaws in this technique, mainly to capture the deficiency in non-discounted cash flow (Shaari Isa 1994; Wambach 2000; Boardman, Reinhart, and Celec 1982; Boardman 1985; Yard 2000). However, the improvement made to the payback period method only increase the complexity of the calculation and is best used as secondary tools to support other discounted cash flows tools (Dobbs 2009; Boyle and Guthrie 2006).

On the other hand, classical net present value technique ignores the uncertain of cash flows and managerial flexibilities which may undervalue potential investment and misled decision makers (Liao and Ho 2010). Therefore, the improvement of classical net present value via sophisticated techniques can reduce discrepancies in its formula. Payam Hanafizadeh (2011) presented an IT approach to encounter the ambiguity in cash flows in NPV method. The computational approach generates 10000 random scenarios which presented certain region of NPV. This model incorporates covariance of historical data with the purpose to assist investors in making better decisions.

Tsao (2012) proposed fuzzy concept in mean, standard deviation and cost of capital. The study developed an algorithm to deal with unequal durations and risk. Huang (2007) proposed investment outlays and annual cash flows as fuzzy variables. The study employed fuzzy simulation based on genetic algorithm procedure. The employment of fuzzy simulation is used to calculate the objective value and the value of credibility. Credibility measure is suited to represent the occurrence of fuzzy event. On the other hand, genetic algorithm procedure is used to find the optimal solution of the capital budgeting problems. The proposed model increased time spent on fuzzy simulation due to high number of fuzzy variables involved.

Liao and Ho (2010) presented real option concept in capital investment valuation. They proposed extended fuzzy net present value (EFNV); obtained from the classical net present value and option value of the investment. Fuzzy number was adopted to estimate the possibilities in binomial option tree and estimate the net present value from the investment.

Monte Carlo simulation was first used in business in the 1960s. It was then extended into other financial applications. Monte Carlo simulation is considered in many studies due to two main factors. First, when a complete data may be impossible to obtain or may not be available. Secondly, Monte Carlo simulation reduced complexity of analytical solution that needs to be solved. Hence, Monte Carlo simplified the mathematical limitation that must be considered to estimate the cash flows in the uncertainty of the investment market (Nawrocki 2001).
Monte Carlo simulation works effectively with high scale investment. This simulation considers risk analysis by adopting random numbers in the probability distribution to generate the possibility of uncertainty in net present value model (Verbeeten 2006; Huang 2008; Nawrocki 2001). In this study, Monte Carlo simulation is employed to examine the impact of growth on the net present value in public capital investment.

3. Cash flows estimation

Capital investment incorporates with the uncertainty of cash flows estimation. This study proposed that the uncertainty of the cash flows can be randomized by Monte Carlo simulation.

Classical net present value: $$NPV = -C_0 + \sum_{i=1}^{n} \frac{CF_i}{(1+r)^i} \tag{1}$$

where

C_0 : Cost of capital

CF_i : Cash flows

r : Discount rate (discounted time value of money)

Equation (1) can be written as:

$$NPV = -C_0 + \left[\frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \ldots + \frac{CF_n}{(1+r)^n} \right] \tag{2}$$

where $CF_1 \neq CF_2 \neq \ldots \neq CF_n$

Assume that cash flows are estimated at certain degree of growth rate (g) every year. The annual cash flows equivalent to:

Year 1 : CF_1 (initial cash flow)

Year 2 : $CF_2 = CF_1(1+g)$

Year 3 : $CF_3 = CF_2(1+g) = CF_1(1+g)(1+g) = CF_1(1+g)^2$

⋮

Year n : $CF_n = CF_1(1+g)^{n-1}$

Thus, the net present value model becomes:

$$NPV = -C_0 + \sum_{i=0}^{n} \frac{CF_1(1+g)^i}{(1+r)^{i+1}} \tag{3}$$

or equivalent to

$$NPV = -C_0 + \frac{CF_1}{(1+r)} + \frac{CF_1(1+g)}{(1+r)^2} + \frac{CF_1(1+g)^2}{(1+r)^3} + \frac{CF_1(1+g)^3}{(1+r)^4} + \ldots + \frac{CF_1(1+g)^n}{(1+r)^{n+1}}$$

With the uncertainty of the capital market, the cash flows are assumed to follow the randomization of growth rate (g), estimated in the Monte Carlo simulation. Application of equation (3) is shown in figure 1.

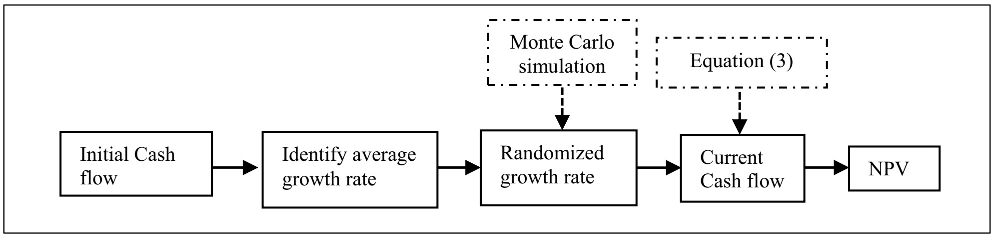

Fig. 1. Monte Carlo on NPV flow chart

Monte Carlo simulation incorporates random number in the probability distribution. The anticipated element reflects the uncertainty associated with the investment valuation.

