Business Valuation of Location-Specific Infrastructure Projects
In Data-Poor Regions

by

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ABSTRACT

A methodology in determining the financial values (business values) of physical infrastructure projects is presented from the public point of view. The business valuation model in this thesis adopts three concepts of financial modeling, Monte Carlo simulation (probability-generated cash flow), Capital Asset Pricing Model, and Adjusted Present Value. Using this model, the business values of a hypothetical infrastructure project are simulated 1,000 times and the mean business value is analyzed in terms of patterns and magnitudes of the simulation.

The results from the 1,000 simulations showed large differences between the value derived by this model and those by the traditional net present value method. Also, this model elucidated qualitative information on how levels of government's financial support such as subsidies, tax incentives and revenue guarantees will affect the project's business value by components. The model elucidated, as well, the qualitative information on how project's contractual framework may affect the business value when private contractors bear key uncertain risks, such as demand changes and construction cost overruns.

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Glossary of Acronym and Abbreviation

ANPV	Adjusted Net Present Value
APV	Adjusted Present Value
CAPM	Capital Asset Pricing Model
D	Duration
DCF	Discounted Cash Flow Analysis
DTS	Depreciation Tax Shields
IRR	Internal Rate of Return
ITS	Interest Tax Shields
MD	Modified Duration
NPV	Net Present Value
NYSE	New York Stock Exchange
PV	Present Value
ROR	Rate of Return
S&P	Standard & Poor's
SML	Security Market Line

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Chapter 1

Introduction

1 Valuation

The assessment of valuation of infrastructure projects can be a useful process when a government, due to various reasons, needs to determine the financial value of public infrastructure projects before and after construction. This thesis presents a hypothetical public infrastructure project of a data-poor country[1] and demonstrates how planners can assess the project's intrinsic financial value (not the economic evaluation of the project). The aim is to present a methodology for public planners in developing countries to determine the financial feasibility of a project based on various variables and institutional frameworks. This technique is geared for a closed financial system for which various assumptions, such as social, political, and financial factors, as well as tax and subsidy frameworks, can be made. The methodology presented can assist governments or taxpayers assess whether they should undertake such a project and the roles they must play to ensure its success.

To perform a valuation means to determine the value of any of the following: (1) the asset and liabilities, (2) the business as an on-going concern (to assess future cash flow), and (3) the final sales price of a project (United Nations [UN], 1993, p. 32).[2] This thesis addresses the second concern (#2), and this kind of valuation is hereafter called "business valuation," according to professional valuers' notation (Jones & West, 1999; Reilly & Schweihs, 1999). The word "business" can be confusing for government

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[1] Data-poor countries generally refer to developing countries that do not have a long history of infrastructure development and thus lack various types of data, such as demand forecasts, construction costs forecasts, and other uncertain economic variables.

planners because it implies profit-making, but the meaning is not limited to private profit-making enterprises; rather it has a broader meaning regarding the value of (and cost of) operating a project. For this reason, the United Nations' definition of business valuation takes into account future cash flow as an on-going concern.[3]

In many cases, governments hire investment banks or professional valuers (business appraisers) as consultants to assess such business values (World Bank, 1998, p. 4, 26, Jones & West, 1999, p. 5 - 8). Generally, when a consultant values a public enterprise or government asset, they add risk premiums as discount factors based on:[4]

- Inflation

- Market stability

- Political stability

- Currency convertibility (UN, 1993, p.40)

Next, they determine a discount rate for the public enterprise or the government asset and they compare the net present value of the enterprise with similar structures in the same industry (UN 1993, p. 40).

Such values can vary depending on the specific modeling and assumptions the valuer uses, which are often proprietary knowledge.[5] Despite the fact that financial

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[2] One can learn the general valuation procedures in a book by Frémond and Welch (1998), and in more detail (but fragmented), Jones and West (1999), and Reilly and Schweihs (1999).

[3] More specifically, the business valuation is based on the premise that the project's financial value should reflect "overall value of the business." And it should be the residual value after deducting all liabilities (UN, 1993, p. 33).

[4] These items are for illustration purposes only and do not precisely correspond to the procedure that this thesis contemplates. The items differ from project to project and valuer to valuer, depending on the characteristics of the project and the assumptions the valuer makes.

[5] Such a proprietary status could affect government planners in a way that they over- or underestimate the financial value of the public projects and therefore they could be misguided in designing and evaluating financial/organizational/managerial structures and operational performance.

consultants often do the modeling, urban planners can gain much by modeling such valuation processes themselves because they can better understand the risks and benefits of a project. This process could serve as a guide for planning an infrastructure project's institutional financing and contractual design. This model also provides a "first-look" measure of the default risk of a government bond that is specific to a project. In addition, this model can provide a basic cost-risk analysis for planners and government officials when dealing with valuation consultants or when negotiating with private developers of an infrastructure project.

1-1 Approach

This thesis demonstrates one way of building an original cash flow simulation model that combines the following three techniques in the field of financial economics: probability-generated cash flow, Capital Asset Pricing Model ("CAPM"), and Adjusted Present Value ("APV"). Although precision is an important matter in estimating the variable with above techniques, this thesis presents only one illustrative way of using such techniques, assuming that key variables can be detected or properly inferred from past experience in other regions or countries. This thesis then describes how to assess the results generated by such a cash flow model and it discusses the advantages and disadvantages of this model so that experts can implement theoretical evaluations and practical improvements.

The financial valuation model of this thesis is built to evaluate infrastructure projects independently from the broader economic or political systems. In this way, the quantitative information generated from this model will signify the risk-benefit structure of the project's frameworks based on underlying financial, regulatory and economic

environments. Thus the model will facilitate some qualitative assessment of the policies for the project.

The reasons for pursuing this approach rather than the traditional discounted cash flow analysis, which uses a single cash flow forecast and a single discount rate, are both technical and policy related. First, the values derived by the traditional cash-flow method can be unreliable due to the subjective determination of variables and the discount rate. Second, the traditional method does not elucidate the financial structure of the project, nor does it elucidate the risk-benefit relationships of economy-wide or project-specific risks, which provide information to assist planners in assessing the level of government responsibilities in aspects such as institutional and financial design.

1-2   Thesis Outline

While Chapter 1 introduces the central theme, Chapter 2 provides background on particular types of infrastructure projects appropriate for this valuation model. Chapter 3 presents the valuation model using a hypothetical infrastructure project. Chapter 4 describes how to assess the results generated from the model and it discusses how urban planners can interpret such results and apply them to specific projects. Chapter 5 summarizes the process of building this model and presents possible advantages and disadvantages (and possible improvements) of this model.

Chapter 2

Characteristics of Infrastructure Projects

Before I discuss the specific valuation model that I have designed in the next chapter, this chapter briefly reviews the characteristics of particular types of infrastructure projects applicable for this model.[6]

2-1   Infrastructure Projects

In general, infrastructure projects include various physical and social projects that governments undertake such as transportation, telecom, schools, and social welfare programs as presented in **Figure 1**.

Figure 1 Types of Infrastructure

- Physical Infrastructure
  Transportation (highways, railways, bridges, pipelines, navigable inland waterways, ports, docks, aviation routes, airports)
  Telecommunication
  Energy
  Environment
- Social Infrastructure
  Education
  Health care
  Social welfare programs

(Source: United Nations, 1997, p. 15 - 16)

This thesis focuses on physical infrastructure (hereafter called "infrastructure") projects. Such infrastructure projects tend to be large, dedicated systems tied to specific sites and involving many local users. Therefore, infrastructure projects require large

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[6] The explanations in this chapter are presented in a brief and simple manner because the intention here is to present a few key characteristics that would help readers follow subsequent valuation modeling, which is presented in the following chapter. For this purpose, I did not mention specifically economic theory perspectives regarding institutional forms of infrastructure provisions. For example, see books by Kessides (1993), Roth (1987), and Wolf (1988).

sums of money and long-term payout periods. In such systems, project operators face various uncertainties that are not only subject to the business cycle of the country, but also to the project-specific or location-specific variables, such as weather conditions, earthquakes, construction delays, and local competitors, which could result in either upside cash flow or downside cash flow potentials.

2-2   Government Principles behind Business Valuation of Infrastructure Projects

One benefit of applying business valuation for a government infrastructure project is to clearly assess financial input-output flows. Such valuation can serve as a cheap model that can simulate possible questions specific to the project before construction, and provide a benchmark of good operational performance after construction. For instance, if a rival transit system appeared, or if construction costs increased, the planners would have fall-back or contingency plans. Specific policy assessments using this model are further explored in section 4-2.

Another benefit of using this model is to determine the sales value of a privatization project. Since physical infrastructure projects require a long time to realize payoffs, it is in the taxpayer's interest to cover such costs from the sale of the projects. Moreover, governments could gain some profit when selling the asset. But how to determine the value is not an easy task because such value must reflect not only construction costs, but also the future cash flows based on forecasts of various variables (Cowan, 1990, p. 61).

Chapter 3

Probability-Generated Cash Flow, CAPM and APV

This chapter develops an illustrative cash flow model. Based partly on an actual project, I created a hypothetical highway project that is located in a town in an unspecified country.[7]

Appendix 1 provides further technical discussion on this model for readers who need more background. Specific input assumptions, such as costs, traffic volume, toll rates, funding, depreciation methods, are described in Appendix 2. Appendix 3 demonstrates the computer screens of this spreadsheet model.

3-1   A Hypothetical Highway Project

Suppose that a local governmental agency in a data-poor country is planning a highway project. And suppose that they would like this project to be financially self-supportive when it is constructed, but they will provide a level of subsidy for site acquisitions. That is, the government plans to contribute (acquire) land for the project, whereas the project entity will pay a predetermined amount after construction to lease the site from the government, regardless of how much the actual site costs. This means that the government will subsidize the project by the amount of the difference between the actual purchase price (government paid) and the present value of the lease payments:

$$\text{Subsidy} = \text{PV(price)} - \text{PV(lease)}$$

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[7] Based on Bangkok's Second Stage Expressway project (Tom, 1996), I used a general institutional framework of the operating body, toll rate, traffic volume and costs. Since the intention of this chapter is not to precisely replicate the actual project, I changed actual numbers and computations where information provided was insufficient.

To determine the business value of the project (this can be construed as "financial value" for readers who are more familiar to the latter term), by definition, one must conduct a discounted cash flow ("DCF") analysis. For this purpose, I assumed that the government planner of this project is interested in using the "opportunity cost of capital" concept to determine the project's discount rate.[8] Since the planning agency is not a private enterprise that can use any subjective discount rate for strategic reasons, the discount rate has to be generated based on some logic (government has the ultimate responsibility to explain it directly to the residents). The government body is also interested in measuring the magnitude (upside and downside potentials) of the business value. In addition, it will want to measure such business value by separate components, such as an estimated value generated from the project itself, the effect of the subsidy, the effect of tax deductions for capital depreciation ("depreciation-tax-shields") and the effect of tax deductions of interest payments for the construction loan ("interest-tax-shields"). We will use the "value additivity" principle to determine the business value.[9] Based on this principle, we will separate cash flows from the normal cash flow method into four components: (1) basic cash flow, (2) subsidy, (3) depreciation tax-shields, and (4) interest tax-shields.

To conduct a business valuation of an infrastructure project, it is important that its value is measured from the project's (operating entity's) perspective rather than an

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[8] The discount rate can be derived from either the opportunity cost of capital, investment rate of interest, or consumption rate of interest. The opportunity cost of capital reflects the best alternative use of capital for a specific entity or sector, thereby such an entity (and ultimately, the sector and the nation as a whole) will attain optimal resource allocation, provided that their allocation decision relies only on financial return or productive efficiency of their production resources. In theory, the above three measures shall equal the same value. Since government projects usually lack information on opportunity cost of capital, planners have used either of the other two methods as a proxy (Matsuno & Yaguchi, 1999, p. 26 – 27, 30).

[9] "The property value must equal the sum of the claims held by each of the claimants to the property (the equity investor and the debt investor)" (Geltner, 1998a, p. 62).

economy-wide perspective or any private developer's perspective. The reason is that the economy-wide costs and benefits cannot be evaluated within this closed model and a private developer's perspective is not always the same as the project's perspective. In specific, information such as socially optimal supply level and the consumers' willingness to pay, as well as effects of taxes passed on to consumers, cannot be determined by this model alone. Also, a private developer's value is a residual of operating profit less the government's share of profit less taxes, loan amortization and interests. On the other hand, a project's intrinsic value is the operating profit less taxes, plus implicit monetary injection from the government, such as subsidies and tax deductions.

It is noteworthy that a value from the project's perspective is different from society's (the public) view as a whole. The value from the project's perspective indicates a monetary input and output measure of benefits and costs that the project receives from and pays to the society. In other words, it indicates how much value the project receives from and how much value the project provides for the society, which can be seen as an external monetary input-output system from the project's perspective. Therefore, government cannot determine the social value of the project from the information in this closed financial model alone, but they can assess who will benefit and who will assume certain responsibilities to implement the project by this model. I will show more specific examples of this kind of assessment later as I develop the model based on a specific case.

3-2   Basic Cash Flow Component

I assumed that revenue is a function of traffic volume and toll rate. In other words, revenue will be generated from the number of vehicles travelling on the new highway who pay the toll. For example, in year 2:

Revenue, year 2 = traffic volume, year 2 × toll rate, year 2

The principal elements of business value is the cash flow from tolls that are derived from the above revenue, less expenditures, less taxes:

Basic cash flow, year 2 = revenue, year 2 – (capital expenditures + operating expenses + tax), year 2

Note that the tax amount here is not actually the paid amount. It is calculated as if interest payments and depreciation are taxable. The reason we do this is that we later will add the effects of the interest tax shields and depreciation tax shields to the basic cash flow.

Next, this basic cash flow is discounted by an opportunity cost of capital that is derived by (calculating an equation presented later in this chapter), using market indices, to determine the net present value of this cash flow component.

