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Game-options approach on Infrastructure Investment in Vietnam: based on Smart City Project.

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Abstract: Successful countries provide economy and society with infrastructure needed to maintain growth. Over the last decade, the government of Vietnam was able to sustain infrastructure investment at 10 percent of GDP which has resulted in a rapid expansion of infrastructure stocks and improved access. Despite that, the electricity shortage, natural disasters and the emission of greenhouse gasses are challenges that Vietnam has to confront to sustain high economic growth in the long term. Japan, one of the most developed nations, is moving forward aggressively to become a major global player in smart cities-a new style of city providing sustainable growth and designed to encourage healthy economic activities that reduce the burden on the environment while improving the QOL (Quality of Life) of their residents. For this reason, we are going to focus on this potential "Smart City" project in Japan for considering the investment in Vietnam. However, this project requires large investment amounts and long term to profitability under high-risk perception for innovative solutions and uncertainties. Simultaneously, it is important to bring stakeholders together in agreement of the Smart City vision. Therefore, this paper shows the combination of real options and game theory to provide a useful framework for analyzing the trade-off between strategic adaptability and commitment of investing in infrastructure in Vietnam under Smart City project. Then the result is proposed to value the flexibility of investment decision in terms of cost-effective way for national development and the strategic choices of stakeholders compatible with others' behaviors.

I. Introduction

In recent years, Vietnam has spent about 10% of GDP for infrastructure investment (Fig.1), however, it has not kept pace with population growth, the rate of urbanization and GDP growth (at 7-8%/ year). This has been causing pressure on the existing infrastructural system and this has a negative impact on the country's ability to sustain high economic growth in the long term. Transportation and electricity, two activities most essential infrastructure, proved to be two areas poor infrastructure in Vietnam when the power outages, traffic congestion, greenhouse gas emissions, occurs more often. Moreover, changes in the Vietnam economic structure, especially the process of urbanization, industrialization and global integration require high demand for infrastructure services in key areas such as electricity, transportation, telecommunications, housing, and so on. In this condition, technology investment is also important for the industrial development as a result of economic progress of Vietnam. Besides, one of the most potential project which concerns infrastructure development is Smart City in Japan.

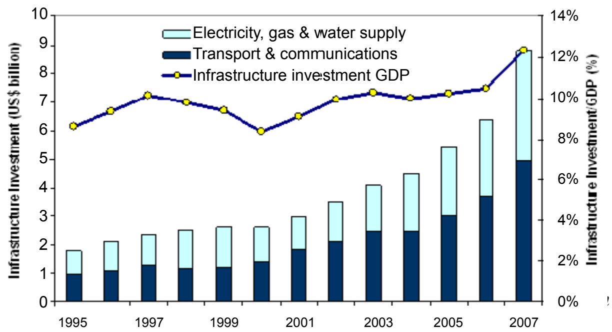


Figure1: Investment in infrastructure, including electricity, gas, water, transportation and telecommunications.

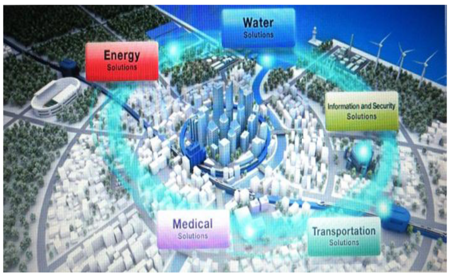
However, this project is a large-scale and big-budget investment that requires cooperation among many stakeholders, not only the Vietnamese government, but other domestic or foreign investors. On the other hand, making decision should be carefully considered under uncertainties over demand, market, policy and other risks. This means that investors must always make decisions on big-budget investments in consideration of both competitive pressure and flexibility of investment options at the same time.

2. Promise of Smart City in Infrastructure development

A smart community (Fig 2&3) is defined that the way for every Government can be used to develop “smart” solutions for the community as a whole by utilizing information and communications technology (ICT) while promoting the introduction of renewable energies and achieving the integrated management and optimized control of all manner of infrastructure, including electric power, heat, water, traffic, healthcare and lifestyle information. Moreover, this project will help to create smart communities that strike a balance between environmental considerations and comfortable lifestyles with solutions that comprise multiple components, from energy and water to traffic, healthcare, offices, plants and households.

