Government Supports as bundle of Real Options in Built-Operate-Transfer Highways Projects

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Government Supports as Real Options in Built-Operate-Transfer Highways Projects

Santi Charoenpornpattana[1], Takayuki Minato[2], Shunsuke Nakahama[3]

Abstract

Recently government of many countries have adopted plan to encourage private investment on infrastructure undertaken normally by public sector. These infrastructures include highway, expressway, airport, power generation, water supply, and so on. Build-Operate-Transfer (BOT) scheme is widely employed in private financing of public infrastructure. BOT project normally involves dealing with many parties, huge amount of budget, long period of time, and many uncontrollable factors. These features make the BOT project very risky. Important risks include development risk, completion risk, cost increase risk, performance risk, operation risk, political risk, environmental risk, credit risk, and market risk. As a private financing scheme, BOT does not imply that private sector undertaking project must assume all the project risks. On the contrary, success of this scheme depends very much on reasonable supports or risk sharing from the government side.

The main focus of this paper is government supports in highway BOT project. In BOT highway project, government normally provides supports which mitigating financial-related risks such as market risk, because this kind of support has direct impact on project. Examples of such supports are direct financial subsidy, demand guarantee, revenue sharing, extension of concession period, and shadow tolls. However, the designs of such supports are somehow subjective, and irrational. Subjectivity is the result of lacking of quantitative method for evaluation. Irrationality comes from shortfalls of the current evaluation method.

Real Options approach is proposed as a method for design and formulation of government supports. The main point is that government support can be taken as '*Bundle of Options*' from government given to private investor. In this paper, design and formulation of the Options-like government supports in BOT projects based on Real Options theory are explored.

Keywords: Real Options, Bundle of Options, Build-Operate-Transfer, Highway, Risks, Government supports, Minimum traffic guarantee, Shadow tolls system

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1. Introduction

Global demand of infrastructure such as power generation, water supply, sewage treatment, airport, highways has increased very rapidly during the last decades. However, public financial resources to provide such infrastructure somehow are somehow insufficient. Therefore, private financing for infrastructure has been increasingly of interest of governments of many countries.

One of the well accepted forms of private financing is the 'Build-Operate-Transfer' (BOT) scheme. Typically, government grants a concession to a private company, called Project Company, to finance, develop and operate what would traditionally be a government project. Project Company will undertake construction (build), operation and maintenance including toll collection (operate), and finally after a certain period transfer the project property to government (transfer). BOT scheme is now widely used in many countries.

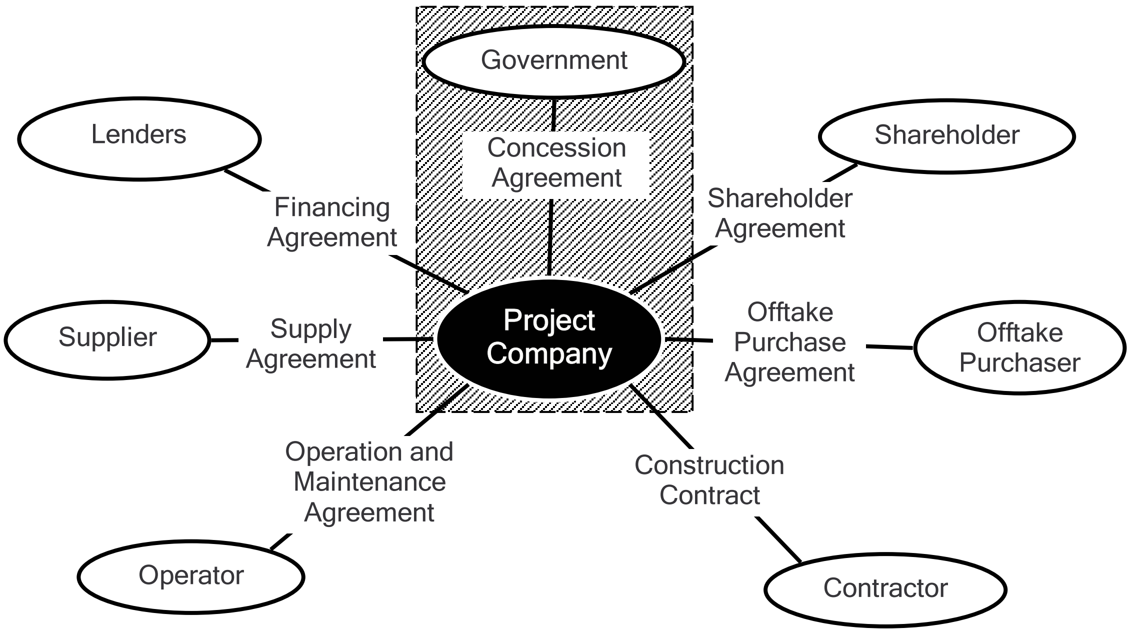

Figure 1 – Participants and contractual relationships in BOT project

As a nature of BOT project, it involves dealing with many parties, huge amount of money, and long period of time. Therefore BOT project is said to be very risky. Figure 1 shows typical participants and relationships in BOT project. However, BOT scheme does not imply that Project Company must assume all the risks. Many literatures, such as Fishbein and Babbar (1996), Dailami and Leipziger (1997), Irwin et al. (1997), Klein (1997), and Ye and Tiong (2000), indicated that supports from government play important roles in project success. However, designs of supports are still subjective, intuitive and irrational. In this paper, design of support is proposed based on Real Options theory.

2. Risks in BOT Highway project

In BOT project, Project Company is responsible for financing, development, and operation of project. As explained earlier, BOT project must face with various kinds and large amount of risks. In highway project, Project Company particularly has to face with some major risks. These risks include (Fishbein and Babbar, 1996):

1. **Pre-construction risk** - Right-of-way acquisition, environmental compliances.