3-3   Government Subsidy Component

The implicit effect of a government subsidy should be added to the project's value because when government programs promote urban development projects, which means

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more inputs from society, the project's financial value shall subsequently increase (Geltner, 1998a, p. 61). To measure this effect, the subsidy for this project is valued as if it is a separate cash flow component (from the basic cash flow). This cash flow component is recognized as:

Capital grant, year 2 = site acquisition costs, true price, year 2 – lease payments, year 2

Such effects of the subsidy are evaluated separately from the basic cash flow because the discount rate - which will be determined later in this chapter - for the subsidy should be different from that of the basic cash flow.

3-4 Depreciation Tax Shields

In this proposed model, the effect of depreciation is evaluated separately from the basic cash flow because the discount rate, which will be determined later in this chapter, for depreciation is different from that of the basic cash flow.

The method of depreciation used in this model, a 20-year straight-line method with no final salvage value, is determined specifically for this project to show how to measure the effect of depreciation. To compute the effect of such depreciation scheme we separate such depreciation tax amounts from our basic cash flow, i.e., we calculate the basic cash flow as if the operator pays the fully taxed amount. Then we add back the deducted tax amount. The reason for this calculation is that this component is discounted by a different rate to measure the effect of such a depreciation framework.

Depreciation tax shield, year 2 = salvage value of capital, year 2 ×

depreciation rate × tax rate

3-5   Interest Tax Shields

For the same reason, interest tax shields are added back to the basic cash flow.

Interest tax shield, year 2 = interest accrued, year 2 × tax rate

This will be discounted by another rate later, to arrive at a net present value for this component.

3-6   Business Value

A single value of this project can be derived by adding all of the above net present values that are discounted by different rates, which will be determined for each component later on. This single value is technically called an "adjusted present value" ("APV") or "adjusted net present value" ("ANPV"). (The business value can be derived by any discount method, but in this thesis the adjusted present value is considered the business value of the project.)
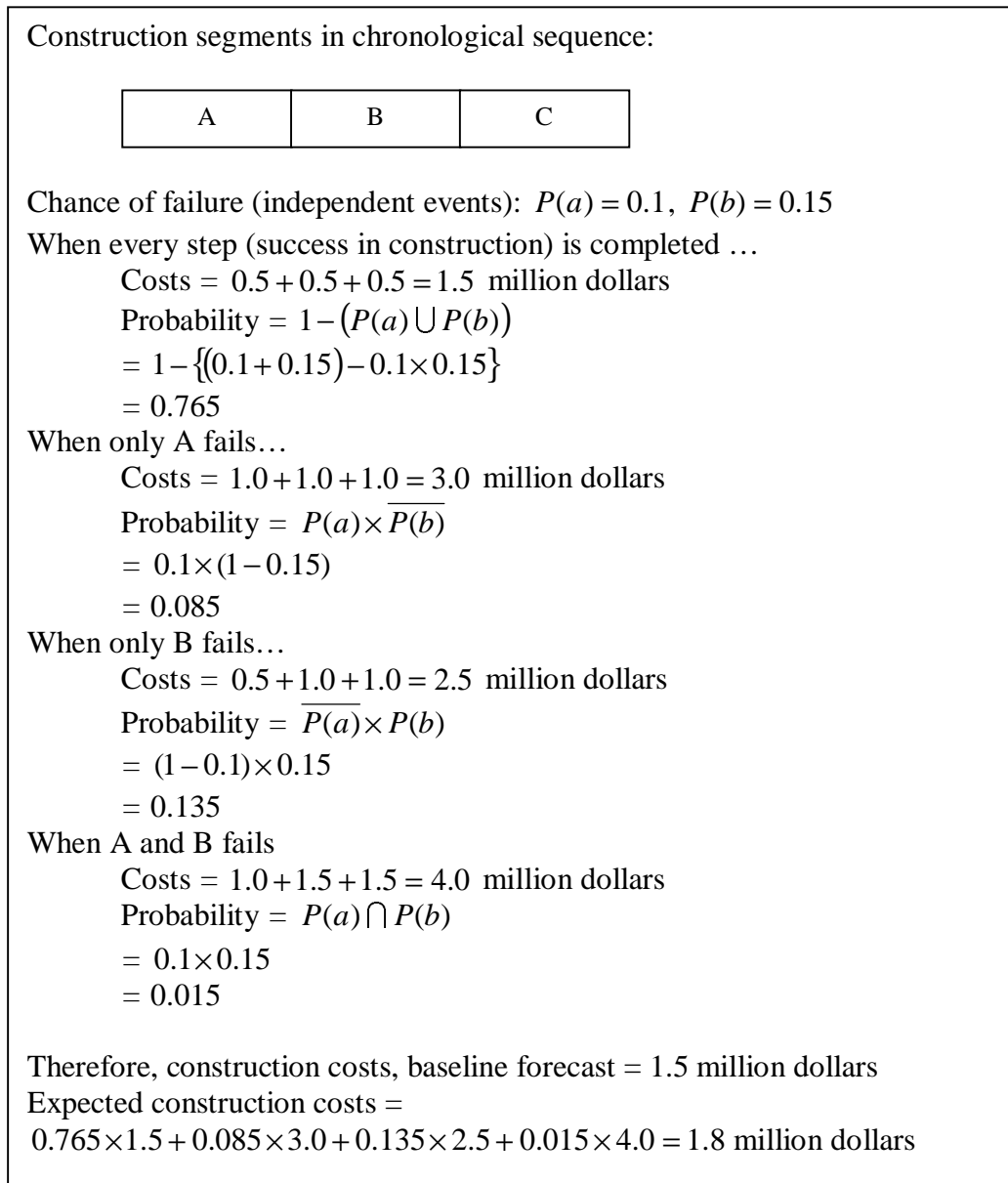
3-7   Simulation

Consider the following situation: A potential hotel owner wants to value a single hotel asset. Such a person may compute a typical value using the appropriate discount rate for the hotel industry, but what if a rival hotel is built across the street in three years? The original forecast could be reduced to 50%, remain unaffected, or could even increase

(for instance, because of agglomeration effects).[10] In another case, the following

example will explain such a difference between a forecast based on a 100% certain-world

and a probabilistic upside and downside world. Suppose construction segments A, B, and

C are linked chronologically. That is, our ultimate purpose is to finish segment C on time

and on budget. An unforeseen event (natural or human made), or failure, which may or

may not happen during segments A and B independently, shall incur additional costs (see

Figure 2).[11]

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[10] This example is generated from an article by Nygard and Razaire, 1999, p.69.
[11] This example is inferred from arguments on effects of supply failure by Braunschvig, 1984, p. 12.

Figure 2 Baseline forecast and expected value

Construction segments in chronological sequence:

A	B	C

Chance of failure (independent events): $P(a) = 0.1, \ P(b) = 0.15$

When every step (success in construction) is completed …

$$\text{Costs} = 0.5 + 0.5 + 0.5 = 1.5 \text{ million dollars}$$
$$\text{Probability} = 1 - \big(P(a) \cup P(b)\big)$$
$$= 1 - \{(0.1 + 0.15) - 0.1 \times 0.15\}$$
$$= 0.765$$

When only A fails…

$$\text{Costs} = 1.0 + 1.0 + 1.0 = 3.0 \text{ million dollars}$$
$$\text{Probability} = P(a) \times \overline{P(b)}$$
$$= 0.1 \times (1 - 0.15)$$
$$= 0.085$$

When only B fails…

$$\text{Costs} = 0.5 + 1.0 + 1.0 = 2.5 \text{ million dollars}$$
$$\text{Probability} = \overline{P(a)} \times P(b)$$
$$= (1 - 0.1) \times 0.15$$
$$= 0.135$$

When A and B fails

$$\text{Costs} = 1.0 + 1.5 + 1.5 = 4.0 \text{ million dollars}$$
$$\text{Probability} = P(a) \cap P(b)$$
$$= 0.1 \times 0.15$$
$$= 0.015$$

Therefore, construction costs, baseline forecast = 1.5 million dollars
Expected construction costs =
$0.765 \times 1.5 + 0.085 \times 3.0 + 0.135 \times 2.5 + 0.015 \times 4.0 = 1.8$ million dollars

(Source: author)

Therefore, if our forecast is based on a baseline forecast (1.5 million dollars), which is often called "best-estimate," it is likely that we will underestimate the construction costs (1.8 million dollars). Although this is an example of downside cash flow potential using costs as an uncertain variable, the same is true for upside cash flow

potential such as cost reductions and demand increases. In this thesis, I will show the degree to which the business values based on these forecasts differ, under certain probabilities and variable ranges.

To justify the value of a single asset in such situations from a single-asset owner's point of view (such as the aforementioned hotel owner, or a government that implements an infrastructure project), a Monte Carlo simulation is incorporated in this model. The Monte Carlo simulation in financial modeling was proposed by David Hertz and McKinsey and Company (Brealey & Myers, 1996, p. 247)[12], a management consultant, but has not been used commonly in business valuation practices.[13]

Using the CAPM theory, we can infer a mean discount rate for an individual asset assuming that such an individual asset (a hotel) behaves similarly to the average hotel across the industry relative to the performance of the country's stock market, which is presumed to reflect overall historical economic trends. However, this rate alone does not reflect uncertainties due to project-specific phenomena, or location-specific phenomena. In theory, capital-market investors can reduce ("diversify away") such location-specific risks by holding the stock of – or owning – various hotels in different locations in the country. But a single-asset investor who is considering an investment value of a single asset will likely have a different point of view, as in the case of above rival hotel, since such an owner takes on the risk of such location-specific phenomena.

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[12] Hertz (1968) as quoted by Brealey and Myers (1996).

[13] In recent articles, professional real estate appraisers and the World Bank independently demonstrated such a simulation model using real estate and infrastructure examples respectively in specific details (Nygard and Razaire, 1999; Dailami, Lipkovich, & Van Dyck, 1999). In their examples, they used certain discount rates after generating cash flow using the Monte Carlo simulation, but neither document mentioned how to determine the discount rates for such simulation models nor did they mention the relationship between the Monte Carlo simulation and CAPM discount rate. Yuichiro Kawaguchi, a professor of Japan's Meikai University, Department of Real Estate, has pointed out the option to combine

This thesis assumes that the location-specific phenomena represent most of the project-specific values when applicable, especially infrastructure assets. As explained in Chapter 2, infrastructure projects are location-specific in many respects such as capacity design, construction and the type of users. Therefore, if we can identify location-specific effects that are isolated from economy-wide phenomena, such effects are more likely to highlight the project-specific risks than any other projects that operate identically across the nation. Provided that such a premise is valid, this thesis indicates how one can build a Monte Carlo simulation model that can incorporate the CAPM discount rate. For illustration, the following five cash flow items are assumed location-specific phenomena and mostly sensitive to the project-specific value:[14]

- Traffic volume

- Traffic competition

- Site acquisition costs

- Construction costs

- Operating expenditures (Tom, 1996)

3-7-1   Traffic Volume

Actual traffic volume could be influenced by two major factors: economic climate and location-specific phenomena such as weather conditions, geographical distribution of population by occupation or income, patterns of local industrial linkages, and distance from other consumption (or industry) centers. As will be explained later, economic

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the Monte Carlo simulation and the CAPM or Arbitrage Pricing Model, (which takes into account more variables than the CAPM) to determine a discount rate (Kawaguchi, 2000).

climate is presumed to be incorporated in the baseline forecast and the CAPM discount rate. Therefore, traffic volume is simulated only to the extent that location-specific factors cause traffic volume fluctuation. Since the proposed highway is the first of its kind in this region, the planner does not have any comparable historical data within this region.

This thesis assumes that a single "best-estimate" ("baseline forecast") is provided by an engineering firm's technical department. Therefore, the model is built to randomly simulate such traffic volume based on a baseline forecast. Although combinations of random variables and time-series effects may be considered in estimating traffic volume of each year,[15] this model generates random variables independently across time. Also, logical consistency may support this method in a way that a baseline forecast (a static forecast) incorporates exogenous economic climates and is valued by a discount rate that incorporates the historical (dynamic) economy-wide behavior; this means that economy-wide effects do not need to be simulated in this model. From a practical point of view, replicating the historic data and incorporating it in a forecast requires much work and money; furthermore, such a forecast could be different from ex-post evaluation. Since the purpose of this business valuation is not to predict the future, I recommend a

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[14] The reason that this model does not consider user charge simulation is that the user charge shall be determined exogenously to the model (and less likely to catch up with abrupt events). Exception is IRR pricing, which is endogenously set so that the rate of return will achieve 15% (for example).

[15] One such pattern is proposed by Hurley (1998). He proposed that estimation error will be corrected over time and the forecasts will converge over time (Martingale process). Its use in cash flow forecast is demonstrated by the World Bank's INFRISK^{TM} model (Dailami, et al., 1999). But again, this method (Martingale process) deals with a time-series effect in ways that the first year's value evolves to the second year's value based on certain distribution patterns and ranges, and to the third year's value and so forth. For example, the INFRISK authors reported that toll road revenue follows beta distribution, and that exchange rates follow lognormal distribution. This process creates the universe, whereas the model in this thesis is approximating the universe by a discount rate.

combination of a CAPM discount rate and random cash flow simulation, as a matter of practical justification in determining business value.

The forecast error of traffic volume in year 2 is generated in such a way as:

Error, traffic volume, year 2 = baseline forecast, traffic volume, year 2 × RAND, year 2;

where RAND, year 2 = random variable, year 2 of an evenly distributed population between (–50%) and (+50%).[16]

The error range is tentatively set so that any person can replace the number based on preferred underlying assumptions.

When we can use a certain pattern of distribution in such a simulation, we may build the model so that the user can specify the types of distribution in the spreadsheet software's random number generation function.[17] But, for the sake of clarity and time, the model in this thesis is built to generate evenly distributed random variables.

