Application of real option in risk evaluation and management of PPP/PFI projects

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APPLICATION OF REAL OPTION IN RISK EVALUATION AND MANAGEMENT OF PPP/PFI PROJECTS

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2006

Application of Real Option in Risk Evaluation and Management of PPP/PFI Projects

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of the Requirement for the Degree of Doctor of Philosophy

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ABSTRACT

Public-Private Partnership / Private Finance Initiative (PPP/PFI) has been a widely applied scheme to deliver large-scale infrastructure systems, industrial plants and other development projects, all of which form an essential pillar for global economic growth. The global movement away from heavy dependence on public sector financing, and toward greater reliance on private capital and control, means that the project finance mechanism will constitute an important tool to finance the large-scale infrastructure and industrial projects needed to support their economic development.

A privately financed infrastructure project is inherently risky. Risk management in a project becomes a critical issue to both public sectors and private sectors. Risks mean losses to a project in the traditional risk management sense, and when the values of flexible measures to counteract such risks are overlooked, the value of a project may be understated. As an alternative approach, real option assumes that managers can take advantage of upsides and avoid obvious pitfalls during the development of a project. Such actions thus enhance the value of a project, and these are not captured in conventional evaluation methods such as Net Present Value. In this research, the primary objective is to study how real option can be applied to infrastructure projects with risks and uncertainties. The research aims to identify typical options in a project and evaluate them, design a new risk management framework incorporating the real option concept, which will lead to fairer risk allocation in a PPP/PFI setting.

Based on the literature review, knowledge about risk management of PPP/PFI and real option theory is acquired. The case study method is used to achieve the research objectives based on the data collected. These case studies can be classified into short and major cases. The analyses of short cases identify embedded options in each

project, based on which preliminary strategies incorporating the real option concept are designed. In the analysis of Major Case No. 1, the Dabhol Power Plant project in India, it is demonstrated that the real option evaluation methodology is more superior to the traditional NPV approach, and some of the flexible measures embedded in the case could contribute up to 26% of the base case NPV. Analysis of Major Case No. 2, the Malaysia-Singapore Second Crossing, includes an additional dimension, which is the sensitivity analysis of options subject to variations of input parameters. The case also illustrates the significance of creating options during design, construction and operation of a project. Based on the transaction structure and cash flows, Major Case No. 3 analyzes the options in a wastewater treatment plant project in southern China and proposes a new concept of “negotiation bands”.

Ultimately, the findings in this research lead to a new risk management framework that incorporates the real option concept. The framework includes the following elements: risk identification; option structuring in risk management strategies; option modeling; and design of a negotiation setting. This framework should contribute toward structuring a more equitable risk and value sharing arrangement among project stakeholders.

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LIST OF ABBREVIATIONS

AWSA	:	Autostrada Wielkopolska, S.A.
BOO	:	Build-Own-Operate
BOOT	:	Build-Own-Operate-Transfer
BOT	:	Build-Operate-Transfer
CAPEX	:	Capital Expenditure
CAPM	:	Capital Asset Pricing Model
CDG	:	City Development Group
CIQ	:	Immigration and Quarantine
CPI	:	Consumer Price Index
CSFs	:	Critical Success Factors
DBFO	:	Design–Build–Finance–Operate
DBO	:	Design–Build–Operate
DC	:	Development Company
DCF	:	Discounted Cash Flow
DPC	:	Dabhol Power Company
FCFE	:	Free Cash Flows to Equity
FPL	:	Florida Power & Light Company
GE	:	General Electric
CI	:	Imperial Chemical Industries
IDA	:	International Development Association
IRR	:	Internal Rate of Return
LNG	:	Liquefied natural gas
MOU	:	Memorandum of Understanding
MSEB	:	Maharashtra State Electricity Board
NPV	:	Net Present Value method
O&M	:	Operation and Management
PDE	:	Partial Differential Equation

PFI	:	Private Finance Initiative
PPA	:	Power Purchase Agreement
PPP	:	Public-Private Partnership
PURPA	:	Public Utilities Regulatory Policy Act of 1978
THSRC	:	Texas High-Speed Rail Corporation
TOT	:	Transfer-Operate-Transfer

CHAPTER 1

INTRODUCTION

This chapter provides a brief introduction to the main aspects of this research: project evaluation and risk management. With privately financed infrastructure projects as the contextual background, the chapter discusses associated challenges in evaluation and risk management. The aims and objectives, methodologies, scope of the research, and structure of the thesis are also described.

1.1 Background

Public-Private Partnership (PPP) / Private Finance Initiative (PFI) has been a widely used scheme by government to deliver large-scale infrastructure projects, which provide public service and become an essential pillar for global economic growth (Benoit, 1995). Through the early 1970s, these kinds of projects were frequently financed through official resources, such as host country government, multilateral development institutions and export promotion agencies of industrial countries. Recent trends, however, have reduced the availability of public sector financing for these projects, and at the same time increased the importance of private sector participation in such projects.

Private sector participation in infrastructure development has been a priority area in many developing countries' policy agenda in the 1990s (World Bank, 2003). This particular method of financing is becoming more important in large-scale, high-risk regional and international business ventures, largely in asset-based industries. For example, project financing has been widely applied to finance private infrastructure projects both in Asia as well as in Europe in the recent past. According to the World Bank's Private Participation in Infrastructure (PPI) Project Database, committed total investments involving private participation amounted to more than US\$1,100 billion during the period 1990-2005 in developing countries alone.