2. **Construction –** Design changes, unforeseen geological, delays, cost overruns
3. **Traffic and revenue –** Low traffic demands, low toll rates
4. **Currency –** Exchange rate fluctuations, inconvertibility
5. **Force majeure –** Floods, earthquakes, war
6. **Tort liability –** Accidents
7. **Political –** Termination of project, breaches of concession agreement, imposing high tax
8. **Financial –** Insufficient cash flow for debt or equity service

From these eight types of risks, major groups that can generate enormous impact to project success are Traffic and revenue, Currency, Political, and Financial risk. Therefore, government normally provides support to these types of risks. Support schemes are explicitly written in the concession agreement between government and Project Company as shown in the shaded area in figure 1.

In BOT highways project, Project Company mainly obtains income from collection of tolls from users. Majority of this income (around 80%) will be used in debt and equity servicing (Delmon, 2000). Therefore, stability of income stream is very critical to project success from viewpoint of Project Company. In the other words, the project is very sensitive to Traffic demand risk. In order to attract private company to invest, government may assume the risk to some degree by providing supports to Project Company. Next section is the detail discussion about government supports.

3. <u>Government support</u>

Fishbein and Babbar (1996) indicated that there are two reasons for government to provide support to Project Company in highway BOT project. Firstly, it is expected to reduce capital requirement and to improve income stream during the project. Secondly, it is to protect investors from risk of inadequate cash flows. There are mainly eight categories of government financial support given to Project Company:

1. <u>Equity guarantees.</u> This kind of guarantee gives Project Company a right to sell the project to the government with a guaranteed minimum return on equity. Under this support, it implies that government
2. <u>Debt guarantees.</u> Under this guarantee, government provides a full guarantee or a cash-flow deficiency guarantee for repayment of debt.
3. <u>Exchange rate guarantees.</u> Fluctuation of currency can create significant impact on project which involved foreign capital. By the guarantee, government compensates the Project Company for increases in local cost of debt service due to exchange rate movements.
4. <u>Grants and subordinated loans.</u> Government can help in enhancing project economics by providing non-repaying grants or subordinated loan. Subordinated loan will be repaid to government after the senior loan. At such time, project would normally be in the relieved financial stage.
5. <u>Shadow tolls.</u> In this system, government, instead of users, pay a specific annual payment per vehicle recorded on the road to Project Company. The shadow tolls can be made into several rates depending on demand volume, such as declining schedule rate.

6. Minimum traffic guarantee. Government will compensate to Project Company in cash if traffic falls below a specified minimum level. This is the common type of support in BOT project. In some case, besides the minimum guarantee, the contract may specify ceiling traffic level too. If traffic volume goes beyond the ceiling level, government has benefit sharing from the excess volume too.
7. Concession extensions. Government may give right to Project Company to extend the concession term if revenue falls below a specified level. This type of support give less financial exposure to government, but also give less efficiency in easing financial status of Project.
8. Revenue enhancements. Government normally enhances project revenue by limiting competition, facilitating demands, or allowing development of ancillary facilities.

These eight types of government support have different features. Figure 2 shows impact in project financing and government financial exposure of each type of the supports.

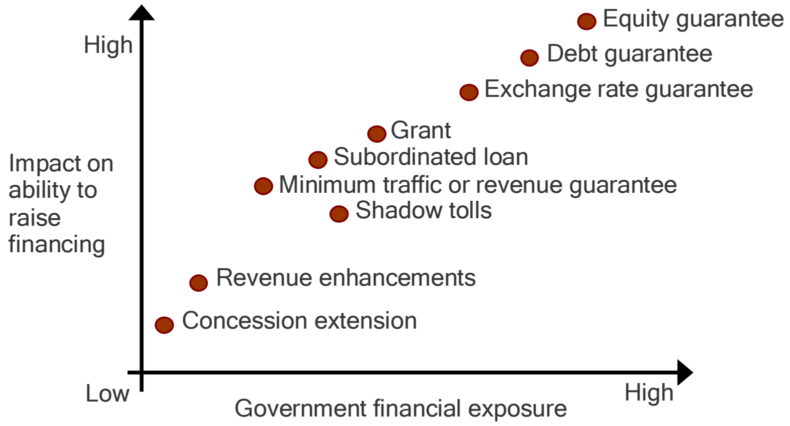

Figure 2 - Range of options for government support (Fishbein and Babbar, 1996)

Within these eight types of supports, Minimum traffic guarantee and Shadow tolls system have the feature of enhancing cash flow by limiting the downside. This feature is shown in figure 3. This feature is similar to the hedging feature of Options. Therefore, these kinds of supports could be formulated as Options that government gives to Project Company.

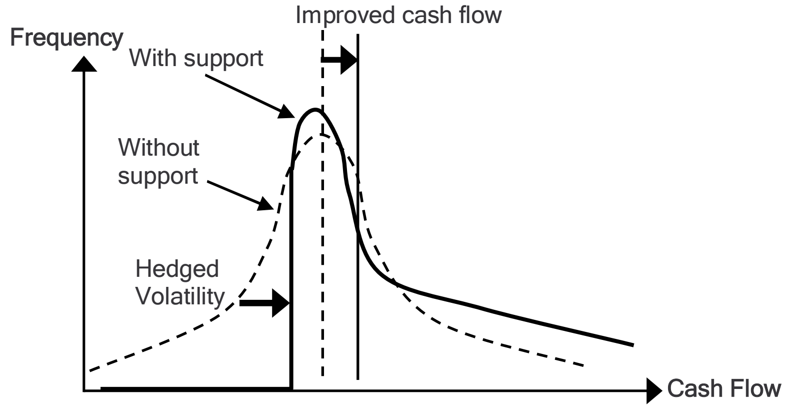

Figure 3 – Support limits downside of cash flow

Current designs of such supports are somehow intuitive, irrational, and subjective because of the following reasons:

1. There is no quantitative tool to evaluate value of the supports. Only qualitative studies have been done in the past.
2. Uncertainties change according to the stage of project. Therefore, to find the appropriate discount rates for evaluation of value of the supports is very difficult.