3-7-2 Traffic Competition

This model assumes the effect of traffic competition. The traffic competition is Standard & Poor's concept for infrastructure finance rating (Standard and Poor's [S&P], 1998, p. 5). Any possible rival transportation system plans in the local area, such as upgrading existing highways or railways, can be considered rival plans. (That, however,

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[16] In the computer spreadsheet program software, Microsoft Excel®, this could be programmed as: RAND()*(50%-(-50%))+(-50%).

[17] In the Excel, we can choose this command from the pull-down menu "Tools" – "Data Analysis" – "Random Number Generation." And we can specify the types of distribution and ranges. Then, the Excel generates the random variables that fit within the specified distribution. However, since the Random Number Generation is not a repeatable function, the structure of the spreadsheet model has to be adjusted significantly from the model of this thesis.

does not always suggest a negative outcome for society). But in many cases such effects can be considered minimal because a new project may be designed to fit the regional plan. However, this section aims to show how to build a model that takes into account traffic competition from rival entrances.

This thesis employs the same logic that George Treyz presented in developing his regional econometric simulation model (Treyz, 1993, p. 17, 87, 98 – 100). Namely, regional investments cannot be readily predicted within a single region, single sector model, since they may include the past decisions of various regional sectors, abrupt entrances of external entrepreneurs or central government programs, and increasing demands of external regions (including foreign trade). Also, to predict optimal capital stock levels, such a model has to incorporate historical inventory adjustment process. As this thesis' scope is limited to a single region, single sector, and a single project's financial simulation, such investments can be considered exogenous variables. As a consequence, this model is built to randomly choose a single year of rival entrance.[18]

Once a year of entrance is chosen, traffic volumes of that year and the following years will be reduced by 10% of baseline forecasts. (This number is tentatively set.) In addition, this model considers the possibility of random forecast error of the $\pm 50\%$ range (tentative). Accordingly, this model simulates the traffic reduction as:

Volume reduction, traffic competition, year 2 = 10%×(1+RAND, year 2)×traffic volume, year 2, after simulation;

where RAND, year 2 = random variable, year 2, of an evenly distributed population between (–50%) and (+50%).

3-7-3 Site Acquisition Costs

Site acquisition costs will fluctuate during the construction phase depending on local factors such as land speculation, residents' refusal to sell, and price bid-ups (Tom, 1996, p.88). Since our project's city has no basis to estimate such fluctuations, random forecast error is tentatively assumed as:

Error, site acquisitions, year 2 = site acquisition costs, true price, year 2 $\times$ RAND, year 2;

where RAND, year 2 = random variable, year 2, of an evenly-distributed population between (–10%) and (+150%).[19]

Consequential losses in delays in site acquisitions are not specifically considered in this analysis (see **Appendix 1**).

3-7-4 Construction Costs

Construction costs could differ from the baseline forecast, if the baseline forecast does not include realistic contingency estimates that consider variables such as location-specific problems including weather delays, equipment importation problems and logistics errors, as well as skilled labor and material shortages (S&P, 1999, p. 43). Construction costs can be simulated in many ways.[20] In this model, fluctuation (forecast errors) in construction costs is randomly generated as follows:

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[18] The model is also built to consider the possibility of no rival entrance (see **Appendix 1**).
[19] RAND()*(150% - (-10%))+(-10%).
[20] For example, one can break down construction cost items into sequential categories to predict uncertainties more realistically (Braunschvig, 1984, p. 12). In that case, one can build the model in a way

Error, construction costs, year 2 = baseline forecast, year 2 × RAND, year 2;

where RAND, year 2 = random variable, year 2, of an evenly-distributed population between (–10%) and (+100%).

Again the range is tentatively specified and can be replaced with any numbers that users may feel appropriate.

3-7-5   Operating Expenditures

Likewise, errors in forecasting operating expenditures can be simulated as follows:

Error, operating expenditures, year 2 = baseline forecast, year 2 × RAND, year 2;

where RAND, year 2 = random variable, year 2, of an evenly distributed population between (–10%) and (+50%).

Again, the above range is tentatively set.

3-8-1   Discounted Cash Flow Method

Although the discounted cash flow (DCF) method is well known and has been used by both public and private investment planners, the difference between the project's

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that the first year's cost increase in one construction sequence is highly likely to increase the following year's cost of construction in that sequence (Nygard & Razaire, 1999, p. 72). See Appendix 1, 3-1 and 3-2.

internal rate of return (IRR) and the discount rate remains ambiguous. Therefore, the

implication of the DCF method in project modeling is clarified in the following steps:

1. Build a cash flow model that is comprised of expenditures and revenues

    over the project's life (see **Figure 3**).

Figure 3 A Model Cash Flow (for discussion in 3-8-1 only)

Year	0	1	2	3	4	5	6	7	8	9
Revenues			20	30	40	40	40	40	40	40
Expenditures	-50	-40	-10	-10	-10	-10	-10	-10	-10	-10
Cash Flow	-50	-40	10	20	30	30	30	30	30	30

(Source: author)

2. Compute the internal rate of return (IRR). In this case, IRR is 17.80%.

    This suggests that a single expenditure value, $119 (derived by using a

    discount rate of 17.80% for all of the expenditures), will return a single

    future revenue, $519 (derived by a compounding rate of 17.80% for all the

    revenues up to year 9). This means that the project is equivalent to a 10-

    year, zero-coupon bond that sells for $119 initially, and pays $519 in 10

    years. In other words, the claim to the future cash flow that will be worth

    $519 in 10 years is $119 today.

3. Next, we must ask, is the project's value is truly $119 today? The answer

    is that, if discounted by IRR (17.80%), the project's value is $0[21] because

    we observed that IRR is a measure of a return that a series of expenditures

will generate. However, such a return does not indicate an opportunity cost of capital. When we assess a project's financial value, we have to discount it by an opportunity cost of capital that represents the best alternative use of such an investor's budget. Since the project in question alone cannot determine the best alternative use of such a budget, the opportunity cost of capital is determined exogenously to the model, as explained later in section 3-8-2.

Suppose the appropriate opportunity cost of capital for the above project is determined as 10%, then the project's net present value (NPV) is:

$$NPV @ 10\% = \left(\sum_{t=0}^{9} \frac{\text{revenue}_t}{1.1^t} \right) - \left(\sum_{t=0}^{9} \frac{\text{expenditure}_t}{1.1^t} \right)$$

$$= \left(\frac{40}{1.10^9} + \frac{40}{1.10^8} + \frac{40}{1.10^7} + \frac{40}{1.10^6} + \frac{40}{1.10^5} + \frac{40}{1.10^4} + \frac{30}{1.10^3} + \frac{20}{1.10^2} \right) -$$

$$\left(\frac{10}{1.10^9} + \frac{10}{1.10^8} + \frac{10}{1.10^7} + \frac{10}{1.10^6} + \frac{10}{1.10^5} + \frac{10}{1.10^4} + \frac{10}{1.10^3} + \frac{10}{1.10^2} + \frac{40}{1.10^1} + \frac{50}{1.10^0} \right)$$

$$= \$35$$

This means that if the project yields 10%, the future onetime payment will be:

$$\left(\sum_{t=0}^{9} \frac{\text{expenditure}_t}{1.1^t} \right) \times 1.1^9 = \$318$$

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[21] $\dfrac{\$519}{(1.1780)^9} - \$119 = \$0$

However, in reality, the project will generate more than $318. The present value of such an excess amount is actually $35. We can check this by adding the future value of $35 to the above 10% yield value, $318:

$$\$318 + \$35 \times 1.1^9 = \$400$$

This amount is exactly the same as the future value of the entire revenue stream:

$$\sum_{t=0}^{9} \left(\text{revenue}_t \times 1.1^{9-t} \right) = \$400$$

Therefore, this project's financial payoff is determined as $35 instead of $0. In this way, the business value is determined by a discount rate that is determined exogenously to the model.[22]

3-8-2 Discount Rates

Using the CAPM, the project's discount rate can be determined by a formula that is calculated exogenously to the cash flow model (see **Appendix 1, 4** for more details):

Expected return of an individual asset, $r_i = r_f + \beta_i \times \left(r_m - r_f \right)$;

where r_f = risk-free interest rate

β_i = individual asset's "beta" value $= \dfrac{\text{cov}(r_i, r_m)}{\text{var}(r_m)} = \dfrac{\sigma_{i,m}}{\sigma_m^2}$

r_m = return of stock market portfolio.

Given that the government's budget is allocated for domestic projects, the planner recognizes that the domestic economy should be the direct measure of comparison for determining the appropriate opportunity cost of capital. In this regard, we know the domestic risk-free interest rate of the country and the rate of return of the country's stock-market's portfolio. However, since this project is assumed to be the first of its kind in this country, the planner can not obtain the infrastructure's beta value (correlation with the stock market). Therefore, the planner could decide to choose comparable data from a foreign country. I assumed that the following method could be used to determine an appropriate beta value as a proxy for the infrastructure assets.

According to an empirical study concerning cost of capital for infrastructure projects by Alexander, Mayer and Weeds (1996), the cost of capital differs according to the underlying operational environment (such as price regulation, government control, ownership, industry structure, etc.) (p. 8). For example, the price cap mechanism, which is an underlying assumption of this project, essentially involves determining the nominal value of the user charge, regardless of current costs and demand and supply levels, unless the price cap mechanisms operate truly instantaneously (Alexander et al, 1996, p. 8, 9). Hence, the project should be operated so that it achieves a higher rate of return on average to allow for economy-wide fluctuations ("systematic risk"), since certain costs are beyond the control of the regulated pricing (Alexander et al., 1996, p. 9) (**Figure 4**).

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[22] For additional analysis on IRR and the discount rate from the real asset perspective, see Appendix 1, 4.

Figure 4 Asset beta, utility sector average across countries,[23] by price regulations

	Average beta[24]
Price and/or revenue cap	0.71
Discretionary[25]	0.60
ROR regulation	0.32

(Source: Alexander et. al., 1996, p. 29)

Although a question remains as to the proper level of profits that the infrastructure project should be allowed to garner, this thesis assumes that the appropriate discount rate is determined by the best alternative use of such a budget in capital markets, which trade private and public securities such as bonds and stocks.

In such capital markets, Alexander et al. (1996) revealed that government ownership, whether large or small, reduces the cost of capital, since the government will be an ultimate guarantor of any claims (p. 16). A question remains as to whether the government should bear such guarantees at the expense of the public treasury. But the government ownership is to be considered when one determines appropriate discount rate using the performance of the similar entity.

In this thesis's project case, vertical integration is less relevant because the toll road project was chosen, but it is worth noting the effect of industry integration on the opportunity cost of capital when one assess different types of projects. An integrated company may have businesses ranging from gas delivery, electricity generation and transmission, to water supplies. Since such an integrated company is likely to offset nation-wide economic fluctuations by vertical integration, the cost of capital for such company could be small (Alexander et al., 1996, p. 19 - 20).

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[23] United Kingdom, United States, Canada, Japan, Argentina, Chile, Germany, Spain, Sweden, Australia, and New Zealand.

[24] Industry averages across electricity, gas, energy, water and telecoms.

Diversification affects the project's cost of capital. For example, an entity may own non-infrastructure businesses such as engineering, property management and environmental services. These non-infrastructure areas are more vulnerable to economy-wide risks, so that these entities are more likely to have higher costs of capital (Alexander et al., 1996, p. 20).

International diversification influences the cost of capital.[26] Therefore, domestically oriented entities would be a suitable measure of comparison for this project.

Several indices are available from which to choose a beta value. For example, in the United States, beta values for AT&T relative to all publicly traded companies on the New York Stock Exchange (NYSE), and Dow Jones Composite 65 are readily available (**Figure 5**).

Figure 5 Daily asset beta estimates for AT&T against a different index

NYSE all shares	Dow Jones Composite 65
0.85	0.72

(Source, Alexander et. al., 1996)

Alexander, et al. (1996) recommend the Dow Jones Composite 65 for use as an appropriate beta for the utility industry because it contains only large companies that are frequently traded and therefore less prone to price adjustment lags (p. 25).

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[25] Discretionary systems are considered intermediate incentive effects. They have no explicit regulations but committees may review the prices (Alexander et al., 1996, p. 14).

[26] There are two perspectives: (1) International diversification should have higher expected costs of capital because it is far riskier than similar domestic projects in terms of regulatory and political risks (Alexander et. al., 1996, p. 21). (2) International diversification should have lower costs of capital because it is not the discount rate that adjusts risks of foreign operation, it is the cash flow that reflects actual risks, based on the mathematical definition of CAPM: Opportunity cost of capital is low when the correlation of the economy between the two countries is low (Shapiro, 1983, p. 41).

Another factor to consider is the return interval. Return data of publicly traded stock are taken daily, weekly, monthly, and longer. According to Alexander et al (1996), a beta value is systematically overestimated when returns are calculated using shorter interval returns. Likewise, a beta value is systematically underestimated when returns are calculated using longer interval returns. Alexander et al. (1996) suggested that daily estimates, if possible, are more indicative because they reflect frequent changes in operational and regulatory environments (p. 25). However, according to Geltner and Siegel, return intervals significantly affect the mean returns of a stock market (Geltner, 1998b, p. 37; Siegel, 1998, p. 13)[27]. This thesis assumes that daily returns in the past few years provide a close proxy for the opportunity cost of capital.[28] (The data available to the author of this thesis are limited to such short-term data.) However, since government projects are long-term, the appropriate opportunity cost of capital should be taken from long-term historical data where possible.

Where beta values significantly differ across companies, calculating an industry average should counter the bias of using a single company beta (Alexander et al., 1996, p. 26)[29]. The composition of comparable stock portfolios could lead to different beta values. For example, in a country where infrastructure and utility sectors occupy a large portion of the stock market, the beta values of such sectors tend to be high, due to the industry shares' relatively large degree of covariability with the market movement. On the other hand, in another country where such sectors occupy a small portion of the

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[27] Siegel (1998) reported that the U. S. stock markets' geometric-average nominal return over past 195 years was 8.4%, while it was 16.7% in the recent 15 years from 1982 to 1997, 11.5% in the recent 31 years from 1966 to 1997, 12.2% in the recent 51 years from 1946 to 1997.