Nevertheless, because of huge capital requirements and long term to profitability under high risk perception for innovative solutions and uncertainties can make the financial burden on the public if only the Government invest in this project. Nowadays, Public–Private Partnership (PPP) model will be a good solution to help government reduce the burden of capital guarantees, solve the problem of attracting investment in infrastructure and also provide an investment opportunity for private investors.

In the aftermath of the massive earthquake and tsunami in 2011, Japan has placed heightened urgency on building smart, sustainable cities, but it was moving in that direction even before then. The country has been actively supporting smart city projects in four cities since 2010 as part of its Next-Generation Energy and Social Systems Verification Experiment.



(Source: TOSHIBA-Smart Community)

Figure 2: Smart Community

(Source: IBM - Smart Cities)

Figure 3: Combination of Planning and management, Infrastructure and Human solutions for Smart city.

3. Methodology

It can be clearly seen that discounted cash flow (DCF) method is not suitable to give a right decision because it cannot account for uncertainty and competition in the real market.

Therefore, Real Options Analysis (ROA) is a financial approach that values a flexible response to future uncertainties. The ROA enables stakeholders to consider when it is suitable to initiate or continue a project. On the other hand, ROA can allow decision makers to accurately estimate the expected value of an investment by reducing negative risks and increasing opportunities (Suttinon and Nasu 2010).

Game theory an economic approach concerned with the effect of competitor decisions. The game theory analyzes the multi-decision making process when there is more than one decision maker. Each player's payoff depends on the actions taken by other players.

As a methodology here, the procedure is consisted of basically comparing both the value of flexibility by real options and the commitment value by game theory in a game tree, and then of utilizing it for the optimal strategic decision through the backward induction. In other words, option-games is a combined method by integrating a real-option binomial tree with a payoff matrix under strategy scenarios.

4. Application of NPV, Option to Project Investment

4.1. NPV and ROA approaches

NPV and ROA approaches consider all cash flows over the life of a project, both discount cash flows back to the present, and both use market opportunity costs of capital. They are fundamentally different and the NPV approach is a special case of the real options approach. We could say that NPV is a real options approach that assumes no flexibility in decision making.

The net present value of a project is written as

$$\mathrm{NPV} = -\mathrm{I} + \sum_{t=1}^{N} \frac{E(FCF_t)}{(1+k)^t}$$

Where, E (FCF): expected free cash inflow

k: risk-adjusted rate; t: time point

Note that the uncertainty of cash flows is not explicitly modeled in the NPV approach.

For the real options method, the binomial model is formulated as follows:

$$C_0 = \frac{[pC_u + (1-p)C_d]}{1 + r_f}$$

Where, C_0: current option value

p: risk-neutral probabilities

C_u, C_d: call value in up state, down state

r_f: risk-free interest rate

Where, u: up movement, d: down movement.

In addition, if a firm's investment decisions are contingent upon and sensitive to competitor's moves, a more involved game-theoretic treatment might be necessary.

4.2. Assumption of Model

We assume the investment I=\$450 (in Million), volatility parameter $\sigma = 0.3$, up or down with binomial parameter u= $e^{\sigma\sqrt{\Delta t}} = 1.35$ and d $= e^{-\sigma\sqrt{\Delta t}} = 0.74$, risk-free rate r_f=0.08, actual probability q=0.5 and original project value V_0=\$500. If so, risk-neutral probability will be given:

$$\mathrm{p} = \frac{(1+0.08) - 0.74}{1.35 - 0.74} = 0.557, 1 - p = 0.44$$

0	1	2	3	4	5
					2240.84
				1660.06	
			1229.80		1229.80
		911.06		911.06	
	674.93		674.93		674.93
500		500		500	
	370.41		370.41		370.41
		274.41		274.41	
			203.28		203.28
				150.60	
					111.57

Figure 4: Present value event tree of project without managerial flexibility.