Next section describes the evaluation of the supports.

4. <u>Government supports as '*Bundle of Options*'</u>

In this paper, two types of supports are focused. They are 'Minimum traffic guarantee', 'Shadow tolls'. Each type has its own characteristics and comprises different structure of Options Bundle. Figure 4 show diagram explaining process of evaluation of the supported cash flow. Firstly, cash flow from project is broken down into two parts – cash flow without support and Support component. Support component actually contains *Bundle of Options*. It is the component composed of several Option elements. *Bundle of Options* can be broken down again into multiple Options for evaluation of their values. Summation of all value of Option elements is the value of the bundle. Then, the value of cash flow without support pluses value of the *Bundle of Options* is value of the cash flow with support (Options).

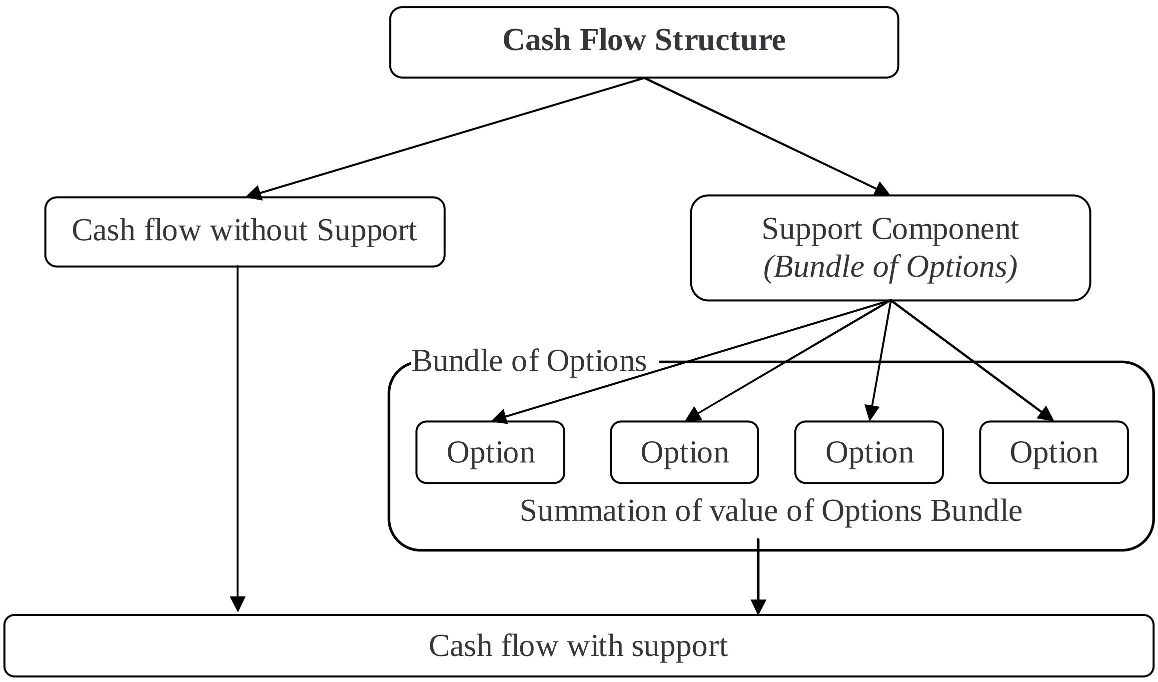

Figure 4 Structure of Cash flow and Support Options Bundle

Followings are detail explanation of characteristics and Option-like structure of these government supports.

4.1 <u>Minimum traffic guarantee</u>

With this type of support, Project Company can claim for compensation from government if traffic volume of any year does not meet the agreed minimum threshold. It means Project Company holds yearly 'Put Options' through out the project life. As the traffic decreases below a certain point, value of the option increases. Structure of this kind of support is shown in figure 6. In this type of support, there is only single Option. The options variables in this case are shown in Table 1.