[28] This is called the "random walk" hypothesis, an assumption when the modern portfolio theory was invented during 1960s. In such a world, the holding period does not affect the performance (Siegel, 1998, p. 25 – 37; Geltner, 1998b, p. 34 - 37).

[29] Alexander et al. (1996) simply calculated the arithmetic average (p.57).

securities market, the beta values of such sectors tend to be low (Alexander et al. 1996, p. 31).[30]

Also, debt ratios vary across companies. Therefore, the beta value has to be corrected based on the value additivity principle of beta:

$$\beta_i = (1 - D)\beta_E + D\beta_D\ ;$$

where β_i = beta value for an individual asset i

β_E = equity beta, which we usually observe from stock market data

β_D = debt beta

D= debt ratio = (debt) / (debt + equity)

Since debt beta is considered marginal,[31] corrections for obtaining asset beta can be done by:

$$\beta_i = \beta_E(1 - D)$$

In this thesis, the asset beta of this highway project is assumed to be, for instance, an arithmetic average of 0.46 based on the U.K. utility sectors average (see **Figure 6**).

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[30] For example, Alexander et al. reported that UK utilities, which occupy a large portion of the national stock market, have large betas compared with US utilities, which occupy a small portion and act as regionally isolated players (Alexander et al., 1996, p. 31). See below table for average betas of these countries.

	Electricity	Gas	Energy	Water	Telecoms
UK	0.60	0.84	-	0.67	0.87
US	0.30	0.20	0.25	0.29	0.72

(Source: Alexander et al., 1996, p. 27)

Because no better alternative data are available to the author at this time, I assumed that, of the many aspects measured by the above criteria, the U.K. regional utility sectors are the closest proxies of the regional highway's expected performance in the country of this project case. Among all, the possible major reason would be the similarity of, for example, pricing regulations, industry structures, and the sector's relative size of the national stock market.

Figure 6 Average betas of UK utility companies[32]

UK regional electricity companies

	Eastern	East Midlands	London	Manweb	Midlands	Northern
beta	0.55	0.56	0.59	0.57	0.56	0.54

electricity continued

	Norweb	SEEBOARD	Southern	South Wales	South Western
beta	0.59	0.64	0.61	0.61	0.52

electricity continued

	Yorkshire
beta	0.56

UK regional water companies

	Anglian	Northumbrian	North West	Severn Trent	Southern
beta	0.53	0.66	0.71	0.79	0.60

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[31] Alexander et al. (1996) examined the observed effect of the debt beta and reported such an effect was marginal (p. 42 - 44).

[32] These data are calculated from daily averages over 5 years.

water continued

	South West	Thames	Welsh	Wessex	Yorkshire
beta	0.87	0.63	0.76	0.66	0.53

(Source: Alexander et al., 1996, p. 50)

In this thesis, the risk-free interest rate is temporarily assumed to be 6.00% and the mean of the stock market returns is assumed to be 8.00% in this country (i.e., the stock market's risk premium is 2.00%, for calculation purposes).[33] With this information, the discount rate for the basic cash flow is computed as:

$$r_i = r_f + \beta_i \times (r_m - r_f)$$

$$= 6.00\% + 0.46\,(0.02)$$

$$= 6.92\%$$

Determining discount rates for subsidies, interest tax shields, and depreciation tax shields requires thoughtful analysis, rather than mechanical determination of the discount rate for the basic cash flow as in above example. One penetrating philosophy is that in this model, the discount rates of each cash flow components are determined based on capital markets' perception on the risk-return measure.

Accordingly, the subsidy discount rate for this model reflects the risk-premium that the capital markets placed on the government authority. For example, if the site acquisition is paid by the government's bond issue, the same opportunity cost of capital

can be adopted as the subsidy discount rate in this model (Tom, 1996, p. 78). The underlying assumption is that the failure risk of a government in delivering land would be the same as that of the default risk of such a government. In this thesis, the risk free rate is set as 6.00% and such a default premium is assumed to be inferred from the default premium on the government's bond (1.00%). Accordingly, the model's subsidy discount rate for this project is assumed to be 7.00% (= 6.00%+1.00%).

Depreciation tax shields are receivable only to the extent that the project is financially viable. In such a context, the rate is considered the same as the debt cost of capital for this project's loan, 12%. Since depreciation tax shields are considered tax-deductibles and therefore tax-free, the loan's cost of capital of 12% is further reduced by the tax rate for this purpose (Tom, 1996, p. 78). Therefore, depreciation discount rate is:

$$12\% \, (1\text{-}tax\%) = 12\% \, (70\%) = 8.4\%$$

Interest tax shields are discounted by the same rate as the borrowing rate of 12% because project money has already been borrowed at a 12% interest rate but is reimbursed by the government as a tax-deductible item (Shapiro, 1983, p. 28; Geltner, 1998a, p. 61; Tom, 1996, p. 78).

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[33] One can collect these data from published data, such as Ibbotson Associates, Inc. (1999), Erik Banks (1994), International Finance Corporation (1999), and S&P (2000).

Chapter 4

Interpreting the Results

Using the above cash flow model, I simulate the cash flows of this hypothetical project 1,000 times. In this chapter, I will show how the mean business value is different from the traditional net present values (NPV). Factors such as discount rates and implicit capital grant (subsidy) will explain the major difference. The simulation patterns and magnitudes are another factors that affect the mean business value.

In section 4-1, we will see how the business values in the two methods differ based on the baseline forecast scenario, which excludes the effects of the random simulation.

4-1   NPV and APV/CAPM Comparison (Baseline Forecast)

On the basis of the baseline forecast (before generating random variables), the business values generated by the single-discount rate (NPV) and by the multiple discount rate using CAPM (APV/CAPM) are compared (**Figure 7**).

Figure 7 Comparison of Business Values based on the Baseline Forecast

	APV/CAPM	NPV	Difference	% under-estimate (Diff./NPV)
NPV@8%	50,764	30,790	(19,974)	65%
NPV@10%	50,764	20,736	(30,028)	145%
NPV@12%	50,764	13,719	(37,045)	270%

(Source: author)

Namely, in this project (before random simulation), the APV/CAPM is higher than the NPVs in multiples of 1.65, 2.45, and 3.70 times, respectively.

The major reason for the differences in such values between the APV/CAPM and

NPV is the differences of discount rates between the APV method and the NPV method.

In **Figure 8**, we observe that the large difference was generated in (1) subsidy and (2)

overall discount rates. However, as the NPV discount rate increases, the significance of

these factors change. This means that the discount rates are the primary factor of the

difference of the business values between these two methods, and secondary factors are

the values generated by subsidy, depending on the magnitude of the implicit capital grant.

Figure 8 Difference of Business Values due to Different Discount Rates, by Components, based on Baseline Forecast

| | Difference by components | | | | | | | |
	APV (Basic CF)	%	APV (Subsidy)	%	APV (DTS+ITS)	%	Total	%
NPV@8%	4,085	20%	11,403	57%	4,486	22%	(19,974)	100%
NPV@10%	14,139	47%	11,403	38%	4,486	15%	(30,028)	100%
NPV@12%	21,156	57%	11,403	31%	4,486	12%	(37,045)	100%

(Source: author)

4-2   Effects of Random Simulation

In this section, we will examine how business values deviate from the baseline

forecast. To observe the effects of each random variable, we simulate each variable

separately and take the mean values. The mean value is determined as the arithmetic

average of 1,000 business values based on the assumption that such random variables are

evenly distributed:

$$\mu = \frac{\sum_{i=1}^{1000} APV_i}{1000}$$

Before we evaluate such effects in detail, the following sections 4-2-1 to 4-2-5 briefly show the independent results of each simulation.

4-2-1 Traffic Volume Simulation

The mean business value of the 1,000 simulations (randomly generated simulations in the range of $\pm 50\%$) of the traffic volume is 50,770.

4-2-2 Traffic competition

In this simulation, the year of rival entrance is randomly generated so that the chance of occurrence falls within 40% over 1,000 simulations. Once such a rival entrance occurred, traffic competition begins, and subsequent revenues decrease by 10%. In addition, this reduction rate is randomly simulated within $\pm 50\%$ range (see Appendix 1, 1 for detailed explanation). The mean business value of the 1,000 simulations of traffic competition is 49,845.

4-2-3 Construction Costs Simulation

The mean business value of the 1,000 simulations (randomly generated simulations ranging between –10% and +100%) of the construction costs is 44,635.

4-2-4 Operating Costs Simulation

The mean business value of the 1,000 simulations (randomly generated simulations in the range between –10% and +50%) of the operating costs is 48,806.

4-2-5 Site Acquisitions Costs Simulation

The mean business value of the 1,000 simulations (randomly generated simulations in the –10% and +150% range) of the site acquisitions costs is 60,872.

4-2-6 Simulations of All Variables

When all of the above variables are simulated 1,000 times, the mean business

value is 52,059. This number is 1,295 larger than the baseline business value, 50,764.

Since all of the above variables are additive (not multiple) variables to a business value,

the effects of each independent simulation can be simply added (**Figure 9**):

Figure 9 Effects of Separate Simulations (Mean Business Value, 1,000 runs)

(Separate Simulations)	(Baht)	(Differences from the baseline)
Baseline Business Value	50,764	-
Traffic Volume ($\pm 50\%$)	50,770	+7
Traffic Competition (40% chance of random entrance with –10% volume reduction)	49,845	–919
Construction Costs (–10%/+100%)	44,635	–6,129
Operating Costs (–10%/+50%)	48,806	–1,958
Site Acquisitions Costs (–10%/+150%)	60,872	+10,108
Total Difference	-	+1,109
All Simulated Business Value	52,059	+1,295

(Source: author)

Next, the above random variables are simulated simultaneously to make sure that

the same degrees of differences are observed (**Figure 10**).

Figure 10 Effects of Compounded Simulations (Mean Business Values, 1,000 runs)

(Compounded Simulations)	(Baht)	(Difference)
Baseline Business Value	50,764	-
+Traffic Volume ($\pm 50\%$)	50,776	+12
+Traffic Competition (40% chance of random entrance with –10% volume reduction)	49,777	–999
+Construction Costs (–10%/+100%)	43,704	–6,073
+Operating Costs (–10%/+50%)	41,625	–2,079
+Site Acquisitions Costs (–10%/+150%)	51,859	+10,234
Total Difference	-	+1,095

(Source: author)

4-3   Effects of Patterns of Random Variables

In this section information based on observation is provided so that one can preliminarily assess the sensitivity of the patterns of simulation.

As we saw in the traffic volume simulation in Figure 9, the change in mean business value implies that the effect is marginal (close to the baseline forecast) when the value is simulated symmetrically. It holds regardless of the magnitude of the simulation (I observed this by changing the magnitude such as $\pm 10\%$, $\pm 50\%$ and $\pm 100\%$: see **Figure 11**.)

Figure 11 Effects of Magnitude of Symmetric Simulation (Mean Business Values, 1,000 runs)

(Magnitude of Simulations)	(Mean Business Values, Baht)	(Differences from Baseline)
Traffic Volume ±10%	50,781	+17
Traffic Volume ±50%	50,776	+12
Traffic Volume ±100%:	50,612	-152

(Source: author)

Next, to evaluate the extent to which the various user-specified patterns affect a mean business value, the major variables are simulated asymmetrically (**Figure 12**).

Figure 12 Effects of Asymmetric Simulations (Mean Business Values, 1,000 runs)

(Separate Simulations)	(Baht)	(Differences from the baseline)
Baseline Business Value	50,764	-
Traffic Volume (0%/+50%)	63,790	+13,026
Traffic Volume (–50%/0%)	37,756	–13,008
Construction Costs (0%/+100%)	43,933	–6,831
Construction Costs (–100%/0%)	57,650	+6,886
Operating Costs (0%/+50%)	48,311	–2,453
Operating Costs (–50%/0%)	53,221	+2,457
Site Acquisitions Costs (0%/+150%)	61,589	+10,825
Site Acquisitions Costs (–150%/0%)	39,816	–10,948

(Source: author)

In Figure 12, when all of these variables are combined, the total difference will be between –33,240 (assuming all downside risks) and +33,194 (assuming all upside risks), which is the $\pm 65\%$ ranges of the baseline business value. This suggests that the business values vary between 17,524 and 83,958, depending on both the patterns of distribution and the combination of the simulated variables.

4-4   Effects of Magnitudes of Random Variables

To show the extent to which the user-specified magnitudes of such random variables affect a mean business value, I increased the magnitudes of the major random variables by a multiple of 2, simulated them separately and recorded the mean business values (**Figure 13**).

Figure 13 Effects of Magnitudes of Random Variables (Mean Business Values, 1,000 runs)

(Separate Simulations)	(Baht)	(Differences from the baseline)
Baseline Business Value	50,764	-
Traffic Volume ($\pm 100\%$)	50,477	–287
Traffic Competition (80% chance of random entrance with –10% volume reduction)	48,713	–2,051
Construction Costs (–20%/+200%)	38,586	–12,178
Operating Costs (–20%/+100%)	46,838	–3,926
Site Acquisitions Costs (–20%/+300%)	70,989	+20,225
Total Difference	-	–1,783
All Simulated Business Value	52,886	+2,122

(Source: author)

If we compare Figure 13 with Figure 9, we observe that the magnitude of the random variables affects a mean business value. When the magnitudes of the original simulation are doubled, the difference of the two mean business values is roughly twice that of the original simulation. However, in our hypothetical project case, the contribution to the value was slight (**Figure 14**). This can be construed as the risk-characteristics of the variables identified in this project. In Figure 9 and 13, we know that the positive effect (subsidy) and the negative effects (others) roughly cancel out each other in this hypothetical project case.