If invest now, commitment value: NPV= -450+500 =50 > 0

With managerial flexibility to its original plans

This project may seek to envision infrastructure development in more than ten years' time. As a results, we simply assume that there are two decisions: both players will invest now (year 0) or invest after 5 years for preparation time, so if the investors do not invest now, they have to wait until 5 years later, so we chose European model for doing exercise at the expired day.

According to ROA rule, at time T= 5, the value of project with flexibility: Max (V_{Ti}–X, 0) (where V_{Ti} is the value of project at point i in year 5 and X= \$450 is exercise value).

From the option perspective, a project is undertaken, at the future time, if and only if V_{Ti} >X. In the figure below, the project will be invested at the upper three points (with payoff $=V_{Ti} - X$) and will be ejected at the three remaining points (with no payoff). For the remaining year from year 4 to year 0, we used risk-neutral probability approach to calculate the value of project with flexibility all nodes in every year.

0	1	2	3	4	5
					1790.84
				1243.39	
			844.00		779.80
		559.33		494.39	
	362.49		302.52		224.93
230.31		180.54		115.99	
	105.75		59.81		0
		30.84		0	
			0		0
				0	
					0

Figure 5: Call option valuation: Decision tree with project value.

From the figures above, the option value at time 0, C_0=\$230.31> NPV=\$50. This shows the managerial flexibility to defer investment for 5 years and invest if developments are favorable (upward movement) or back out with limited loss (0) under unfavorable developments. Many investment opportunities with high barriers of entry for competitors are such kinds of proprietary real options. And the option to wait is valuable in the industries of high uncertainties, long investment horizons and limited competitive erosion.

Moreover, when the type of investment invites a rival's cooperation in huge capital investment that in turn affects players' investment decisions, this issued will be discussed in next sections.

5. Strategic Games between the Government and Private firms.

In the long term, the Government cannot provide funds from the State budget for Infrastructure development because the current Vietnam's public debt is high while the loans are more and more difficult. As mentioned above, the PPP model will be the vital key for economic development. Therefore, the Government should improve the policy on PPP model which focuses more on creating more favorable conditions for outside investors. In this paper, assume that the Government gives some incentives about low dividends for private investors, particularly, 25% on the payoff of project that they will get if they cooperate with the Government to share half investment capital for each party.

The following step is calculation of both investors' payoffs for each case in the four scenarios.

5.1. Both Government and Private firms invest now

Based on the first our assumption, the project value if invest now V_0=\$500, so the cash flow of the Government is included by half of total pay-off and dividend 25% from private firms, and private firms' cash flow is equal half-payoff minus dividend submitted to the Government.

0	1	2	3	4	5
					1400.53
				1037.54	
			768.63		768.63
		569.41		569.41	
	421.83		421.83		421.83
312.50		312.50		312.50	
	231.51		231.51		**231.51**
		171.50		171.50	
			127.05		127.05
				94.12	
					69.73

Figure 6: Annual cash flows for the Vietnamese Government

0	1	2	3	4	5
					840.32
				622.52	
			461.18		461.18
		341.65		341.65	
	253.10		253.10		253.10
187.50		187.50		187.50	
	138.90		138.90		138.90
		102.90		102.90	
			76.23		76.23
				56.47	
					41.84

Figure 7: Annual cash flows for Private firms

Cash flow of Government $=1/2\ V_0 + 25\%(1/2\ V_0) = 250 + 25\%.250 =$ **312.5**

Cash flow of Private = 500 – 312.50 = **187.5**

Following that results, the payoff of both players are calculated if they invest now:

Payoff of Government=312.5 – 225= 87.5

Payoff of private=187.5 – 225= –37.5 (Loss)

5.2. When one firm (Government or Private firms) invests first while the other waits and it pre-empts its competitor, appropriating the full NPV (50) for itself. However, if the private invests now, it must pay 25% dividend on its payoff or 25%x50=$12.5 and resulting in a payoff of (50,0) or (12.5,37.5); respectively.