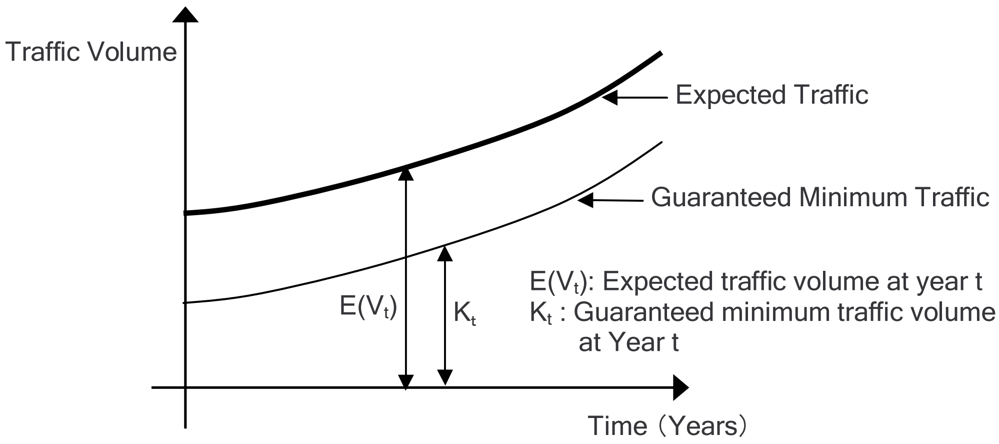

Figure 5 Expected traffic and Guaranteed minimum traffic

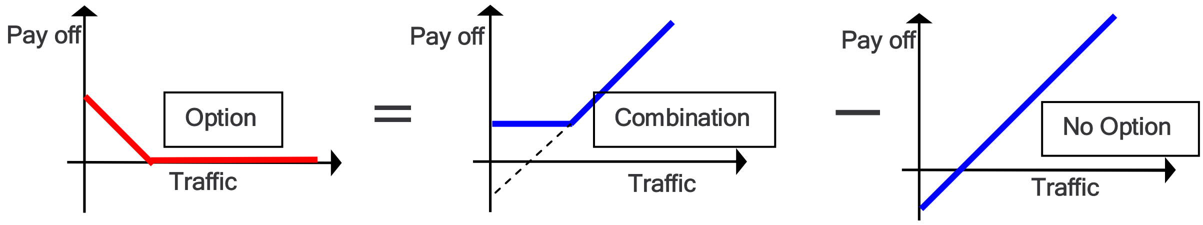

Figure 6 Bundle of Options of Minimum traffic guarantee support

Table 1 Variables in the case of Minimum traffic guarantee support

Variables	Minimum traffic guarantee support
Type of Option	Put
Underlying asset	Underlying cash flow
Exercise price	Cash flow at minimum traffic guarantee
Maturity time	1 Year
Volatility	Volatility of cash flow
Risk-free interest rate	Risk-free interest rate

Underlying cash flow is determined by the following equation:

$$Underlying\ cash\ flow\ (Cf_t) = (V_t X - E_t)(1 - T) \qquad [1]$$

V_t= *Expected Traffic volume at year t*
X = *Toll rate*
E_t = *Expenses at year t*
T = *Tax rate*

Cash flow at minimum traffic guarantee is determined by the following equation:

$$\textit{Cash flow at Minimum traffic guarantee } (Cf_{Kt}) = (K_t X - E_t)(1-T) \qquad [2]$$

K_t: Minimum guarantee traffic volume at year t
X : Toll rate
E_t : Expenses at year t
T : Tax rate

Volatility of cash flow is determined from the volatility of traffic volume. By theory of statistics, the following equation shows the calculation of volatility of cash flow.

$$\textit{Volatility of cash flow}(\sigma_{cashflow}) = \left(\frac{V_t X}{V_t X - E_t}\right)\sigma_{traffic} \qquad [3]$$

$\sigma_{traffic}$: Volatility of traffic volume
V_t :Expected Traffic volume at year t
X : Toll rate
E_t : Expenses at year t

Value of Options is determined by:

$$Op_t = \text{function } (Cf_t, Cf_{Kt}, r_f, \sigma_{cashflow}, \text{Maturity}) \qquad [4]$$

Op_t: Option value at year t
Cf_t: Underlying cash flow at year t
$Cf_{Kt:}$: Cash flow at guarantee traffic volume at year t
r_f: Risk free interest rate
$\sigma_{cashflow}$: Volatility of cash flow
Maturity: Maturity of Option = 1 year in this case

After all variables are obtained, Real Options valuation is performed. Then, total Option value is

$$\textit{Total Option value} = \sum_{t=1}^{n} Op_t \qquad [5]$$

Op_t : Option value at year t
n : Concession period (years)

4.2 Shadow tolls

Shadow tolls are per vehicle amounts paid to Project Company by government. By this system, users are not required to pay for usage. Government will pay directly to Project Company according to actual traffic volume. However the toll rates (per vehicle) are normally set to two to four levels according to actual traffic volume such as the example in figure 7. This implies that government would pay toll (per vehicle) at the higher rate when the traffic volume is less. The rate (per vehicle) will decrease as the traffic volume increases.