Figure 14 Mean Business Values by Magnitude of Simulations

(Separate Simulations)	(Baht)	(Differences from the baseline)
Simulation 1 (Figure 9)	52,059	+1,295
Simulation 2 (Figure 13)	52,886	+2,122

Although this model was not built to rely on different probabilistic patterns (this model relies on evenly distributed sample-spaces), the above two experiments (of the symmetric and asymmetric patterns) suggest that the business values also vary depending on the user-specified probabilities. As a conclusion on the effects of simulations, we observed that the distribution patterns, magnitudes and combinations of the variables affect the mean business value.

4-5   Policy Arguments

Here I present a few examples on how this model can be useful for government planners. The following examples concretely illustrate that this model is built to

elucidate the financial input-output interactions with the outer financial system, the society. While the question of the extent to which a government undertakes such responsibilities should be determined externally to this model, this model can provide some direction as to how to start the following assessments.

The significant differences in the business values between the simulated APV (52,059 Baht) and the NPV (13,719 ~ 30,790 Baht) implies that this project is financially self-sustainable without a need for this subsidy. For example, we observed that the government undertook the site acquisitions, thereby the project's intrinsic value increased by 10,108 Baht (Figure 9). In the meantime, we can infer that such a subsidy shifts the financial responsibility from the operator to the taxpayers, which needs further examination from a public finance point of view.

Instead of the financial injection from the society, or instead of raising user charges, a project's financial accountability could be encouraged by variable tax rates. If legally and politically possible, as in oil and gas concession agreements in many countries, by separating a project's tax structure from a nation's general corporate or income tax law, the government could achieve price stability and provide operator incentives by allowing the project operator to recover adequate financial earnings. For example, if the operator's profit falls below a certain level (e.g., IRR<15%), the government allows the operator the lower tax rate or higher proportion of the operator's revenue share.

This model also implies that if this project is privatized, the government can make a deal with private developers in which the government does not guarantee the traffic revenue, which, based on this model that simulated 1,000 times, is likely to yield a

positive mean business value more so than the private investor's expected NPVs. In this way, governments can negotiate the deal structure of the privatized project in a way that does not force the public to bear undue risks.

What would this model's policy implication be when the government guarantees traffic volume? This means that government compensates for the downside risk, in which case this closed system receives a financial input from the society, thereby reducing the magnitude of the downward traffic volume simulation by the model. Such a guarantee will generate upwardly asymmetric forecast errors, which will yield a higher mean business-value for the project (as in Figure 12) at the expense of society. But again, this model alone does not solve the question of whether such an expense is appropriate from the public finance point of view.

Another policy example that this model can consider is illustrated in the case of the British M6 highway project (S&P, 1998, p. 3). In the M6 project, the government instead of users pays the project's toll revenues. This is called "shadow tolls" and it insulates users from the effect of their elasticity of demand. That is, the users are sheltered from price and therefore use is price inelastic, which eventually leads to less downside fluctuations of traffic volume. In contrast, the public should question whether government should bear such a responsibility. One advantage of involving the private sector is that government will bear less risk, such that the private operator both benefit and lose as demand fluctuates.

In the M6 project, construction was awarded to a private contractor on a turnkey, date-certain, lump-sum basis. That is, the contractor bears the risk of cost overruns. This means that construction costs will not change for the government and the project

throughout the construction (S&P, 1998, p. 3). Therefore, the model is likely to simulate

fewer construction costs, which may increase the mean business-value at the expense of

the private contractor.

Chapter 5

Conclusion

In this thesis, I built a business valuation model for location-specific infrastructure projects based on the following assumptions:

(1) The cash flow is separated into different project components according to the different opportunity costs of capital concept: basic cash flow, subsidies, depreciation tax shields, and interest tax shields.

(2) Such components can be valued properly by a discounted cash flow method using appropriate discount rates, such as the CAPM discount rate, domestic tax-free borrowing rate, and domestic after-tax borrowing rate.

(3) To compute a value that is suitable for a single-asset investor, project-specific values are incorporated in the basic cash flow component. Such values can be largely represented by location-specific phenomena and simulated by specifying the distribution patterns and the magnitude of ranges of the location-specific variables. In this thesis, such variables are randomly simulated from 1,000 evenly distributed sample spaces.

We observed that a set of business values would vary depending on the patterns and ranges of distributions we set. Also, we observed that a mean business value differs from the normal DCF method, which uses a single discount rate based on a single cash flow forecast. Also, in this building process, we learned that subsidies and tax incentives may have large effects on a project's intrinsic value. Likewise, we learned that by building this model, we perceived an infrastructure project as a closed financial system in

which we can assess the extent to which a government undertakes economic and financial responsibilities (section 4-5).

The process of building this model also raises some issues regarding privatization, which sometimes involves requests to the government to guarantee market risks, such as traffic-volume fluctuations. The model presented in this thesis suggests that, when traffic volume is highly likely to fluctuate from the baseline forecast, such a guarantee shifts market risks from the privatized project to the government. However, shifting such market risks from the private to the public means that the risk-benefit characteristics (upside and downside cash flow potentials) are left to the government, which may run counter to some of the objectives of privatization.

In conclusion, this model would be appropriate to objectively justify a business value of location-specific infrastructure projects, as well as a tool for discussing the issue of transfer of financial responsibilities. However, users must realize that this model evaluates only the financial responsibilities of governments and therefore is less useful for assessing political, economic and environmental issues that public decisions must consider. Below, I list the pros and cons of this model relative to a single, arbitrary discount-rate model based only on a fixed baseline forecast.

5-1   Advantages (Pros)

1) As discussed above, this model will help urban planners systematically understand the tradeoffs among policy purposes, economic-fluctuations, location-specific fluctuations, institutional framework and financial responsibilities in financial input-output context. In specific, planners can judge which component belongs to what risks and who can be responsible for

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each risk. For example, when an analysis is based on economic trends, a user

of this model will identify that such an analysis will relate to an increase or

decrease of the project's value (business value) through the changes in

baseline forecasts and risk-adjusted discount rates. When it comes to a

subsidy and taxation scheme, the planner will be able to better assess what

factors will increase or reduce the business value through the changes in the

level of subsidy, tax rates, or tax allowances, such as depreciation tax shields

and interest tax shields.

2) Planners can avoid unreliable business value based on subjective discount

rates. Also, by combining the objective discount rates and user-specified cash

flow simulations, planners can establish justification to decide on a financial

value of government infrastructure.

Overall, the first advantage presents technical benefits of this model when a

government officer assesses infrastructure projects from the public point of view. The

second advantage relates to tax-payers more directly: it presents a benchmark of the

project's value based on the assumed financial input-output relationship with the society.

5-2   Improvements needed

1) It is still likely that beta value and simulation patterns are not close proxies.

In such cases, this model will not be an appropriate measure of valuation:

explanatory variables in this model (economy–wide fluctuations represented

by stock market performance and location-specific phenomena represented by

cash flow simulation) may not be 100% explanatory.[34] Although technical

discussions to collect and process each type of data are beyond this thesis's

scope, it is clear that survey methods for observing alternative investment

opportunities, such as capital markets, and distribution patterns of the

probabilistic simulations will improve the reliability of this model. For

example, to calculate beta values, the average security returns of capital

markets must be calculated on a realistic time-horizon (Alexander et al., 1996,

p. 35).[35] In addition, the underlying assumption of this model's method of

beta-value estimation is that a foreign country's utility/infrastructure beta is

applicable to the planner's own country. This is backed by the premise that

today's capital markets are linked to the international climate and that

arbitrage opportunities correct differences in pricing (and thus returns) of the

national capital markets (Alexander et al., 1996, p. 36).

However, in a country such as Korea, where a small number of

companies dominate the national stock ownership, it is highly likely that such

indices are inapplicable to other countries since the behavior of these stocks

are insulated from the world (Alexander et al., 1996, p. 36). Also, the

different sizes of the stock markets may cause time differences in price

adjustment across different countries (Alexander et al., 1996, p. 40).

Therefore, if we pursue this thesis's method, we need to establish reliable

---

[34] According to Geltner (1998b), the comparable investment portfolio should include all the possible assets in the economy so the CAPM measure reflects realistic risk-return relationship. Such assets would include stocks, bonds, real estate, human resource investment, and various non-tradable assets (p. 36).

[35] If we assume that the random walk hypothesis holds for the economy's performance, modern portfolio theory suggests that the asset beta is constant regardless of time-horizon. However, Alexander et al. (1996, p. 57 - 60) and Siegel (1998, p. 13) pointed out that empirically, time-horizon has significant effect on beta values and return indices.

world indices that can be reasonably used by public valuers of infrastructure projects across different countries. The World Bank and rating agencies are the appropriate organizations to establish such indices, so that the survey's cost-effectiveness can be maximized, since such a survey ultimately will provide indices that can be used by many countries (positive externalities).

In addition, independent research to identify location-specific behaviors shall reinforce the reliability of this cash flow model. However, such research improves the reliability of the business value only if realistic production functions for each variable are programmed into the simulation model.

2) Since this model generates business values by ranges and the mean value of possible events, it can serve as a justification for determining a business value. But it should not be used to make operational decisions, such as production resource input and output levels, capacity design, and budget appropriation because the probabilistic simulation is based on the assumption that future variables are unpredictable and thus the pure contribution of changing these production resources is blurred in this model. In addition, the complexity of this model (multiple cash flow components) makes it impossible to provide quantitatively precise information for other types of sensitivity analysis, such as investment timing, interest rate changes, inflation changes, etc. Overall, simply running this model does not provide precise answers to various sensitivity questions.

5-3   Conclusion

Assuming that the valuation model of this thesis is plausible from both practical and theoretical points of views, the following logical conclusion may be drawn regarding how to handle the results of the simulation:

Infrastructure projects are unique, in terms of location, operational framework, and physical design and capacity. Therefore, there are no identical assets in reality such that similar transactions are iterated. In this regard, there seems to be no meaning to the process of computing the mean value of 1,000 simulations. For example, suppose that a person must choose one piece of paper out of a bag that contains 1,000 pieces of paper on which different values are printed. And suppose that the person is allowed to pick such a piece of paper one time only. If the person is a manager of a public enterprise, who has no chance of repeating similar projects all over the world, it would be logical that the person would need to know the most-likely value within a certain range. In this regard, I recommend that a government assesses the financial value of an infrastructure project based on a modal interval. For illustration, I arbitrarily determined 5% increment intervals starting from the minimum business value. Next, we construct a histogram based on such interval ranges. Using this histogram, we can detect the modal value interval (the highest bar) (**Figure 15**).

Figure 15 Frequency Distribution of 1,000 Possible Business Values by 5% Intervals
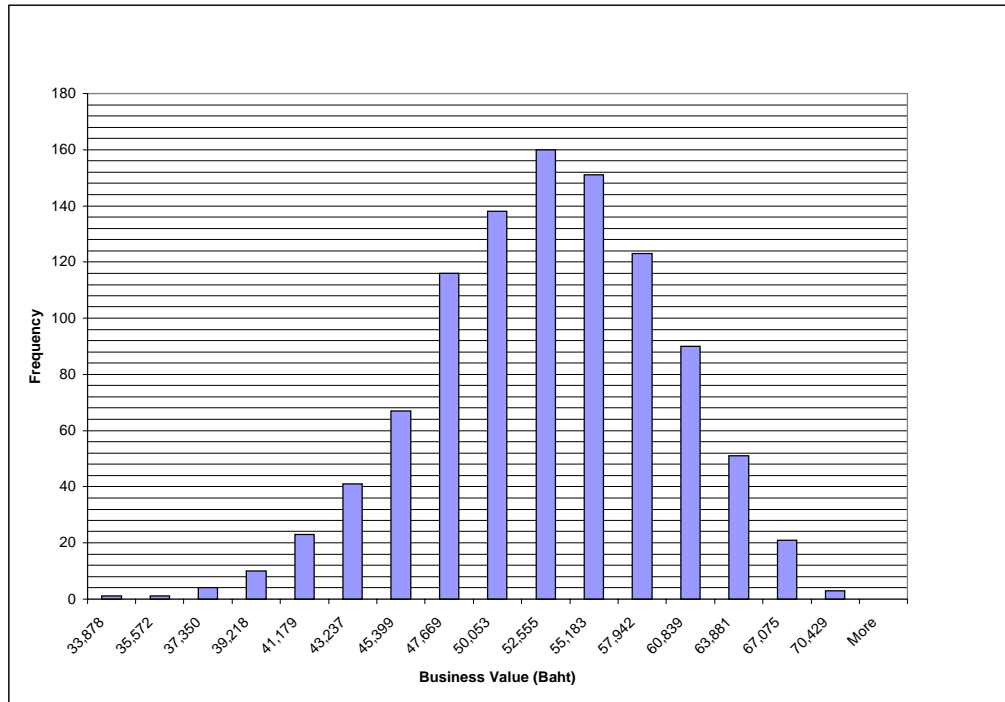
(Source: author)

In the above figure, the modal interval of the business values is between 50,053 and 52,555 with a frequency of 160. This means that a planner is most likely to draw a piece of paper with a value slightly above or below ($\pm 2.5\%$) 51,355 (the mean value within this interval) with a 16% chance of drawing.

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Appendix 1

Further Technical Discussions

This part contains supplemental information such as technical descriptions of spreadsheet modeling and some mathematical analysis tools. The latter tools were originally developed for financial products, but I believe that these are also useful for urban or investment planners who want to intuitively understand a construction project's financial sensitivity to hypothetical questions, such as a delay in the construction schedule or a 1% increase in market interest rates.

1. Rival Entrance

This model randomly chooses a single year of rival entrance. Also, no new rivals could enter during the project's life in this model.

RANDBETWEEN (1993, 2019+x);

where x can be any integer, according to a planner's intuition.