The application of PPP/PFI scheme gave birth to alternative project delivery methods and models such as build–operate–transfer (BOT), design–build–operate (DBO), design–build–finance–operate (DBFO), build–own–operate (BOO) and so on (Miller, 2000). BOT is perhaps the most popular model applied. Technical nuances aside, both private and public sectors adopting these models are ultimately interested in a single, most fundamental question: can the project generate sufficient return (or social benefits from the viewpoint of the public sector) commensurate with the risk

implications. Financial analysis of infrastructure projects, assessed from each party's standing, would shed light on this central issue.

The current process of risk management in infrastructure projects includes risk identification, measurement, and mitigation strategies. The mitigation strategies are designed based on the evaluation of the risks of a project through conventional evaluation models. The traditional method of project evaluation in conventional capital budgeting theory adopts the discounted cash flow (DCF) technique, which results in the most commonly used Net Present Value (NPV) and Internal Rate of Return (IRR) approaches. Under certainty, NPV is the correct approach for project analysis. Nonetheless, there are uncertainties in a project from planning, design, construction, and up to the operating and maintenance stage. In NPV analysis, the impact of uncertainties are not sufficiently captured and appraised. The private sector participants, both lenders and investors, would want to assess the stability of returns generated from the projects through some kind of uncertainty analysis.

Conventional evaluation methods assumed that risks bring losses to a project and lead to passive management strategies. In such models, scenarios in which the project would proceed well and generate additional revenue are overlooked. These turn-up scenarios would bring flexibility to managers of a project. Namely, traditional evaluation methods cannot capture managerial flexibilities to adapt and revise later decisions in response to uncertainties and therefore understate the value of projects by ignoring such managerial flexibility.

Real option theory has proved to be extremely useful for the analysis of many aspects of corporate finance and investment practices. As stated in Products Financiers (April 1999):

Real options are a new and advanced technique that handles uncertainty much better than traditional evaluation methods. Since many managers feel that uncertainty is the most serious issue they

have to face, there is no doubt this method will have a bright future as any industry faces uncertainty in its investment strategies.

Although real options have been adopted for more than two decades in other industries such as oil and gas, real estate and many general manufacturing industries, its application in the context of construction and infrastructure systems is still in its infancy. This research aims to develop a new framework of risk management that incorporates the real option theory and that is suited to the context of infrastructure projects.

1.2 Research Questions and Objectives

Risks generally exist in any projects. For instance, the completion time of a project is critical to both the client and the contractor. In a PPP/PFI project, typical risks are often amplified by the delivery scheme due to project characteristics such as long contractual duration, number of parties and stakeholders involved, and political sensitivity due to an increased level of public scrutiny (since some PPP/PFI projects are major in scale and impose user charges or government commitment in other aspects). In these settings, risk management is even more significant. Ideally, project stakeholders would like to have certain flexibilities in planning and execution to react to unforeseen market and environmental changes.

In the traditional evaluation methods such as NPV- and DCF-based analyses, passive risk management strategies are often assumed. In the face of uncertainty, a passive risk management strategy assigns different probabilities to different scenarios and then evaluates an “expected” outcome for these various scenarios. A decision is then pre-committed based on this expected outcome, while waiting for the uncertainties to unravel. The real option concept approaches the problem from a different angle – flexibilities are built along the way so that managers can react to changes as

uncertainties unravel. Since this is akin to a person holding a financial option and exercise the option only when it is optimal, the option pricing theory is transferred to these industrial problems for evaluation of the flexibilities.

However, even though the real option concept is well developed in other industries, its application in the context of PPP/PFI schemes remains relatively undeveloped and there are still many gaps to be filled. Some of the gaps can be summarized into the following research questions:

1. Collectively, what are the sources and types of options that are typically found or can be created in PPP/PFI projects?
2. Can the real option concept be introduced to complement the four strategies – transfer, avoidance, mitigation and retention – of the conventional risk management process?
3. Which evaluation models are appropriate to analyze which types of options in a PPP/PFI project?
4. How can real option be included in a negotiation setting among project participants?

To answer these questions, this research is founded on the following hypothesis:

1. Common types/sources of real option in PPP/PFI will be largely similar to those found in other industries such as manufacturing, which include: expansion option, abandonment option and deferment option.
2. Real option theory has no direct conflict and is indeed complimentary to the conventional risk management process.
3. In the PPP/PFI context, real option would be more valuable as a *decision-making* tool rather than as a *pricing* tool, therefore evaluation methods should be simple and practical for the ease of implementation, even though they might incorporate more assumptions in modeling.

4. By introducing the value of real options into the deal, the feasible bargaining range between two different parties will actually be enlarged and this will assist in reaching an agreement.

Along with these questions and hypotheses, this research aims to achieve the following objectives:

- a. To identify, understand and categorize the common types of options found in construction and infrastructure projects.
- b. To design a modified risk management process by incorporating the real option concept.
- c. To examine evaluation models in the aspect of practical analysis of options in infrastructure projects.
- d. To design a negotiation setting that is facilitated by the inclusion of real option during project evaluation, which will lead to an equitable risk sharing agreement.

1.3 Scope, Limitations and Methodology of the Research

As will be elaborated later in the next chapter, the analysis of real options can be implemented using either discrete-time or continuous-time models. In view of the desired flexibility in representing actual scenarios of the case studies, this project adopts only discrete-time models for all quantitative analyses. The use of continuous-time models is deemed to be more suitable for cases with ideal boundary conditions for the parameters of the options. These ideal boundary conditions often cannot be found in the design, construction and operation of infrastructure projects.