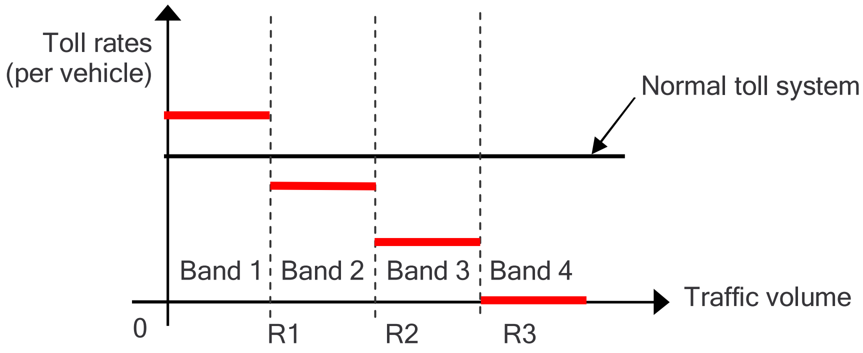

Figure 7 Toll rates at different bands of traffic volume

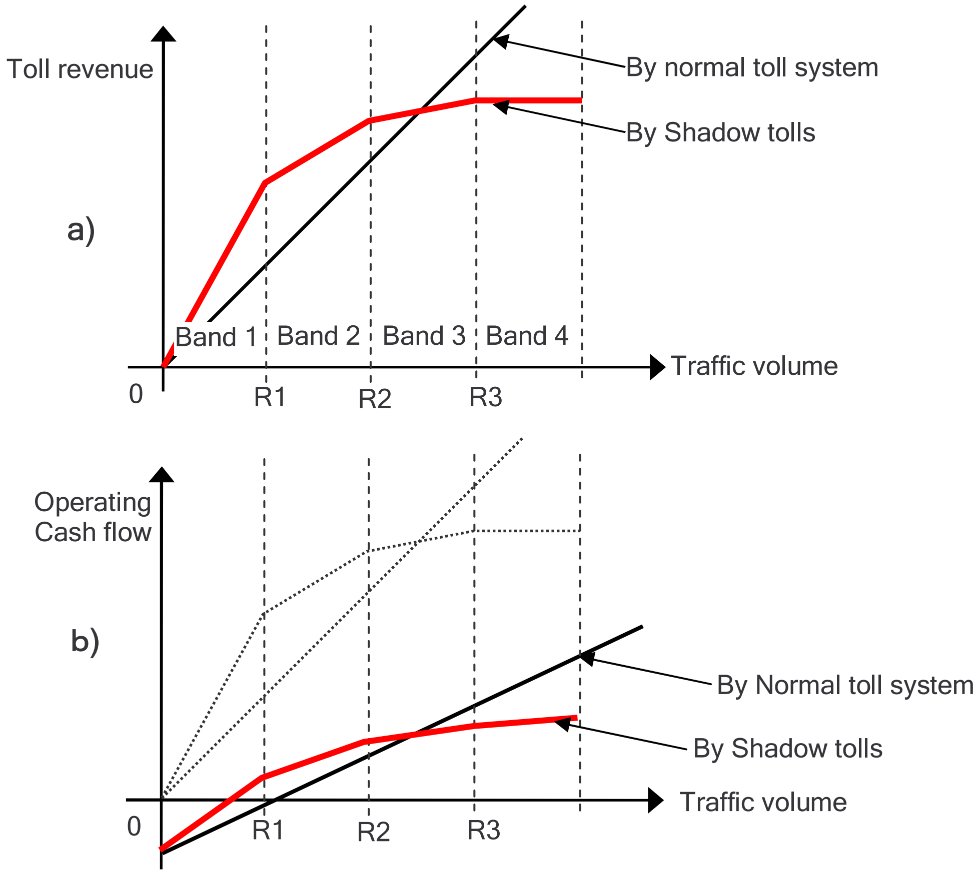

Figure 8 a) Toll revenue of Shadow tolls system; b) Operating CF

By normal toll system, the toll revenue is shown as a straight line (See figure 11a). For the shadow tolls system, the slope of the toll revenue line will change according to the traffic volume. During the Band 1, toll rate is comparatively high. Therefore the slope of toll revenue line is high too. The slope will decreasingly change when traffic volume reach the next bands. Figure 11b shows the operating cash flow of Shadow tolls system and Normal toll system. In Real Options analysis, the Operating cash flow diagram (Figure 8b) is used.

This feature of shadow tolls system is a kind of government support. It comprises several Option elements. Figure 9 shows that the shadow tolls system line can be broken up into non-shadow element (Normal toll system) and shadow elements. The non-shadow element is the profile of normal toll system which is used as the base case. The shadow element also consists of multiple Option elements, as shown in figure 10.

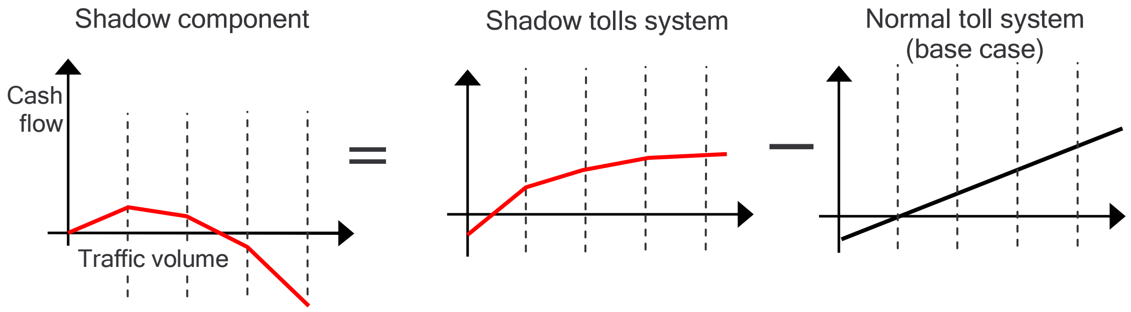

Figure 9 Composition of shadow toll system

Table 2 Variables of Options in Shadow tolls system

Variables	Option 1a	Option 1b	Option 2a	Option 2b	Option 3a	Option 3b	Option 4
Type of Option	Call	Call	Call	Call	Call	Call	Call
Underlying asset	underlying cash flow 1	underlying cash flow 1	underlying cash flow 2	underlying cash flow 2	underlying cash flow 3	underlying cash flow 3	underlying cash flow 4
Exercise price	Cash flow at traffic R0	Cash flow at traffic R1	Cash flow at traffic R2	Cash flow at traffic R1	Cash flow at traffic R3	Cash flow at traffic R2	Cash flow at traffic R3
Maturity time	1 Year	1 Year	1 Year	1 Year	1 Year	1 Year	1 Year
Volatility	Volatility of adjusted underlying cash flow	Volatility of adjusted underlying cash flow	Volatility of adjusted underlying cash flow	Volatility of adjusted underlying cash flow	Volatility of adjusted underlying cash flow	Volatility of adjusted underlying cash flow	Volatility of adjusted underlying cash flow
Risk-free interest rate	Risk-free interest rate	Risk-free interest rate	Risk-free interest rate	Risk-free interest rate	Risk-free interest rate	Risk-free interest rate	Risk-free interest rate

Table 2 shows the input variables of each Options element. It is important that these variables need to be re-calculated, because toll rate of shadow tolls system are varied according to the bands of traffic volume. Different bands have different cash flow structures. Therefore, the variables of Option elements need to be re-calculated. This is a little different from the case of Minimum traffic guarantee which toll rate is consistent.