5.3. Both Government and Private firms wait

In the current analysis, this scenario is the most complicated. Similarly, we calculate the option value from year 5 for each competitor by using formula:

At time T=5, Payoff = Max $(V'_{Ti} - X', 0)$

Where V'_{Ti}: the payoff of project after dividends that each player receives; $X'=1/2X=$ \$225.

And then going backward for the remaining years. Similarly to Fig.5, at the maturity day, the project must be invested at the upper three points (with payoff $=V'_{Ti} - X'$) and must be ejected at the three remaining points (with no payoff) by both players.

0	1	2	3	4	5
					1175.53
				829.20	
			575.72		543.63
		390.35		361.08	
	258.30		227.83		196.83
167.13		138.96		101.50	
	82.73		52.34		0
		26.99		0	
			0		0
				0	
					0

Figure 8: Option valuation: Project value of the Vietnamese Government

However, in Fig.6, at point 4 from above at T=5, the project value is V'_{54}=\$231.51>\$225, then the Government should invest as a partner. In contrast, at the same point in Fig.7, the option value will be equal 0 and the Private will not invest. Hence, if the Government decides to invest, while Private wants to abandon this project, the Government cannot get dividend.

Based on strategy above, the Government must also give up this project and the option value is equal 0.

0	1	2	3	4	5
					615.32
				414.19	
			268.27		236.18
		168.98		133.31	
	104.19		74.69		28.10
63.17		41.58		14.49	
	23.02		7.47		0
		3.85		0	
			0		0
				0	
					0

Figure 9: Option valuation: Project value of Private firms.

Results:

The final payoffs for each player and strategic scenario are entered in the real option games matrix. Each value is calculated from four scenarios above.

		Private	
		Invest	Wait
Government	Invest	(87.5, -37.5)	(50, 0)
	Wait	(12.5, 37.5)	**(167.13, 63.17)**

Table 1: Simultaneous Investment Timing Game Payoff under dividend condition.

What would we expect the Government and Private to do in the game illustrate by Table 1? Consider Private's strategy first. Suppose that the Government has chosen "Invest", then Private would get loss \$–37.5 by choosing "Invest" and no payoff by "Wait". Thus, conditional on the Government's choosing "Invest", Private's payoff is maximized by choosing "Wait". If the Government chose "Wait", then Private would choose "Wait" for a payoff of \$63.17 rather than "Invest" for a payoff of \$37.5. Hence, no matter what the

Government's strategy is, one best strategic response for Private is to decide "Wait". This strategy is known as a dominant strategy.

We look now for the Government's strategy. The Government does better by choosing "Invest" if Private has chosen "Invest", but it does better choosing "Wait" if Private has chosen "Wait". The Government does not have a dominat strategy. Hence, it can consider the dominant strategy of the opponent and so can choose its equilibrium action accordingly. In this situation, the Government will choose "Wait" strategy with the expectation that Private will decide "Wait". And the Nash equilibrium of the game occurs in the bottom right of the table.

In reality, Smart City is a large-scale investment on infrastructure for the developing country as Vietnam. And the Government and Private have to make futuristic decisions under various uncertainties and in the face of competition. These decisions are normally based on incomplete information. However, they can gain more time for the gathering of additional practical data if they decide to defer project.

6. Conclusion and Implication

Under the standard real options approach to investment under uncertainty, agents formulate optimal exercise strategies in isolation and ignore competitive interactions. However, in many real-world asset markets, exercise strategies cannot be determined separately, but must be formed as part of a strategic equilibrium. Option-games can be used by both public and private sectors to quantify payoff options before making decisions on large-scale investments as Smart city. Real options allow decision makers to accurately estimate the expected value of an investment by making the project sufficiently flexible regarding productive opportunity versus abandon in light of future risks. On the other hand, game theory can quantify competitive pressure under different strategies. The option-games approach addresses an existing need in infrastructure management, which is characterized by big budgets, uncertainties, and competition.

These results provide convincing evidence that the option-games valuation of infrastructure investment is more effective than the other methods for use in both Government and the Private sector. Future research should focus on the effects of other infrastructure service supply and demand countermeasures on decision making.

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