The research predominantly relies on the use of a case study methodology. This methodology is selected as it provides in depth understanding of modeling and application issues of real options. Naturally, the number of case studies gathered is

limited by the tenure of this research. Therefore, unlike a questionnaire survey that lends itself to statistical verification of results, additional number of case studies would be required in the future to verify the trends and guidelines that have been identified and developed in this research.

1.4 Significance of the Research

As mentioned in Section 1.1, traditional evaluation methods do not consider managerial flexibilities in a project. This will lead to underestimation of the true value of a project, which in turn results in passive risk management strategy and unfair negotiation between parties involved in the project. On the basis of the short and major case studies conducted in this research, the findings will help to make the most significant contributions to the following:

1. Circumstances to apply a binomial tree method versus a Monte Carlo simulation approach in valuing an option in PPP/PFI project. In the end, it is found that while the binomial tree method is the most handy and practical to evaluate straightforward phenomena such as expansion and abandonment, “special” scenario such as guarantee options are more readily modeled in spreadsheet and evaluated using Monte Carlo simulation. Throughout the modeling experience, it is also felt that development of partial differential equations is practically impossible given the numerous conditions found in the PPP contracts analyzed (unless numerous assumptions are imposed to reduce the problem to a mathematically tractable one).
2. Ways that real option thinking helps to enhance the planning of design, construction and operation of PPP/PFI projects, thereby leading to an integrated and proactive risk management approach.
3. Additional dimension given by real option to widen the feasible bargaining range (with inclusion of the value of flexibility). This helps to develop a negotiation setting that promotes equitable risk and return sharing.

Overall, this research represents an incremental effort to fill some of the gaps in the construction management literature with respect to the applications of real option.

1.5 Outline of the Thesis

This thesis is presented in eight chapters, as illustrated in Figure 1.1.

Figure 1.1: The Structure of the Thesis

Chapter 1 provides a brief introduction to the main aspects of this research: project evaluation and risk management. It provides the background of privately financed infrastructure projects and the associated challenges in evaluation and risk management. The aims and objectives, methodologies, scope of the research, and the structure of the thesis are also described.

In Chapter 2, previous studies on real option theory and risk management of infrastructure project are reviewed. These include an introduction to the development of real option theory, its strength over traditional evaluation methods such as NPV and IRR, and conventional risk management strategies that are often applied to infrastructure projects in the PFI/PPP setting.

Chapter 3 describes the research methodology adopted in this research, providing justification of the case study methodology and outlining the sequence and content of analysis. In this research, cases can be categorized into two types: short cases and major case studies. The analyses of short cases are presented in Chapter 4, whereas the analyses of the three major cases are presented separately in Chapter 5, 6 and 7.

The analyses of short cases are conducted in Chapter 4. Based on an alternative manner of classifying risks, the author recommends two approaches to manage risks: one is at the firm level by utilizing the diversification principle; the other one is at the independent project level by utilizing the real option concept. From each short case analysis, options are first identified based on the background of the case. From the results of the analyses, this chapter summarizes various option design strategies and their relevance to risks.

The subsequent three chapters present the analyses of the three major cases respectively.

Chapter 5 presents the Dabhol Power Project in India, including option identification and their evaluation. Chapter 6 investigates the Malaysia-Singapore Second Crossing, and adds a further dimension to the analysis by using Monte Carlo simulation and sensitivity analysis. Chapter 7 evaluates option identified in a Wastewater Treatment Plant project in Southern China. By studying the transaction structure and conducting cash flow analysis, this chapter introduces the concept of negotiation bands for a couple of parameters — the initial transfer price and the tariff rate for normal treatment volume.

The last chapter concludes on the findings obtained from the short and major case studies. Based on the literature review and results of the case analyses, this chapter proposes a new risk management framework that incorporates the real option concept. This is followed by discussions on issues of option modeling and design of a negotiation setting. Finally, some recommendations for further research are given.

CHAPTER 2

LITERATURE REVIEW AND THEORETICAL FOUNDATION

Previous studies on Public-Private Partnership / Private Finance Initiative (PPP/PFI) and real option theory are reviewed. This chapter includes an introduction to the general features of PPP/PFI and the risk management aspects under the PPP/PFI framework. The review of real option will draw comparisons against conventional evaluation methods.

2.1 Introduction to PPP/PFI

2.1.1 Concept of PPP/PFI

The commitment to PPP (Public-Private Partnership) in large scale infrastructure projects is a commonly policy in countries such as China, India, Indonesia, Australia, UK, Colombia, and Chile (Ranjit, 1990). Nowadays, the PPP procurement is adopted popularly by government to resolve financial constraints in the provision of public facilities and services.

PPP is a key element in a government's strategy for delivering modern, high quality public services and a more competitive economy. Generally, PPPs are developed by following three broad objectives to the government: (i) to deliver significantly improved public services either in terms of the quality of services or the quantity of investments; (ii) to release the full potential of public sector assets to provide value for tax payers and furnish wider benefits for the economy; (iii) to allow stakeholders such as the users of the service, tax payers and employees in both public and the private sectors to receive a share of benefits arising out of the PPP scheme.

There are eight types of PPPs that are identified by the UK government. These include: asset sales, wider market, sales of business, partnership companies, private finance initiative, joint venture, partnership investment, and policy partnership. Among these eight types, PFI (Private Finance Initiative) is the most popular model of PPP (Li, et al., 2005).

PFI is a means of using private finance and skills to deliver capital investment projects that are traditionally provided by the public sector. Instead of the public sector body directly procuring capital assets and subsequently owning, operating and regulating them, PFI generally involves the private sector owning and operating the

facilities, with the public sector playing a larger role in regulating the sector (The Scottish Parliament, 1999). PFI allows the public sector to contract with the private sector to provide quality services on a long-term basis, typically 25-30 years, so as to take advantage of the private sector's management skills incentivised by having private finance or capital at risk.