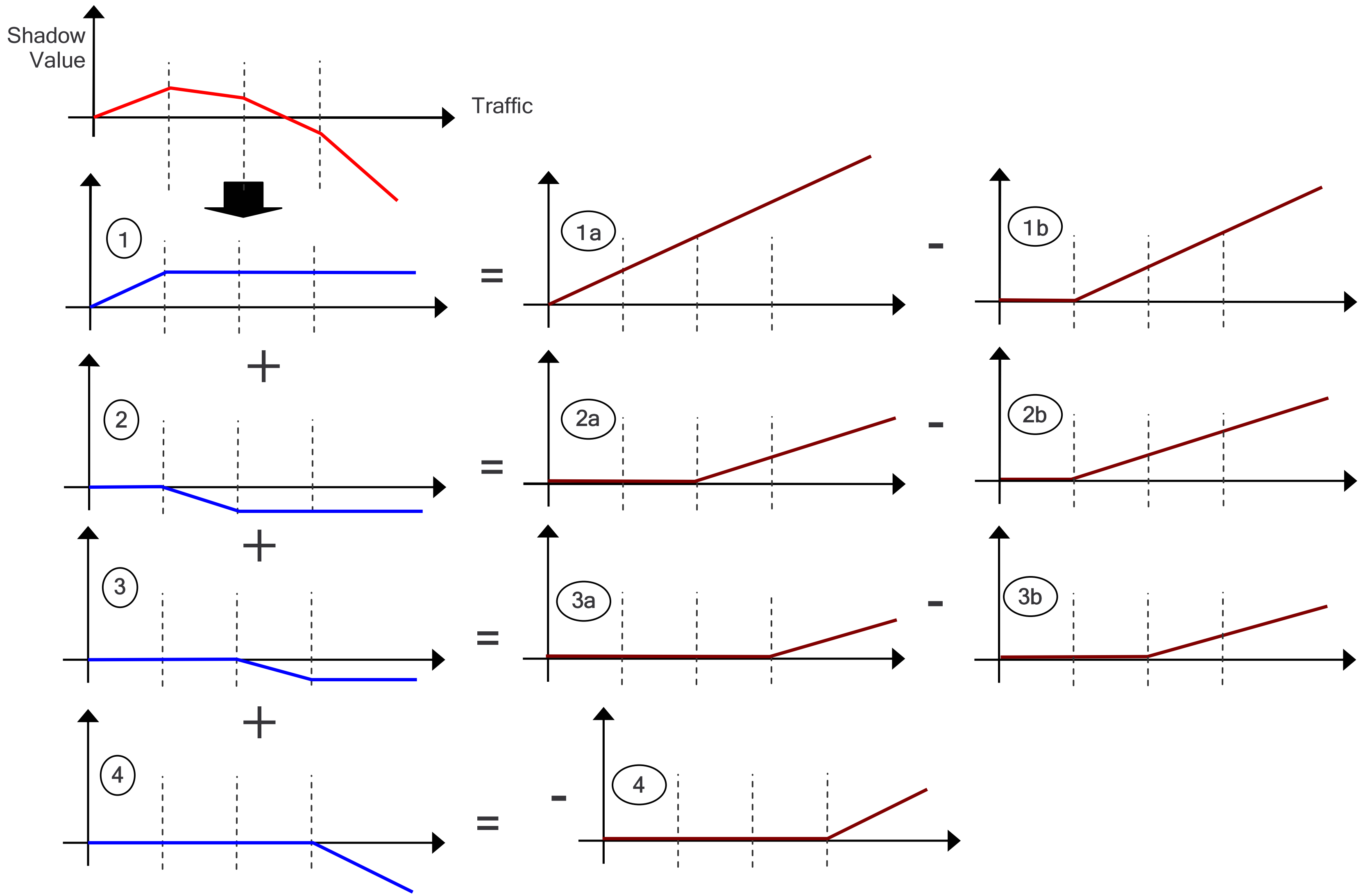

Figure 10 Bundle of Options in Shadow component

Normally underlying cash flow is determined by the equation [1] shown in earlier. However, the toll rates in this case is the different between shadow toll rate of each Band and toll rate in normal toll system (base case). Therefore, the underlying cash flow of *Option n* is determined by the following equation:

Underlying cash flow of Option n at year t (Cf_{n-t}) = $(V_t(X_n - X_0) - E_t)(1-T)$ *[6]*

V_t= Expected Traffic volume at year t
X_0 = Toll rate of normal toll system (base case)
X_n = Toll rate at Band n (for Option n)
E_t = Expenses
T = Tax rate

As the exercise price, cash flow at traffic R_x of each option is determined by:

Cash flow at traffic R_x at year t (Cf_{Rx-t}) = $(R_{x-t}(X_n - X_0) - E_t)(1-T)$ *[7]*

R_{x-t}= Traffic volume at level x at year t
X_0 = Toll rate of normal toll system (base case)
X_n = Toll rate at Band n (for Option n)
E_t = Expenses
T = Tax rate

Volatilities also need to be adjusted in the same manner as equation [3], according to the adjusted underlying cash flow.

$$\text{Volatility of cash flow}(\sigma_{cashflow}) = \left(\frac{V_{n-t}X}{V_{n-t}X - E_t}\right)\sigma_{traffic} \qquad [8]$$

$\sigma_{traffic}$ = Volatility of traffic volume
V_t= Expected Traffic volume of band n at year t
X = Toll rate
E_t = Expenses at year t

After all variable is determined, Real Option valuation can be performed. Value of each Option is determined by:

Op_{n-t} = function (Cf_{n-t}, Cf_{Rx-t}, r_f, $\sigma_{cashflow}$, Maturity) *[9]*

Op_{n-t}: Value of Option n at year t
Cf_{n-t}: Underlying cash flow of Option n at year t
Cf_{Rx-t}: Cash flow at traffic Rx at year t
r_f: Risk free interest rate
$\sigma_{cashflow}$: Volatility of cash flow

From figure 10, shadow component consists of multiple Option elements. In this case, Option elements include 1a, 1b, 2a, 2b, 3a, 3b, and 4. Therefore, value of support is the summation of all option.