For example, if 40 is entered for x, the likelihood of a rival entrance during the project life can be assessed by calculating:

(Project life)/(Time horizon, rival entrance) =

$$\frac{(2019-1993+1)}{(2019+40-1993+1)} = 40\%$$

2. Site Acquisition Delay

In projects such as highways, delays in site acquisition (or any other causes that delay the completion) may cause significant financial losses due to delays in the construction schedule. In extreme instances, the project could be terminated before operations begin. In another instance, consequential delays in the revenue stream could cause a significant impact from a financial perspective. For example, one can conduct a simple analysis using a stylized equation. For analysis, we consider the project's cash flow stream as if it were a long-term bond with constant incoming coupon-payments without balloon payments (no final principal reimbursement). If so, the present value of the project is:

$$pv = \frac{c}{r} \times \left(1 - \frac{1}{(1+r)^n} \right);$$

where

c = coupon (constant payment cash flows)

r = discount rate

n = project life

If the operation commencement is delayed because of delays in site acquisitions, and if the project's revenue stream is postponed to the x th year, the present value will be:

$$pv' = \frac{c}{r} \times \left(1 - \frac{1}{(1+r)^n} \right) \times \frac{1}{(1+r)^x}$$

In one way, the financial loss in the project delay can be represented by two variables:

$$\frac{pv'}{pv} = \frac{1}{(1+r)^x}$$

If we plug in: r = 10% and x = 1,2, and 3, then $\frac{pv'}{pv} \approx 91\%$ when the delay is 1 year, 83% when the delay is 2 years, and 75% (25% decrease) when delay is 3 years, regardless of the revenue stream. This holds true as long as the revenues are postponed without changing the face value.

In addition, because of the delayed operation periods, the revenues may be exposed to uncertainties that could change the discount rate. Such an effect can be illustrated using a financial concept, "modified duration" (Gromb, 1998a, p. 15 - 19).

Modified duration[36] (MD) is a proxy measure of sensitivity to a change in its discount rate such that:

$$- MD \times \Delta r \approx \frac{\Delta pv}{pv}$$

This means that if r increases by 1% (due to an increase in interest rates or any other reasons that may cause the discount rate to rise such as an increase in government bond yields, or increased risk exposure), the present value of the revenue stream results in

---

[36] Modified duration was devised in 1939 by J. R. Hicks (independently from Macaulay, the inventor of duration) (Salomon Brothers, 1985, p. 11).

a decrease (- MD%) in today's value. A modified duration, which has no unit but is

called "years," can be derived as follows:

$$MD = \frac{D}{1+r};$$

where D is "duration"[37] and is construed as the weighted average of time,

weighted by present values of cash flows in each year:

$$D = \sum_{t=1}^{n} \left[\frac{CF_t/(1+r)^t}{\sum_{t=1}^{n} \left\{ CF_t/(1+r)^t \right\}} \times t \right]$$

Note that modified duration is only approximate and is valid within a limited

increase in the discount rate, as illustrated by the following (**Figure 16**):

---

[37] The concept of duration was first put forth by Frederick Macaulay in 1938, and rediscovered in the 1970s (Salomon Brothers, 1985, p.1).

Figure 16 True Present Value and Modified-Duration (inferred) Present Value
(Test demonstration with 10-year, constant payment cash flows of $100
per year)
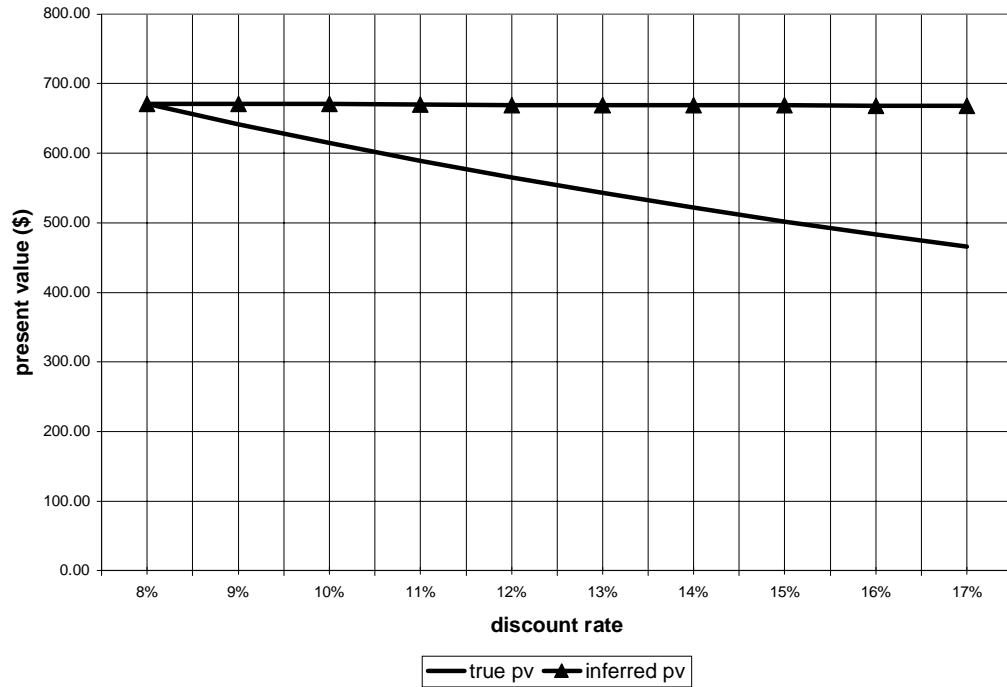
(Source: author)

Mathematically, the modified duration of a constant revenue stream can be conveniently expressed by only two factors: discount rate and time (year) (Gromb, 1998a, p. 18):

$$MD = \left[\frac{1+r}{r} - \frac{t}{(1+r)^t - 1} \right] \times \frac{1}{1+r}$$

As seen in the above figure, modified duration will be the close approximate measure only if one anticipates a 1% or 2% change in the discount rate.[38]

In summary, the financial consequence of a delay in site acquisition could have two effects: (1) the present value could change due to the time discount effect as illustrated by pv'/pv, and (2) the present value could increase or decrease because of the decrease or increase in the long-term opportunity cost of capital, as demonstrated by the modified duration concept.

I have provided useful technical tools to assess a project from a financial perspective only. In this regard, one should be aware that the planning process can be seen, in one way, as a conflict between these environmental variables and ultimate goals (Braunschvig, 1984, p. 7 - 8). In the site acquisition context, the above technical considerations are dictated only by environmental variables that should never prevail in the implementation process without satisfying the residents' interests.

3. Construction Costs

3-1 Developing Random Errors

An abrupt increase in construction costs in year 2 is likely to increase the costs in year 3 due to construction difficulties, delays in procurements, and changes in methods and design.

For example, if a cost increase in year 2 occurs, the model can be designed so that the cost increase in year 3 has a 30% chance of increase between 0% and 15%, and 70% chance of increase between 15% and 50%.

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[38] If the increase exceeds, we can say that the value decline will be more significant. There is a method to correct approximately this error using a quadratic derivative (Gromb, 1998a, p. 25):

$$\Delta pv / pv \approx -MD \times \Delta r + C \times (\Delta r)^2, \text{ where } C = (1/pv) \times 1/2 \times (\delta^2 pv)/(\delta r^2).$$

Using the Excel spreadsheet program, this can be expressed as:

IF(error, cost, year 2>0,IF(RAND()<0.3,RAND()*(0.15-

0)+0,RAND()*(0.5-0.15)+0.15),RAND()*(0.5-0)+0)[39]

3-2   Separation of Construction Segments

Forecast errors of construction costs can be simulated differently according to the construction sequence. Suppose we utilize the following construction sequence A, B and C (**Figure 17**):

Figure 17 Construction Sequence A, B and C
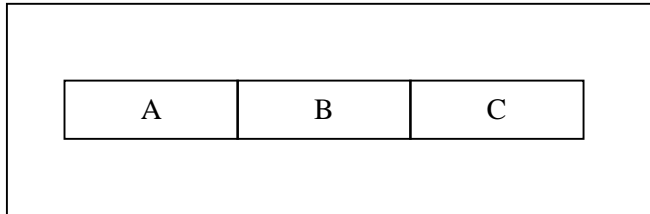
(Source: author)

(1) When A, B and C are linked chronologically, a failure of one segment will jeopardize all other lower segments. But if A and B is substitutable with alternative segments A' and B' respectively, then the likelihood of consequential damages in carrying out segment C can be reduced (Braunschvig, 1984, p. 12).

(2) Also, if the sequence can be implemented independently and simultaneously, the consequential damage in carrying out segment C will be reduced (**Figure 18**) (Braunschvig, 1984, p. 12).

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[39] According to Nygard & Razaire (1999), if the second IF formula is run 1,000 times, it generates approximately 300 values that fit between 0 and 0.15, and 700 values that fit between 0.15 and 0.5 (p. 69).

Figure 18 Separation of Construction Sequence by Segments
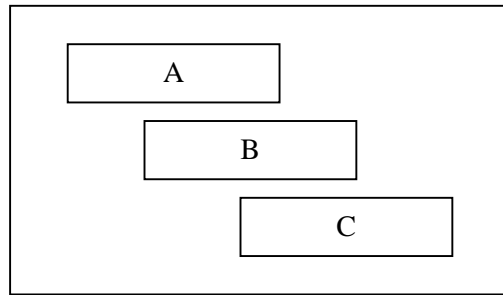
(Source: author)

In summary, by considering substitution and the separation of construction sequences, one can estimate forecast errors independently (albeit not perfectly independent) from failures in other construction segments.

4.   **An Additional Analysis on the IRR and Discount Rate from the Real Asset Perspective**[40]

A bond's rate of return ("yield") is comprised of the three components (**Figure 19**):

Figure 19 A Bond's Rate of Return by Risk Components
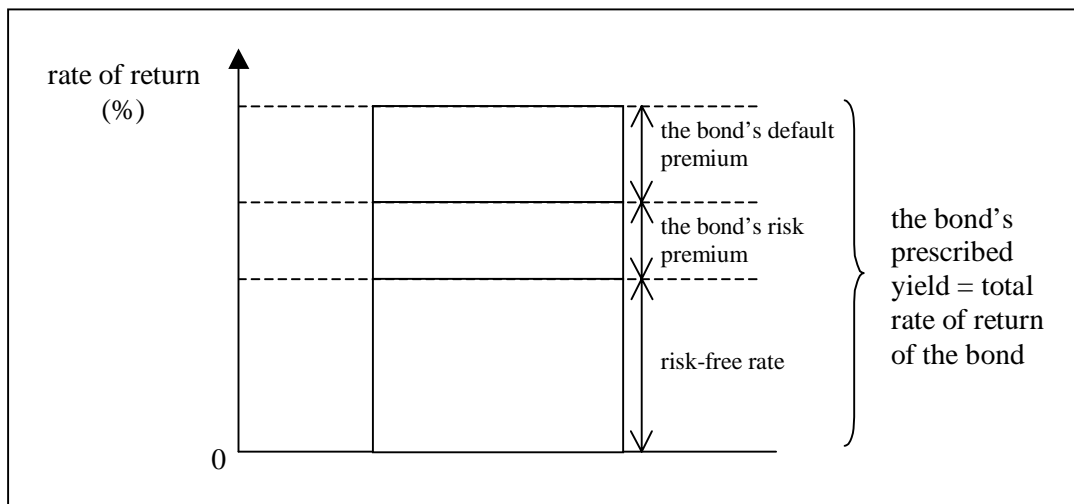
(Source: author)

According to the modern portfolio theory, the CAPM measures only the risk-free rate and the bond's risk premium. The remaining premium, the default premium, is considered project-specific risk-return and therefore, is diversified away by holding many securities with different default risks. This is analogous to the real asset perspective. If we regard the above bond as a project, we can replace two of the above premiums with the project-specific risk premium and the capital market's risk premium (expected rate of return from the best alternative use perspective in the capital market) as follows (**Figure 20**):

Figure 20 A Project's Rate of Return by Risk Components
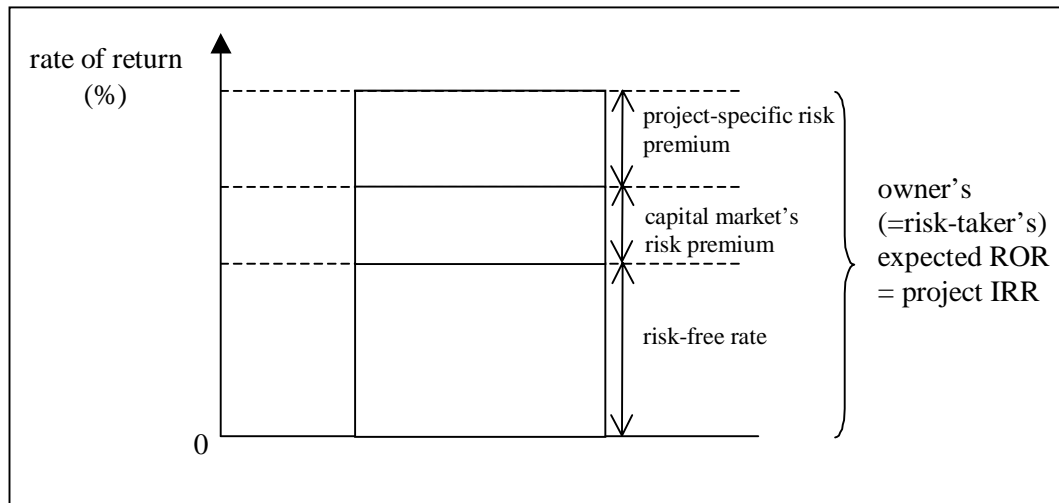
(Source: author)

What this suggests is that the owner, who is the project-specific risk-taker, deserves a reward for undertaking such risks: the value of such reward should be, as we saw in the DCF example in section 3-8-1, the net present value discounted by the capital market's opportunity cost of capital.

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[40] This argument is generated from Gromb, 1998c, p. 27 - 28, 31.