In most PPP/PFI schemes, the private sector carries the responsibility and risks for designing, financing, enhancing or constructing, maintaining and operating the required assets or infrastructures to deliver product/service in accordance with the public sector's output specification. In some projects, the public sector may also pay for the project through a series of performance or throughput related payments, which cover service delivery and return on investment. Depending on the specific arrangement, the Central Government may provide payment support to public agencies (that are directly dealing with the private sector) through grants and other financial mechanisms.

Generally, projects that are clearly open to adopt PPP/PFI scheme would include infrastructure projects such as toll roads, power plants, water treatment plants and metropolitan transport systems (Mountain, 1998).

2.1.2 Advantages of Adopting the PPP/PFI Schemes

The involvement of private sector in the development and financing of public facilities and services has increased substantially over the past decade. Figure 2.1 illustrates the increasing tendency of private sector's participation in International Development Association (IDA) countries. In principle, PPP/PFI procurement is a win-win approach to both public and private sectors.

Figure 2.1: Investment in Infrastructure Projects with Private Participation in IDA Countries, 1990-2001

Source: World Bank PPI Project Database (2003)

First, PPP/PFI relieves the government of a substantial proportion of public debt. Generally, financing of PPP/PFI projects is arranged partly or sometimes completely by the private sector and the government does not play a main and direct role in such financing matter. Through the PPP/PFI scheme, the government does not need to provide funds for these projects, while it has still found an avenue to provide public services to its people.

Second, PPP/PFI procurement is acceptable to both public and private sector participants because the financing can be recovered from the cash flows of the project itself. In some arrangements, the public funding or the debt cannot be secured in a form of a non-recourse arrangement. Non-recourse project finance is an arrangement under which investors and creditors financing the project do not have any direct recourse to the sponsors, as might traditionally be expected (for example, through loan guarantees) (Dejan, etc., 2006). Generally, at the end of the concession period, the ownership of the project would be transferred back to the government without payment.

Third, some researchers suggest that PPP/PFI schemes encourage private sector commercial efficiency to replace public sector bureaucratic inefficiency (Hambros,

1999). It is therefore reasonable to expect that the total life-cycle cost of the project can be reduced.

Fourth, both the public client and the private contractor would have more freedom to select innovative methods in the provision of assets and services in the PPP/PFI procurement method (Li, et al. 2005). This should lead to time saving by accelerating project development and by avoiding delays in project delivery (Downer and Porter, 1992; Hall, 1998; Utt, 1999).

Last but not least, at the international level and particularly in developing countries, PPP/PFI is seen as attractive in terms of its capacity to achieve the transfer of technological knowledge to local enterprises.

In summary, to the government, PPP/PFI procurement can enhance its capacity, bring innovation in delivering public services, reduce cost and time of project implementation, and proper transfer of major risks to the private sector in order to secure value for money for the taxpayers. From the private sector's viewpoint, they perceive the PPP/PFI market as providing a broader base of business opportunities in which they could possibly make some profits by utilizing their management skills and technology.

2.1.3 Structure of PPP/PFI

As formerly mentioned, some degree of privatization has become a common trend in the development of large-scale infrastructure projects. This has come in different forms of private sector participation models such as Build-Operate-Transfer (BOT), Build-Own-Operate (BOO) and Build-Own-Operate-Transfer (BOOT) type of concessions (Thomas, et al; 2003). Although only public sectors and private sectors are mentioned in PPP/PFI in the previous section, there are indeed many parties

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involved in these infrastructure projects and each party will try to protect their own benefits in the project. Second, an infrastructure project generally involves a huge amount of investments and a lengthy contractual period, which will make it more difficult to predict the uncertainties and take action to deal with uncertainties. Finally, many infrastructure projects are designed and initiated to serve public interest and promote social benefits. As such, it is often subject to public's scrutiny; hence the political sensitivity of the project. As a result, PPP/PFI projects are more risky than most projects that are delivered using the "conventional" modes (such as Design-Bid-Build and Design-and-Build).

Some parties who are typically involved in a privately financed infrastructure project are shown in Figure 2.2. Although the actual contractual arrangement varies from project to project, one common key issue for all parties concerned – government, shareholders, lenders, contractors, suppliers, and operators, is to assess the risks and uncertainties inherent in the project from their respective standpoint.

Figure 2.2: Typical Participants in a Privately Financed Infrastructure Project

2.2 Risk Management Aspects of PPP/PFI

2.2.1 Process of Risk Management

Risks and uncertainties are embedded in all PPP/PFI projects. Risk management is a process which enables the analysis and management of risks associated with a project. If risks are managed realistically, the process will increase the likelihood of success of a project. Risk management is not a “once and for all” activity; it should be applied continuously throughout the lifecycle of a project (Thompson and Perry, 1992). A systematic approach to risk management is based on three sub-processes: identification, analysis and risk management strategy (Raftery, 1994). Tiong and Ye (2000) developed an integrated risk management framework of private financed infrastructure projects (as shown in Figure 2.3). The core of this framework is risk control, and the key of risk control is risk allocation. The framework presents four risk control strategies followed by concession design through which all would-be risk-bearers would achieve their trade-offs between risk and return.