Option value = 1a – 1b + 2a - 2b + 3a - 3b – 4 *[10]*

$$\text{Total Option value} = \sum_{t=1}^{n}[1a - 1b + 2a - 2b + 3a - 3b - 4]_t \qquad [11]$$

5. <u>Examples of support design</u>

This example is taken from M2 Toll road project in Australia with modifications. The feature of project is given in the table 3. Firstly, NPV of project is determined by the traditional discount cash flow method. Then two scenarios are generated. First scenario is the project with guarantee of minimum traffic volume. Second scenario is the project with shadow tolls system. After these two scenarios are examined, discussion of the result is made.

Table 3 Features of a case study of BOT highway project

Investment	3,000,000,000 Yen
Traffic forecast	75,000 car per day Volatility of traffic = 30% Yearly Growth of traffic : 2% (Year 1-10), 1% (Year11-20), 0%(Year21-30)
Toll rate	250 yen per vehicle
Concession Period	30 years excluding construction period
Yearly Operating expenses	30,000,000 Yen Increasing 5% yearly
Tax rate	40%
Weight Average Cost of Capital (WACC)	15% (Continuous)
Risk free interest rate	5% (Continuous)

From the information provided in Table 3, NPV of this project can be determined.

$$\text{Cash flow at Year t } (Cf_t) = (VX\text{-}E)(1\text{-}T)$$

V: Expected traffic volume
X: Toll rate
E: Operating expenses
T: Tax rate

$$\text{Net Present Value (NPV)} = \sum_{t=1}^{n} \frac{CF_t}{e^{rt}}$$

CF_t : Cash flow at Year t
r : Discount rate (WACC)
t : year

From calculation (see Table 4), NPV of the project is **-2.29 Billion Yen**. The negative NPV means that the project is financially not feasible. As a result, the project features do not attract private sector to invest in this project. Therefore, government may need to provide support in order to make the project more attractive. In this case, government may consider two kinds of support Minimum traffic guarantee or Shadow tolls. The support should be equivalent to the amount making NPV to the desired level. Assume that the suitable NPV of project is **+ 1 Billion Yen** in order to attract private investor. Therefore, support value should be **3.39 Billion Yen**. The next step is that 'How to formulate such support?'. As mentioned earlier, Real Options approach is used to value the supports.

Table 4 Calculation of NPV of the example project

Year		1	2	3	4	5	6	7	8
Growth			2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
Daily traffic		75,000	76,500	78,030	79,591	81,183	82,807	84,463	86,152
Yearly traffic		27,375,000	27,922,500	28,480,950	29,050,715	29,631,795	30,224,555	30,828,995	31,445,480
Toll rate		250	250	250	250	250	250	250	250
Toll revenue		6,843,750,000	6,980,625,000	7,120,237,500	7,262,678,750	7,407,948,750	7,556,138,750	7,707,248,750	7,861,370,000
Yearly expenses		30,000,000	31,500,000	33,075,000	34,728,750	36,465,188	38,288,447	40,202,869	42,213,013
Tax rate		40%	40%	40%	40%	40%	40%	40%	40%
Pre-tax cash flow		6,813,750,000	6,949,125,000	7,087,162,500	7,227,950,000	7,371,483,563	7,517,850,303	7,667,045,881	7,819,156,987
Taxed cash flow		4,088,250,000	4,169,475,000	4,252,297,500	4,336,770,000	4,422,890,138	4,510,710,182	4,600,227,528	4,691,494,192
Present Value of cash flow	**27,707,458,606**	**3,518,789,385**	**3,088,823,051**	**2,711,384,595**	**2,380,069,839**	**2,089,225,367**	**1,833,917,904**	**1,609,793,267**	**1,413,050,896**
Investment	30,000,000,000								
NPV	(-2,292,541,394)								
Year		9	10	11	12	13	14	15	16
Growth		2.0%	2.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
Daily traffic		87,875	89,633	90,529	91,434	92,348	93,271	94,204	95,146
Yearly traffic		32,074,375	32,716,045	33,043,085	33,373,410	33,707,020	34,043,915	34,384,460	34,728,290
Toll rate		250	250	250	250	250	250	250	250
Toll revenue		8,018,593,750	8,179,011,250	8,260,771,250	8,343,352,500	8,426,755,000	8,510,978,750	8,596,115,000	8,682,072,500
Yearly expenses		44,323,663	46,539,846	48,866,839	51,310,181	53,875,690	56,569,474	59,397,948	62,367,845
Tax rate		40%	40%	40%	40%	40%	40%	40%	40%
Pre-tax cash flow		7,974,270,087	8,132,471,404	8,211,904,411	8,292,042,319	8,372,879,310	8,454,409,276	8,536,717,052	8,619,704,655
Taxed cash flow		4,784,562,052	4,879,482,842	4,927,142,647	4,975,225,392	5,023,727,586	5,072,645,565	5,122,030,231	5,171,822,793
		1,240,351,113	**1,088,759,788**	**946,257,295**	**822,399,226**	**714,746,178**	**621,178,058**	**539,858,015**	**469,177,179**
Year		17	18	19	20	21	22	23	24
Growth		1.0%	1.0%	1.0%	1.0%	0.0%	0.0%	0.0%	0.0%
Daily traffic		96,097	97,058	98,029	99,009	99,009	99,009	99,009	99,009
Yearly traffic		35,075,405	35,426,170	35,780,585	36,138,285	36,138,285	36,138,285	36,138,285	36,138,285
Toll rate		250	250	250	250	250	250	250	250
Toll revenue		8,768,851,250	8,856,542,500	8,945,146,250	9,034,571,250	9,034,571,250	9,034,571,250	9,034,571,250	9,034,571,250
Yearly expenses		65,486,238	68,760,550	72,198,577	75,808,506	79,598,931	83,578,878	87,757,822	92,145,713
Tax rate		40%	40%	40%	40%	40%	40%	40%	40%
Pre-tax cash flow		8,703,365,012	8,787,781,950	8,872,947,673	8,958,762,744	8,954,972,319	8,950,992,372	8,946,813,428	8,942,425,537
Taxed cash flow		5,222,019,007	5,272,669,170	5,323,768,604	5,375,257,646	5,372,983,391	5,370,595,423	5,368,088,057	5,365,455,322
		407,743,944	**354,352,435**	**307,949,779**	**267,618,320**	**230,243,766**	**198,084,570**	**170,413,372**	**146,604,212**
Year		25	26	27	28	29	30		
Growth		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		
Daily traffic		99,009	99,009	99,009	99,009	99,009	99,009		
Yearly traffic		36,138,285	36,138,285	36,138,285	36,138,285	36,138,285	36,138,285		
Toll rate		250	250	250	250	250	250		
Toll revenue		9,034,571,250	9,034,571,250	9,034,571,250	9,034,571,250	9,034,571,250	9,034,571,250		
Yearly expenses		96,752,998	101,590,648	106,670,181	112,003,690	117,603,874	123,484,068		
Tax rate		40%	40%	40%	40%	40%	40%		
Pre-tax cash flow		8,937,818,252	8,932,980,602	8,927,901,069	8,922,567,560	8,916,967,376	8,911,087,182		
Taxed cash flow		5,362,690,951	5,359,788,361	5,356,740,642	5,353,540,536	5,350,180,426	5,346,652,309		
Year		**126,118,403**	**108,492,361**	**93,327,142**	**80,279,428**	**69,053,776**	**59,395,942**		