5.   A Brief Review of the Capital Asset Pricing Model (CAPM) (Gromb 1998d, p. 26 – 27, 30)

The CAPM, in terms of real asset valuation, adopts an appropriate discount rate based on the assumption that an individual asset's opportunity cost of capital can be inferred from the best alternative use of capital, which is a market portfolio in capital markets. Such a measure of comparison could be refuted as inappropriate for policy planners, whose purpose is to deploy capital for purposes other than market-based sectors. For example, planners may use the money for non-commercial sectors such as low-income housing, social welfare or disease control. Therefore, the business value inferred from the CAPM rate should not be construed as true value for the government. Instead, it should be regarded as one indicator of financial and operational soundness of that infrastructure project provided that capital markets, which are comprised of securities (including stocks and bonds) of various companies and government bodies, provide a comparable measure of value from society as a whole.

5-1   A Brief Review of the Optimal Portfolio Theory

The CAPM evolved from the optimal portfolio theory, which states that given any two assets (or securities) that have different mean returns and standard deviations ("volatility"), one can combine the two securities to gain a higher return with less volatility (as illustrated by a locus in **Figure 21**).[41]

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[41] This can be solved by minimizing the covariance of the two assets, subject to the changing holding ratio (weight) of these assets to be equal to 1.

Figure 21 Portfolio Returns and Volatilities of Two Assets
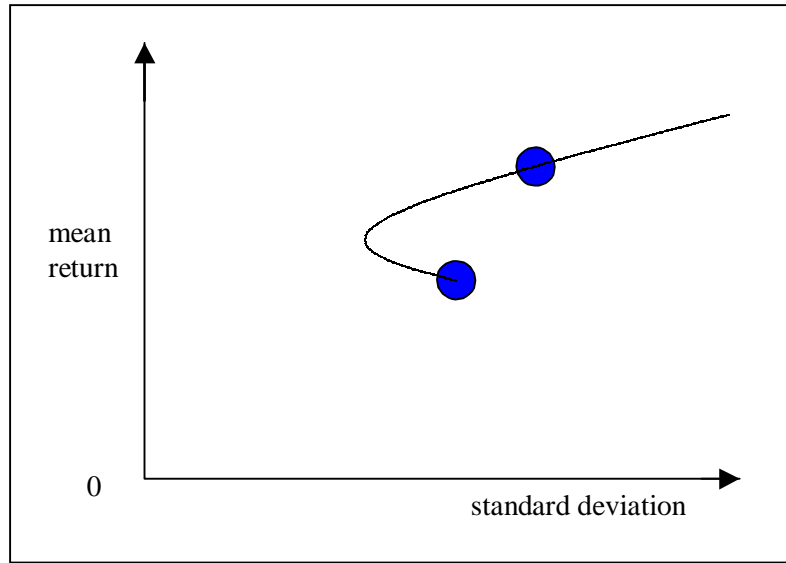
(Source: author)

Given that we know the mean returns of assets, a and b, the asset's holding ratio, or weight, ω, is derived by solving the following equation, for any r_P:

$$r_P = \omega r_a + (1-\omega)r_b$$

$$\therefore \omega = \frac{r_P - r_b}{r_a - r_b};$$

where $\omega =$ weight in asset a.

With such a set of ω and r_p, we can derive a locus by plugging-in such values to the following formula to derive standard deviations of the possible combinations of the portfolios a and b, for any given r_P:

$$\sigma_P = \sqrt{\omega^2\sigma_a^2 + (1-\omega)^2\sigma_b^2 + 2\omega(1-\omega)\sigma_{ab}}$$

By adding more assets, one can construct a more efficient portfolio, which has less volatility with more return. This is represented by a locus that is located on the more northwestern frontier (**Figure 22**).[42]

Figure 22 Portfolio Returns and Volatilities of Three Assets
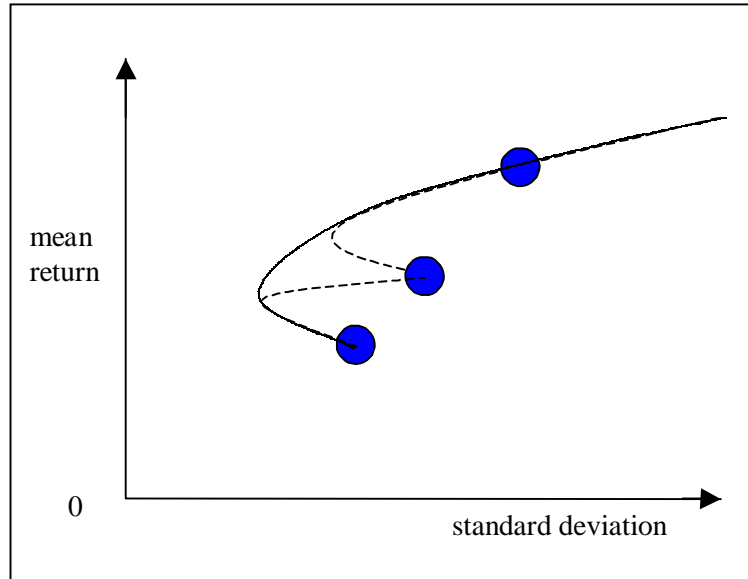
(Source: Geltener, 1998b, p. 19)

By combining a volatile portfolio and a risk-free bond such as a fixed-rate government bond that has 0 standard deviation, the solution set of the possible combination takes the form of a straight-line locus (**Figure 11**).

---

[42] Technically, as the number of assets increases, such optimal combination of assets can be solved by Lagrangian and matrix algebra, or by using Microsoft Excel's solver function (Gromb, 1998d, p. 16, 23):
$\min_{\{\omega_1,\cdots,\omega_n\}} \sigma_P^2 = \sum_{i=1}^{n} \sum_{j=1}^{n} \omega_i \omega_j \sigma_{ij}, \; subject\;to \; (1) \sum_{i=1}^{n} \omega_i = 1, (2) \sum_{i=1}^{n} \omega_i \bar{r}_i = \bar{r}_P;$ where "i" represents the rows and "j" represents the columns of the portfolio's covariance matrix.

Figure 23 A Portfolio Returns and Volatilities of A Safe Asset and Three Risky Assets
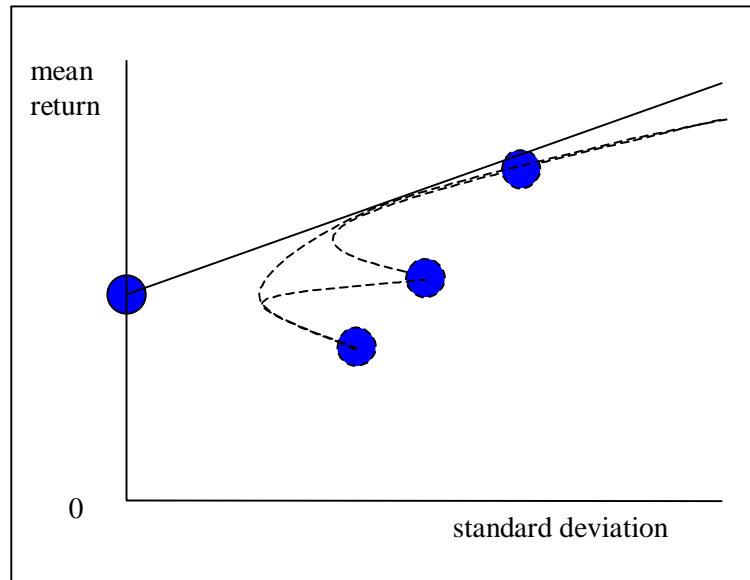
(Source: author)

This straight-line is called a "Frontier Portfolio". Any point on this line represents the best combination of the securities, which has a minimally volatile return.

Based on the above linearity, a dynamic relationship between any one asset's correlation with the market movement can be drawn by a straight line with Y-axis as mean returns and X-axis as beta values of any individual asset (Gromb, 1998d, p. 33 – 35; Gromb, 1998e, p. 14). The line is called the "Security Market Line (SML)" (**Figure 24**).

Figure 24 Beta and An Asset's Return (or Inferred Rate of Returns)
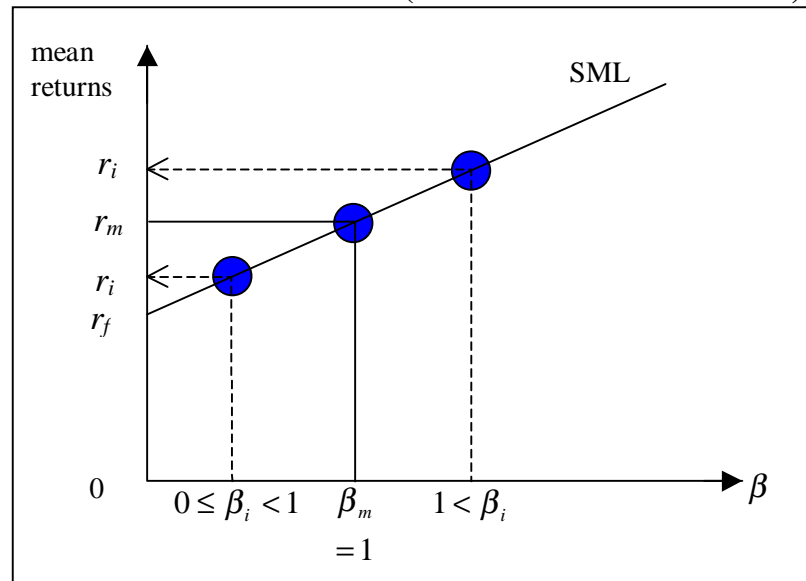
(Source: Gromb, 1998e, p. 14)

Based on the above linear relationship between the rates of returns and the beta values, we can infer a best alternative opportunity cost of capital when we know an individual asset's beta.[43]

5-2   Capital Asset Pricing Model

The CAPM theory was proposed by three economists, William Sharpe, John Lntner, and Jack Treynor in 1960s. The CAPM assumes that a mean return of any one asset is proportional (linear relationship) to the market beta value. The following formula expresses this:

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[43] Note that the market return, r_m, is the mean return of the risky portfolio. In theory, r_m is the mean return of the Tangent Portfolio, which is a point where the Frontier Portfolio and the parabola meet (Gromb, 1998d, p. 29). Therefore, the precise procedure for a planner in developing country is to construct the market portfolio that is comprised of alternative uses of capital, derive the Frontier Portfolio, and identify the Tangent Portfolio. Next, the planner needs to compute the weighted average of the returns of all such assets based on each holding ratio of such assets. However, this is replaced with more convenient way: r_m can be simply assumed as the mean return of the reference securities, such as S&P 500. This is because, in theory, the Tangent Portfolio is qualitatively and generally considered the market average return, based on the assumption that actual market capitalization of each security represents optimal holding ratio in the society (Geltner, 1998b, p. 34; Gromb, 1998e, p. 8).

$$r_i = r_f + \beta_i \times \left(\overline{r}_m - r_f \right);$$

where

r_i = return of an individual asset

r_f = return of a risk free bond

β_i = "beta" coefficient= $\rho_{i,m} \times \dfrac{\sigma_i}{\sigma_m} = \dfrac{\sigma_{i,m}}{\sigma_i \times \sigma_m} \times \dfrac{\sigma_i}{\sigma_m} = \dfrac{\sigma_{i,m}}{\sigma_m^2}$

$\overline{r}_m$ = mean return of the market portfolio

This is construed as the return will be higher as the correlation between any one individual asset and the overall economy gets higher, and vice versa.

5-3   A Brief Discussion of Option Pricing

If we assume that the 1,000 runs of this simulation model represent all of the possible events, then we can use a risk-free (100% safe) interest rate as the discount rate.[44] I did not use such a rate because the location-specific fluctuations do not represent all of the possible events. All such simulations are still based on a single baseline forecast, while such a forecast might be the only event that was chosen out of many possible events.[45] If we want to use a risk-free interest rate as the discount rate, we have to consider changes such as in physical design and capacity in order to generate all of the

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[44] The appropriate discount rate for the Monte-Carlo simulation is said to be the risk-free interest rate, since each simulation represents the cash flow assuming that such a scenario would occur 100% under each simulation, which suggests that such a projection, if realized, is comparable to a safe (secured) debt (Brealey & Myers, 1996, p. 255).

[45] I presume that this is the reason why neither The World Bank's INFRISK model nor the appraisers' probability-based cash flow model explicitly insisted on the use of the risk-free interest rate as the discount rate.

possible cash flow simulations so that they are logically discounted by the risk-free

rates.[46]

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[46] When it comes to the easement rights such as industry license or land value, even the cash flows of alternative uses of the land in question, including the timing decisions, may have to be simulated, unless we have better approximation methodologies. Otherwise, we can use a risk-free rate only when the use of the site is virtually limited to one use, design and capacity by policies such as zoning, urban planning regulations, and environmental regulations.

Appendix 2

Input Assumptions[47]

1. Project Schedule (see Figure 25)

Figure 25 Project Schedule

Construction period	Operation period
1989 – 1995	1993 – 2019 (27 years)

(Source: Tom, 1996)

2. Traffic Volume

Traffic volume is uniformly assumed to be 214 million vehicles per year over the operation period, beginning in 1993 and ending in 2019.

3. Toll rate

Toll rates can be programmed in many ways but in this thesis they are simply assumed to be predetermined in nominal values for each year, since the discussion of socially appropriate service pricing exceeds the scope of this thesis. Also, regardless of the types of vehicles, the same rate is assumed to be charged to the users (**Figure 26**).

Figure 26

Year	1993-	1998-	2003-	2008-	2013-	2018-
Baht[48]	30	40	50	60	70	80

(Source: Tom, 1996)

4. Construction Loan

Although the financing assumption may have a significant impact on a private investor's equity value, such a detailed assumption is replaced in this thesis with a simply stylized financing assumption. The main reason for this assumption is that the financing assumption affects the project's cash flow only in the interest tax-shields. In addition, the

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[47] Mainly based on Tom (1996), otherwise, I created such values and assumptions.

financing assumption, which varies based on actual deal-structures, is determined exogenous to the project's cash flow model. Also, the valuer here is an urban planner who tries to generally determine the value of the project using a hypothetical financing package.