Figure 2.3: Conceptual Integrated Risk Management Framework
Source: Tiong and Ye (2000)

2.2.2 Risk Identification and Categorization

One method of risk identification is the development of a risk checklist (or catalogue). Generally, the checklist includes a set of Critical Success Factors (CSFs), which are simply defined as key areas of activity for a manager to reach goals (Rockart, 1982). This method has been applied to analyze risks in construction management (Yeo, 1991; Sanvido et al., 1992). Tiong (1996) also analyzed the CSFs for private contractors in competitive tendering and negotiation in Build–Operate–Transfer (BOT) projects.

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While the growing number of literature on identifying and analyzing construction project risks provide a useful background, it is also important to focus on risk classifications that are specific to PPP or BOT scenarios. For risk categorization, the works of Li, et al. (2005) and Wang and Tiong (2000) are regarded as insightful. Their works are reviewed in turn.

Li, et al. (2005) proposed a metaclassification approach on the basis of three levels of risk factors for PPP/PFI projects. These three levels comprise: macro level risks, meso level risks and micro level risks (Table 2.1).

The macro level of PPP/PFI risks comprises risks which are external to the project. This level is generally related to the nation's or industry's environmental or "natural" risks, such as the political and legal conditions, economic conditions, social conditions and weather. The effect of these risks is that, although they occur beyond the system boundary of a project, the consequences will influence the outcomes of the project.

The meso level of PPP/PFI risk includes risks such as risk events (and their consequences) that occur within the system boundaries of the project. These include problems of implementing the PPP/PFI framework, involving issues such as project demand/usage, location, design, construction and technology.

The micro level of PPP/PFI risks represents risks that are formed during the procurement process due to inherent differences between the public and private sectors in terms of contract management. This risk category is proposed as that the public sector carries social responsibilities, while the private sector is mainly profit driven.

Within each level of risk grouping, it may be possible to identify sub-categories relating to the nature of specific risks. In this way, public and private sector involved

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in a project would manage risks in a strategic approach, including: risk analysis, risk treatment, and subsequent risk monitoring and control.

Risk meta-level	Risk factor category	Risk factor
Macro level risks	Political and government policy	<ul style="list-style-type: none"> • Unstable government • Expropriation or nationalisation of assets • Poor public decision-making process • Strong political opposition/hostility
	Macroeconomic	<ul style="list-style-type: none"> • Poor financial market • Inflation rate volatility • Interest rate volatility • Influential economic events
	Legal	<ul style="list-style-type: none"> • Legislation change • Change in tax regulation • Industrial regulatory change
	Social	<ul style="list-style-type: none"> • Lack of tradition of private provision of public services • Level of public opposition to project
	Natural	<ul style="list-style-type: none"> • Force majeure • Geotechnical conditions • Weather • Environment
		<ul style="list-style-type: none"> • Land acquisition (site availability)
Meso level risks	Project selection	<ul style="list-style-type: none"> • Level of demand for project
	Project finance	<ul style="list-style-type: none"> • Availability of finance • Financial attraction of project to investors • High finance costs
	Residual risk	<ul style="list-style-type: none"> • Residual risks
	Design	<ul style="list-style-type: none"> • Delay in project approvals and permits • Design deficiency • Unproven engineering techniques
	Construction	<ul style="list-style-type: none"> • Construction cost overrun • Construction time delay • Material/labour availability • Late design changes • Poor quality workmanship • Excessive contract variation • Insolvency/default of sub-contractors or suppliers
	Operation	<ul style="list-style-type: none"> • Operation cost overrun • Operational revenues below expectation • Low operating productivity • Maintenance costs higher than expected • Maintenance more frequent than expected
Micro level risks	Relationship	<ul style="list-style-type: none"> • Organization and co-ordination risk • Inadequate experience in PPP/PFI • Inadequate distribution of responsibilities and risks • Inadequate distribution of authority in partnership • Differences in working method and know-how between partners
	Third party	<ul style="list-style-type: none"> • Lack of commitment from either partner • Third Party Tort Liability • Staff Crises

Table 2.1: Categorized Catalogue of PPP/PFI Project Risk Factors

Source: Li, et al. (2005)

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Catalogues of risks can be sourced in much of the relevant PPP/PFI and project risk management literature. Different from Li, et al's checklist, Wang and Tiong (2000) illustrated the risks of a power project in China according to the nature of these risks (Table 2.2). The checklist includes political risks, construction completion risks, operating risks, market and revenue risks, financial risks, legal risks, and completion risks (before bid award). Each kind of risks again comprises sub-categories of risks. As shown in Table 2.2, the authors also presented the actual bearers of each risk based on their analysis of the Laibin B Power Plant project.

Li, et al (2005) and Wang and Tiong (2000) both developed a checklist to classify risks in a project. The classification of the former was based on the source of risk, while Wang and Tiong (2000) conducted the categorization according to the nature of the risks. Both of them conduct a complete categorization of risks in a project from different viewpoints, but the risk management strategies derived from these categorizations may be only suitable *for an individual project*. Since some large engineering and construction firms, such as Vinci from France and Hochtief from Germany, often have *a portfolio of projects* ongoing concurrently, it is also important for these firms to develop risk management strategies at the company level instead of the project level. Additionally, the two risk categorizations mentioned above assumed that risk only lead to losses; flexibilities derived from some risks are ignored. According to option theory, flexibility can bring opportunity to enhance value of a project which will lead to a different risk management approach.