5.1 Minimum traffic guarantee

Structure of this type of support is simple. The value of support depends solely on the traffic volume which is guaranteed. Therefore, to design this support is to determine the suitable level of guaranteed traffic volume. By taking the expected traffic volume as the base line, guarantee traffic volume is percentage of the expected traffic volume.

$$\text{Guarantee traffic volume } (K_t) = kV_t$$

k: Level of guarantee traffic volume (%)
V_t: Expected traffic volume at year t

Then cash flow at guarantee traffic (Cf_{Kt}) can be determined from equation [2]. By method provided in section 4.1, all Option variables can be obtained.

From above, required value of Options (support) is 3.39 billion yen.

$$3.39 \text{ Billion Yen} = \sum_{t=1}^{n} Op_t$$

By performing Real Option value with binomial method and 10 time steps, then the variable k (Level of guarantee traffic volume) that gives Option value of 3.39 billion yen can be determined. It is 86.4%.

Therefore, **by setting the guarantee of minimum traffic volume at 86.4**% of the expected volume, the support value will be 3.39 billion yen and it improves NPV to the value of +1 billion yen.

5.2 Shadow tolls system

Structure of shadow tolls system is more complex. As discussion in section 4.2, Bundle of Option at each year consists of seven sub-Options. Value of support depends on seven factors namely Toll rate X_1, X_2, X_3, X_4 and Band traffic R_1, R_2, R_3. Therefore, we can generate many set of these factors that give the desired Option (Support) value. From equation [11]

$$\text{Total Option value} = \sum_{t=1}^{n} [1a - 1b + 2a - 2b + 3a - 3b - 4]_t$$

So; $$3.39 \text{ Billion yen} = \sum_{t=1}^{n} [1a - 1b + 2a - 2b + 3a - 3b - 4]_t$$

Possible set of factors that can give total Option value of 3.39 billion yen are shown in table 5: (Option valuation by binomial method with 10 time steps)

Table 5 Possible set of factors providing Option value of 3.39 billion yen

Set	A	B	C	D	E	F
R_1	60%	60%	60%	70%	70%	70%
R_2	120%	120%	120%	125%	125%	125%
R_3	150%	150%	150%	150%	150%	150%
X_1	350	325	300	325	300	290
X_2	157	196	235	153	210	234
X_3	100	100	100	100	100	100
X_4	0	0	0	0	0	0

Therefore, by setting these factors according to any of these sets, the shadow component will have the value of 3.39 billion yen. This shadow toll system has more complex structure. However, it gives more flexibility to structure the support. Government can choose the suitable set of variables of support by setting constant some factors and determine the other factors accordingly.

6. Conclusion

As government supports are important to Build-Operate-Transfer Highways project success, supports should be carefully designed and formulated. Real Options approach can help in design and formulation of such supports because of two reasons. Firstly, government supports can be seen as Bundle of Options. As shown in this paper, a support component of cash flow can be broken down into multiple Options. By this, we can make a complex support structure into several simple Options, as shown in Shadow toll system. Secondly, present value of cash flow of BOT highways project is sensitive to discount rate. Discount rate that can reflect the real uncertainties is essential. Real Options approach can provide the good answer to this problem. This paper proposes the design and formulation method for government support by using Real Options approach.

First step is to break down operating cash flow into non-support component and support component. The support component is a kind of *Bundle of Options*. It comprises multiple Option elements. By broken down the complex Options bundle into several simple Options, we can evaluate each Option by standard Real Options valuation. In this paper binomial method with risk-neutral approach is employed. The value of support is the value of the *Bundle of Option* or, in another word, the summation of value of all Options. By this approach, government can rationally determine value of support it provides to Project Company. Accordingly, government can design and formulate support to the desired value.

Future research may be to apply this approach to the other types of government supports in BOT highways project. Extending this approach to another type of infrastructure with BOT scheme will be also very beneficial.

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