1) Construction loan interests

Construction loan interests are assumed to be capitalized by annually compounded rates of 12% per year since inception until the year 1996, when the grace periods of 4 years (after commencement of operation) ends. The rate is assumed to include the premiums for commitment fees and management fees.

2) Loan-to-value ratio

Loan-to-value ratio for this project is assumed to be a typical 75% for non-recourse loans for infrastructure projects and disbursed in the amount prorated by this proportion of capital costs each year. For simplicity's sake, working capital was not considered, based on the premise that the subject valuer is interested in "accrual basis" cash flow (exact matching of cash flow and physical flow).

3) Repayment

Five years after the commencement of the operation, the annual loan repayment is calculated in the constant payment method with 12% interest annually, over 10-year, single annual payments.

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[48] Baht is this country's currency unit.

5. Depreciation

The depreciation method is assumed to be a 20-year, straight-line method with no final salvage value. Such a scheme is determined specifically for this project. All items of capital expenditures are assumed to be depreciated in this thesis.

6. Site acquisition costs

The total purchase price of land for this highway project is assumed to be 16,816 baht (6,726 baht in 1989 and 10,090 baht in 1991). The government in this case purchased land from the landlords and delivered it for the project. The operator pays a prescribed amount (16,816 baht) [as in below schedule] to the government. The government bears any abrupt increase in costs of the site acquisitions (**Figure 27**).

Figure 27 Operator Lease Payments (in nominal Baht)

2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
100	300	500	700	700	800	1,200	1,200	1,200	1,200	1,200	1,500	1,500	1,500	1,600	1,616

(Source: Tom 1996)

7. Inflation rate

This model assumes a fixed inflation rate, 5.36%, which was included in the nominal cost estimate. This model does not simulate different inflation rates since such rates should be generated outside the model.

Appendix 3

Spreadsheets

Figure 28 Sheet for Economic Parameters
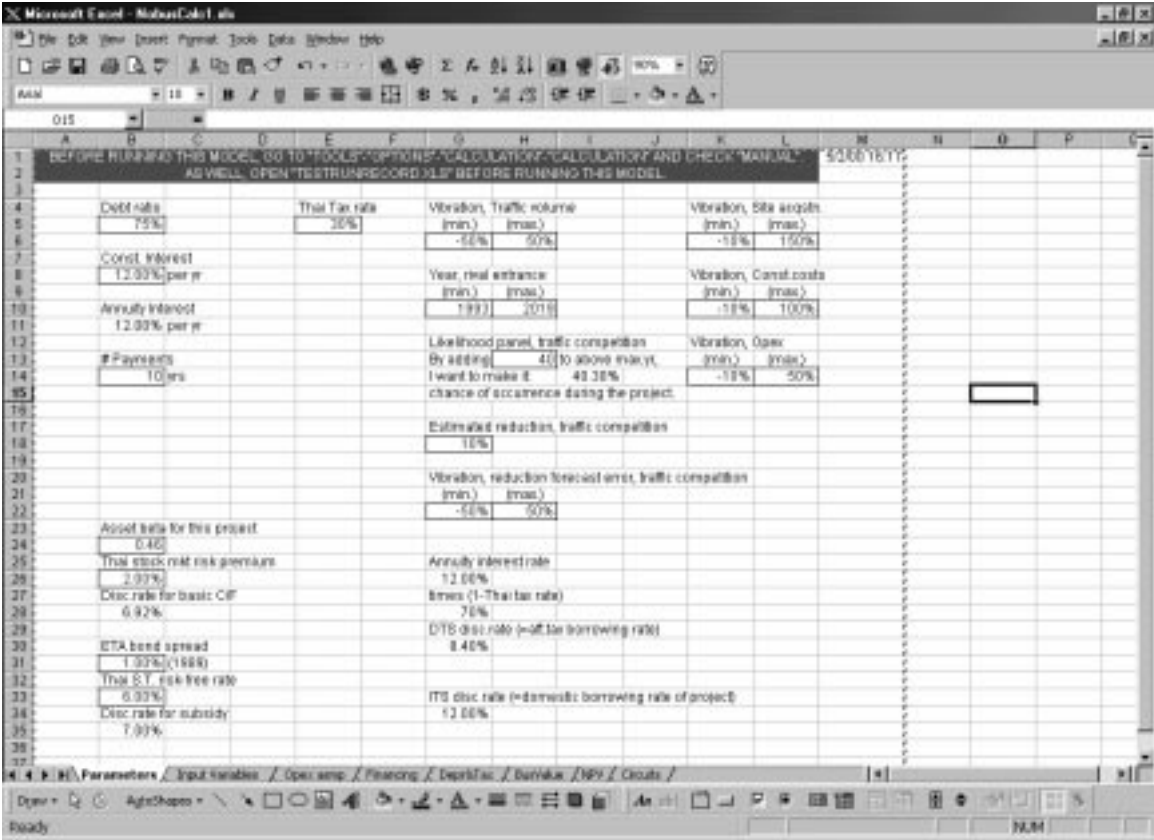
Figure 29 Sheet for Input Variables

Figure 30 "Run" Buttons for 1,000 Simulations
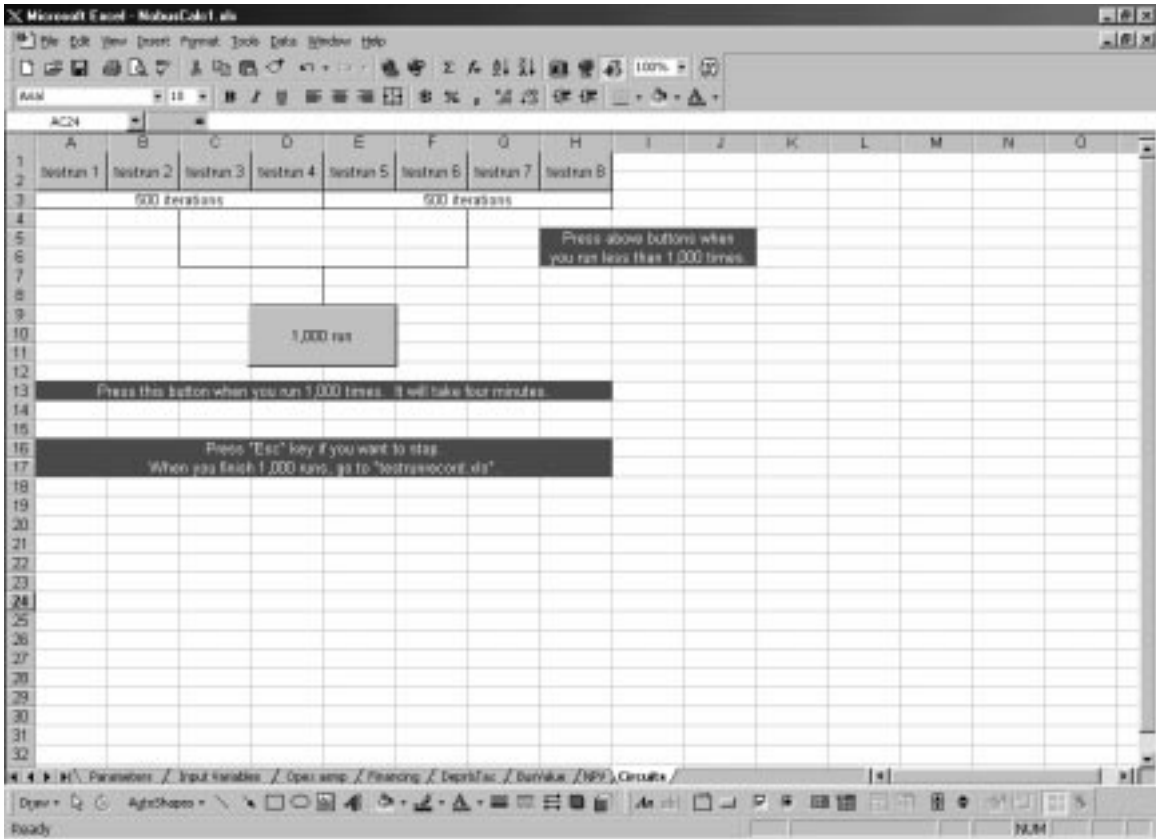
Figure 31 Sheet for Construction Loan Interests Calculation

Figure 32 Sheet for Depreciation and Interest Tax Shields Calculations

	(Row Total)	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2
* EBITDA* earning before interests, depreciation and amortization																	
(in millions of nominal Bahts unless otherwise stated)																	
DEPRECIATION																	
Total capital expenditures	36,720					31,710	3,961	1,029	-	-	-	-	-	-	-	-	-
Depreciation for assets accrued in	31,710					1,585	1,585	1,585	1,585	1,585	1,585	1,585	1,585	1,585	1,585	1,585	1,5
Depreciation for assets accrued in	3,961						199	199	199	199	199	199	199	199	199	199	1
Depreciation for assets accrued in	1,029							51	51	51	51	51	51	51	51	51	
Total Depreciation	36,720					1,585	1,785	1,836	1,836	1,836	1,836	1,836	1,836	1,836	1,836	1,836	1,8
REAL TAX PAYMENT CALCULATION																	
OPCO revenues	320,653	-	-	-	-	7,631	9,084	9,592	9,366	5,474	10,868	7,986	8,223	5,074	9,839	14,514	8,1
Less Total operating expenses	55,700	-	-	-	-	1,363	1,379	1,380	1,217	634	1,019	654	806	462	2,475	1,418	1,4
Less land lease	16,816	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
EBITDA*	248,137	-	-	-	-	6,278	7,705	8,212	8,149	4,840	9,840	7,032	7,417	4,611	7,364	13,095	6,6
Less Total Depreciation	36,720	-	-	-	-	1,585	1,785	1,836	1,836	1,836	1,836	1,836	1,836	1,836	1,836	1,836	1,8
Less Interests accrued	38,989	-	-	-	-	-	-	-	6,077	5,731	5,243	4,309	4,422	3,077	3,267	2,583	1,0
Taxable Income	172,428	-	-	-	-	4,692	5,921	6,376	235	(2,727)	2,861	387	1,159	(1,102)	2,261	8,676	2,9
Real Tax Amount	51,729	-	-	-	-	1,408	1,776	1,913	71	(818)	798	86	348	(331)	678	2,603	8
(For basic cash flow components only to measure benefit of ITS/DTS)																	
INTERIM TAX AMOUNT																	
OPCO revenues	320,653	-	-	-	-	7,631	9,084	9,592	9,366	5,474	10,868	7,986	8,223	5,074	9,839	14,514	8,1
Less Total operating expenses	63,989	-	-	-	-	1,387	1,540	1,890	1,422	596	1,408	734	746	584	2,322	1,287	1,5
Less land lease payments	16,816	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Taxable Income	239,868	-	-	-	-	6,243	7,545	7,702	7,944	4,878	9,451	6,953	7,477	4,490	7,517	13,227	6,5
Interim Tax Amount	71,960	-	-	-	-	1,873	2,263	2,311	2,383	1,463	2,836	2,086	2,243	1,347	2,255	3,968	1,9

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Figure 33 Sheet for Business Value Calculation (APV/CAPM Methods)

		Row Total	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	(in millions of nominal Bahts unless otherwise stated)														
	BASIC CASH FLOW COMPONENT														
	OPCO revenues	320,853	-	-	-	-	7,631	9,084	9,582	9,366	5,474	10,859	7,686	8,223	6,074	9,
	Less capital expenditures, after vibration	36,720	1,726	5,651	9,068	10,374	4,890	3,961	1,029	-	-	-	-	-	-	
	Less operating expenditures, after vibration	63,969	-	-	-	-	1,367	1,540	1,890	1,422	596	1,408	734	746	584	2,
	Less interim tax amount	71,960	-	-	-	-	1,873	2,263	2,311	2,383	1,463	2,835	2,086	2,243	1,347	2,
	Basic Cash Flow Component	148,004	(1,726)	(5,651)	(9,068)	(10,374)	(520)	1,301	4,362	5,561	3,414	6,616	4,867	5,234	3,143	6,
	Net present value@expected return, project	28,197														
	SUBSIDY COMPONENT														
	Capital grant, site acquisition	29,967	9,196	-	20,772	-	-	-	-	-	-	-	-	-	-	
	Less land lease payments	16,816	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Subsidy component	13,151	9,196	-	20,772	-	-	-	-	-	-	-	-	-	-	
	Net present value@subsidy disc. rate	22,431														
	DEPRECIATION TAX SHIELD COMPONENT														
	Total Depreciation	36,720	-	-	-	-	1,585	1,785	1,836	1,836	1,836	1,836	1,836	1,836	1,836	1,
	Depreciation tax shield	11,016	-	-	-	-	476	535	551	551	551	551	551	551	551	
	Net present value@DTS disc. rate	3,755														
	INTEREST TAX SHIELD COMPONENT														
	Interests accrued	38,969	-	-	-	-	-	-	-	6,077	5,731	5,343	4,909	4,422	3,877	3,
	Interest tax shield	11,697	-	-	-	-	-	-	-	1,823	1,719	1,603	1,473	1,327	1,163	
	Net present value@ITS disc. rate	3,376														
	BUSINESS VALUE, NOMINAL CASH FLOW	183,868	7,470	(5,651)	11,702	(10,374)	(44)	1,836	4,913	7,935	5,684	8,770	6,890	7,111	4,857	6,
	NPV, basic cash flow component	28,197														
	NPV, subsidy component	22,431														
	NPV, DTS component	3,755														
	NPV, ITS component	3,376														
	Business value, Adjusted net Present Value	57,759														

Figure 34 Sheet for Net Present Value Calculation

Acknowledgement

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