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Risk	Guangxi government	The consortium (as Sponsor, Contractor and O&M Contractor)	Lender	Insurer	Bond Bank or Insurer
1. Political risks					
revoke, expropriation, sequestration	×				
exclusivity, i.e. not second facility		×			
changes in law	×				
development approvals	×	×			
adverse Government action or inaction	×	×			
provision of utilities	×	×			
increase in taxes (general)	×	×			
increase in taxes (specific)	×				
political force majeure events	×				
termination of concession by government	×				
payment failure by Government	×	×			
2. Construction completion risks					
land acquisition and compensation	×				
restriction on import equipment/materials	×				
cost overruns		×	×		×
increases in financing costs		×	×		
time and quality risk		×			×
Contractor default		×			×
default by Concession Company	×	×			×
time, cost and scope of identified but related					
environmental damage-subsisting	×			×	
environmental damage-ongoing		×			
protection of geological and historical objects	×				
force majeure	×	×		×	×
3. Operating risks					
Government department default	×	×			
Concession company default		×			
Operator inability		×			
termination of concession by Concession	×	×	×	×	
environmental damage-ongoing		×			
force majeure event	×	×		×	
labor risk	×	×			
technology risk		×			
prolonged downtime during operation		×		×	
condition of facility (maintenance)		×		×	
4. Market and revenue risks					
insufficient fare income	×	×			
fluctuating demand of power generated	×				
transmission failure	×				
problem in bill collection	×				
insufficient other income		×	×		
power theft	×				
fluctuation of cost and availability of fuel/coal	×				
Government restriction on profit and tariff.	×				
5. Finance risks					
inflation risk	×	×	×		
interest rate		×	×		
foreign currency exchange rate	×	×			
foreign currency convertibility	×				
6. Legal risks					
title/lease property	×	×			
ownership assets		×			
security structure			×		
insolvency of Concession company		×	×		
breach of financing documents		×	×		
enforceability of security			×		
documentation/contractual risk (conflict and	×	×	×		
7. Competition risk (before bid award)		×			

Table 2.2: Risk Allocation of the Laibin B Power Plant Project
Source: Wang and Tiong (2000)

2.2.3 Risk Analysis

Risk analysis is performed to quantify the effect of risk. Once all risks have been identified, either a quantitative assessment is performed or subjective labeling of each risk in terms of both its impact and its probability of occurrence is created (Norris, et al; 1992).

Quantitative risk analysis techniques can be classified into two types: deterministic and probabilistic. In deterministic analysis, the effect of each risk variable is analyzed independently. In probabilistic analysis, each risk variable assumes a certain range of values and the effect of combinations of risk variables are analyzed.

To sum up, the four risk management strategies, to some extent, help to tackle risks in a project. However, they hold an assumption that risks could only introduce losses and thus should be avoided. As has been emphasized previously, in the case of occurrence of risks, project manager can take actions to take advantages of them and enhance the value of a project.

2.2.3.1 Sensitivity Analysis

Sensitivity analysis is often considered to be a simple form of risk analysis. It determines the effect on the whole project due to changes in the value of one of its risk variables (Norris, et al; 1992). The analysis often has an outcome for a range of values of each variable independently, which is usually considered in terms of a discounting approach such as net present value (NPV), internal rate of return (IRR), or payback period.

Sensitivity analysis is a procedure to determine the sensitivity of the outcomes of an alternative to changes in its parameters (as opposed to changes in the environment). If

a small change in a parameter results in relatively large changes in the outcomes, the outcomes are said to be sensitive to that parameter. This may mean that the parameter has to be determined very accurately or that the alternative has to be redesigned for low sensitivity.

Generally, a sensitivity analysis should be performed for all identified risk variables and the result can indicate the most sensitive or critical variables. However, this approach does not take into account the probability of occurrence of the risk and consequently, it does not give the probabilistic picture of risk exposure.

2.2.3.2 Probability Analysis

Probability analysis overcomes the limitation of sensitivity analysis by utilizing a probability distribution for each risk variable. The result is a range of values in which the final outcome could lie (Thompson and Perry, 1992). Obviously, the probability of each parameter should be determined – in the application of sensitivity analysis, each parameter is technically assumed to be uniformly distributed. The simplest form of probabilistic analysis is the decision tree analysis. There are also other project evaluation models: value-at-risk (Jorion, 2000) and NPV-at-risk (Ye and Tiong, 2000). Both of these two models use Monte Carlo simulation, which is another common form of probabilistic and statistical analysis (Norris, et al; 1992).

2.2.4 Risk Management Strategy

Once the risk is identified and its consequence analyzed, strategies will be undertaken to mitigate the effect of the risks based on the preliminary information and analysis. Generally, four strategies are adopted in terms of risk management in PPP/PFI, including avoidance, reduction, transfer/shifting and retention (Flanagan and Norman,

1993; Thompson and Perry, 1992; Norris, et al; 1992).

Risk avoidance is synonymous with refusal to accept risks and normally associated with pre-contract negotiations. Some risks may be eliminated or avoided by undertaking a redesign or change of the project definition.

Risks cannot be totally eliminated. However, the impacts of certain risks can be reduced by proper planning, sound management and suitable implementation strategy. One of the ways of reducing risk exposure is to share risks with other parties. Partnering and joint venture are examples of risk sharing.

Transfer/shifting risk does not reduce the essence of the risk; it just obliges another party to deal with it. Certain risks can be transferred through insurance and sometimes the owner of risks is expected to pay a premium for this. In some cases, this strategy may inadvertently increase risk because the party to whom the risk is being transferred may not be able to handle the risk.

Even after the three strategies mentioned formerly have been undertaken, certain risks cannot be managed well or it is not economical to do so. For such cases, the fourth strategy — retention, is adopted (Flanagan and Norman, 1993). The owner of the risk will absorb the risk itself and bear the consequences.