4. Illustrated example

This section illustrates an example of public capital investment under the built, operate and transfer (BOT) infrastructure project, a form of project financing given by the government where the private entity is given a concession period to collect the benefit for a specified period of time. In this study, the valuation of capital investment for Penang Bridge is studied, one off high funded project led by the government. However, the project was then handed to private entity due to high deficit.

Penang Bridge was built from 1982 to 1985 under a 24 years and 8 month concession period signed in 1993. The bridge links the mainland and the Penang Island. The bridge would save user travelling time compared to travel by ferry. The initial construction required RM850million cost of capital. Tolls are collected only when the vehicles enter the island. There are seven classes of toll collection, ranging from RM1.40 for motorcycles to RM75 for vehicles with five or more axles. Lembaga Lebuhraya Malaysia recorded 23.23million vehicles crossed the bridge in the year 2007 and successfully collected RM149.96million from the toll collection.

Number of vehicles crossing the bridge will impact the revenues gained of the investment from the toll collection. Expected that the growth of vehicles is at 4 percent yearly (Cooperation 2012). Based on this growth rate, study estimate there were 8.24million vehicles passing the bridge in 1985, during first year of operation. Average inflation rate from 1980-2012 data is taken as the discounted time value of money. The rate obtained is 3.07 percent.

Classical net present value represents uniform cash flows throughout the project lifetime. In this study, Monte Carlo simulation is adopted to obtain reasonable estimation of the yearly cash flows from the number of vehicles passing the bridge. This estimation uses random numbers due to represent uncertainty of toll collection yearly.

Table 1 shows number of traffic flows from 1995-2012. The traffic flows was recorded to increase each year but unexpectedly fall in the year 2008 from the previous year by 0.26% from previous year. However, it is estimated that, the average increment of traffic flows increased by 4.9% yearly.

Table 1. Traffic flows from 1995-2012 (in millions).

Year	Traffic flows	Year	Traffic flows
1995	12.77	2004	20.97
1996	14.51	2005	21.53
1997	16.30	2006	22.41
1998	16.05	2007	23.23
1999	16.77	2008	23.17
2000	18.46	2009	23.74
2001	19.34	2010	26.03
2002	19.55	2011	27.48
2003	19.82	2012	28.86

Source: LLM annual report

Table 2 presents the net present value from the investment at 4 percent growth rate and ranging from 9-12 percent. The Monte Carlo simulation shows that at the growth rate of 11% and above, the investment is consistently showing positive net present value.

Table 2: NPV at 4 and 9-12 percent cash flows increment for duration of 45 years (in millions (RM))

No of trials	Growth rate				
	4%	9%	10%	11%	12%
1	604	-86	590	779	873
2	-188	374	-234	413	1302
3	-561	402	991	552	1783
4	-1011	-106	403	603	427
5	96	358	745	737	986
6	918	-90	544	1126	1322
7	1637	210	542	562	713
8	153	536	781	441	748
9	233	79	662	345	1147
10	-470	620	388	1284	1302

However, the increment of vehicles at 10-12 percent only happened twice, for year 1997 and 2000. Hence, the probability for the investment to success at 4 percent growth rate for 45 years period of investment is only 40%.

Table 3 presents the net present value from the investment at 4 percent growth rate raging from 45-70 years of concession period. The output highlights that, higher probability of success from this investment happen at 50 years and above of concession period.

Table 3: NPV at 4 percent increment with 45-70 years concession period (in millions (RM))

No of trials	Years			
	45	50	60	70
1	604	-263	341	398
2	-188	920	420	550
3	-561	1097	-485	475
4	-1011	517	696	87
5	96	-126	683	607
6	918	576	308	1340
7	1637	882	787	-151
8	153	-187	332	1125
9	233	903	821	1089
10	-470	972	-41	1005

In this study, Monte Carlo simulation presented the estimated possibilities of net present values constitute with growth rate and concession period. From the results, growth rate had greater impact on the cash flows than the concession period. The positive NPV consistently projected at growth rate 11% and above. On the other hand, there are small possibilities of negative NPV even for extended concession period given for the investment. These results are very important for the decision makers as the decision to invest is based on the positive net present values. Discuss that positives NPV are projected more often than the negative NPV, indication that project will provide a positive NPV and a good investment to consider.

5. Conclusion

Monte Carlo simulation is an easy and a practical technique that can be used to improve classical net present value analysis. Monte Carlo provides an easy way to visualize risk and project the possibilities of the outcome from the investment. The results show the estimation of net present values constitute with the uncertainty of the cash flows.

The model proves that the estimated result can be obtained within a short period of time with the assist of current mathematical tool. Nawrocki (2001) stated that simple Monte Carlo simulation do not involve large computational requirement but instead producing realistic result that easily understood by the decision makers. Thus, the simplicity of Monte Carlo can encourage decision makers to adopt this method for reliable capital investment valuation.

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