2.2.5 Risk Allocation Mechanism

Risk allocation refers to a primary measure of assignment of risks among major direct participants of a project. If individual parties bear a certain risk outcome, this would imply a shared risk allocation mechanism. Since risks exist in all projects, each of the risks should be assumed by a suitable party who is in the best position to absorb or handle that risk. Generally, consideration should be paid to three critical factors: the

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ability to influence or control the risky outcomes; the ability to bear adversarial consequence resulting from the risk; and the incentive to bear the risk. These considerations lead to various principles of allocating risks as outlined in Smith (1995), Haley (1996), Irwin (1997), and Kerf (1998).

Li, et al (2005) proposed a process of negotiation for risk allocation (Figure 2.4). The process was derived on the basis of a systematic risk management approach for construction projects proposed by Al-Bahar and Grandall (1990) with the principle of risk sharing in PPP/PFI supported by Grant (1996) and HM Treasury (2000). In the proposed framework, the public sector identifies the risks, sets out the risks relevant to each stage of the project, estimates the likelihood of occurrence for each risk event and evaluates the financial consequences. The private sector participants then receive tender documents which are complete with the risk factors, matrix or preliminary allocation framework. They will analyze the risks themselves, including risk pricing and the cost of managing the risks. Usually, a project will be delivered to the private sector if the bid price is acceptable to the public sponsor and the net present value (NPV) of the payment streams for the project is lower than an equivalent benchmark known as the Public Sector Comparator (PSC).

The Public Sector Comparator (PSC) is a well-constructed benchmark that helps the public sponsor to make decision about procurement selection. Before the final approval of the transaction, the PSC represents a test that is undertaken by preparing a hypothetical set of costs for the public procurement of a project with the same output, including a full evaluation of the project risks borne by the public sector. The PSC methodology will then compare this hypothetical cost with the actual cash flows to be paid to the private sector provider, plus the value of any residual costs and risks not transferred to the private sector and therefore retained by the public sector. This comparison reflects the financial differences between two procurement options for the same project.

Overall, the various principles discussed thus far indicate that risk should be allocated to one who can best control the risk, bear the risk at the lowest cost, and even benefit from controlling the risk.

Figure 2.4: Risk Allocation Process in PPP/PFI Contract Procurement
Source: Li, et al (2005)

2.3 Real Option Theory and Application

2.3.1 Shortcomings of Traditional Project Evaluation Methods

There are various types of quantitative analytical methods to estimate the costs and values associated with a proposed project. Traditionally, the typical approaches of project evaluation are based on the Discounted Cash Flows (DCF) technique, which generates measures such as Net Present Value (NPV), Internal Rate of Return (IRR), payback period and maximum cash exposure.

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Net present value (NPV) is defined as the difference between the present value of estimated cash inflows and cash outflows. It is used when the discount rate (also known as the cost of capital, required rate of return or hurdle rate) is known or specified. According to the NPV approach, the project should be accepted if its NPV is positive.

From an investment evaluation viewpoint, shareholder value is created when the present value of a project's expected cash inflows exceeds that of the outflows, thereby resulting in a positive NPV. Cash flows are discounted to their present value by the firm's cost of capital or a minimum attractive rate that appropriately reflects the perceived project risk. Selecting an appropriate discount rate, however, is a difficult task, especially for projects that are characterized by substantial uncertainty. A conventional approach to deal with investment uncertainties is for the business to develop a project-specific, risk-adjusted discount rate based on the capital asset pricing model (CAPM). The CAPM states that the cost of equity is the sum of a risk-free rate, which is often represented by a short-term government-backed security, and a risk premium.

DCF-based approaches assume implicitly that a project will be undertaken now and operated on continuously according to a preset time scale until the end of its expected useful life, even though the future is uncertain. Therefore, the DCF ignores the upside potential of added value that could be brought to the project through the flexibility and innovations of management to alter the course of investment. Such managerial interventions or operating decisions made during the life of the project reacting to changes in market conditions would provide companies with a better chance to reap higher returns or minimize losses in a volatile marketplace. The weakness of DCF is its failure to account for how uncertainty, other than implying a higher risk-adjusted discount rate, can sometimes increase the value of a project investment. Therefore, by assuming management's passive commitment to a certain "operating strategy",

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DCF-based methods usually underestimate the upside value of investment (Kogut and Kulatilaka, 1994).

In a passive approach, risks may be identified but they are largely ignored in the planning and execution process until undesired events occur, at which time solutions are sought. This approach often includes an assumption that additional resources will be made available to solve the problems that arise, precludes the prevention of some undesirable events, and increases the costs of addressing others (Erik, 2005). A flexible strategy, on the other hand, allows a manager to cultivate a “matrix strategy” with which to respond to market movement in any direction, which means that the manager will take action in the case of occurring of risk/uncertainty (George, 1998).

In essence, the NPV approach makes implicit assumptions concerning a certain “expected scenario” of cash flows. Treating projects as independent investment opportunities, decision is then made to accept a project for which the computed NPV is positive. Effectively, the DCF approach implies an inflexible management who makes at the outset an irrevocable commitment to a certain operating strategy and abides by it until the end of its pre-specified project life. This is of course an unrealistic assumption and not a reflection of reality.

By definition, financial and real options represent the right, but not the obligation, to take action to realize the value of embedded flexibility. However, the application of real options is different from that of financial options. First, the underlying for a financial option is a security such as a stock or a bond (or interest rate), while the underlying for a real option is a tangible asset — for instance, a business unit or a project. Second, financial options are written on traded securities, but the underlying assets of real options are not traded, which makes it difficult to estimate the parameters of the real options.

2.3.2 Basic Concepts of Options

The options theory revolution arose in part as a response to the dissatisfaction of corporate practitioners, strategists, and some academics with traditional capital budgeting techniques. Myers (1987) suggested that option pricing holds the best promise of valuing investment with significant operating or strategic options. Trigeorgis and Mason (1987) explain that option valuation can be seen operationally as a special, economically corrected version of decision tree analysis that is better suited in valuing a variety of corporate operating and strategic options.

At the most basic level, there are two types of options: call option and put option. A call option gives its owner the right to procure a specific asset at a specific price in the future, whereas a put option gives the owner the right to sell the asset at a specific price in the future. If the option can be exercised only on a specific date (known as the date of maturity), it is called a “European option”; otherwise, if it can be exercised at any time before maturity, it is known as an “American option”.

Figure 2.5 shows the theoretical relationship, at maturity, between the value of a call option and the strike price of a call option to buy the asset. In this figure, V denotes current value of the underlying asset, I_0 is the strike price of the option, and C is the Value of the option, namely, the payoff at maturity. Essentially, the 45° line represents the intrinsic value of the option. It is simply the current value of the underlying asset less the strike price of the option. According to the concept of call option, if the value of the underlying asset is lower than the strike price, the option owner will not exercise the option; hence a zero payoff. Conversely, if the value of the underlying asset is higher than the strike price, the option owner will exercise the option.

Figure 2.5: Payoff Function of a Call Option at Maturity

Similarly to Figure 2.5, Figure 2.6 shows the theoretical relationship, at maturity, between the value of a put option and the strike price of a put option to sell the asset. In this figure, V denotes current value of the underlying asset, I_0 is the strike price of the option, and P is the value of the option, namely, the payoff at maturity. The 45° line represents the intrinsic value of the put option. It is the current value of the underlying asset less the strike price of the option. According to the concept of put option, if the value of the underlying asset is higher than the strike price, the option owner will not exercise the option; hence a zero payoff. Conversely, if the value of the underlying asset is lower than the strike price, the option owner will exercise the option.

Figure 2.6: Payoff Function of a Put Option at Maturity

In the case of call option, prior to the maturity of the option, however, it is possible for the value of the option to fluctuate in response to the volatility of the underlying asset value (Curve I in Figure 2.7). In Figure 2.7, Curve II represents the actual value of the option. For a real option, when the factors are not managed efficiently and the value of asset is way below the strike price, the value of the option would be close to zero. On the other hand, if the factors are well managed and the value of asset is way above the strike price, the value would be close to the intrinsic value (Curve III) increasingly.

Effectively, prior to maturity, the difference in value between the option and its payoff function is driven by the flexibility that the owner has — he may choose to exercise now or later depending on how the value of the underlying asset fluctuates.

Figure 2.7: Value of Managerial Flexibility

2.3.3 Real Option Models

Real options are collections of options on real assets that provide strategic or financial flexibility or options. In modeling these real options, certain diffusion processes are assumed for the operating cash flows or asset value of the project, which would be

considered to reasonably represent their stochastic behaviors (Brennan and Schwartz, 1984; Fisher et al., 1989; Mason, 1978; Trigeorgis, 1991; Leland, 1994; Dixit and Pindyck, 1994). In the project financing research, the real options framework provides the capability of modeling project characteristics including cost uncertainty, operating risks and flexibility, and other constraints. Depending on the particular context of application, a number of approaches have been developed to implement real options and capture managerial flexibility incorporating different assumptions, which ultimately determine the suitability of the selected model. In general, there are two main categories of real option models: (a) continuous-time models; and (b) discrete-time models.

2.3.3.1 Continuous-time Models

Most continuous-time models center upon stochastic processes of one or more variables, of which the value of the underlying asset is commonly selected. If an analyst decides to study cash flows at a more detailed level, however, the value of the underlying asset can be further decomposed into other variables such as product/service price, cost components, and volume/quantity. Understandably, most continuous-time models are restricted to just one or two variables due to computational complexity.

The most common stochastic process utilized to model the change in value of a variable (denoted as dV) is the Ito process, which is really a generalized Wiener process with the following form:

$$dV = \mu(V, t)dt + \sigma(V, t)dz \quad (2.1)$$

where dz represents the basic Wiener process:

$$dz = \varepsilon \sqrt{dt} \quad (2.2)$$

where ε is a random variable with a standardized normal distribution $\phi(0,1)$. A favorite form of the model usually treats both the drift term $\mu(V, t)$ and the variance

term $\sigma(V, t)$ as being proportional to the variable V , hence leading to the well known geometric Brownian motion:

$$dV = \mu V dt + \sigma V dz \quad (2.3)$$

A property inherent within this form of mathematical representation is that the variable V is log-normally distributed. Other forms of stochastic processes exist to broaden the regime of stochastic process modeling under different scenarios due to peculiar characteristics or distribution of the underlying. These include the mean-reverting process and the Poisson jump process (Dixit and Pindyck, 1994; Hull, 2002; McDonald, 2002; Wilmott, 1998).

In continuous-time models, solving for the value of a real option contingent on variables such as V often requires the derivation of a partial differential equation (PDE). The procedure then transforms from an intuitive consideration of strategic issues into mathematical manipulation where the PDE is solved subject to a set of boundary conditions related to the features of the option. In the best case, a closed-form solution exists for the PDE, thus allowing it to be solved analytically. The Black-Scholes equation used to evaluate a European option is a good example (Hull, 2002).

The standard Black-Scholes model is not difficult to use, but it has limited use in the context of real options in view of the assumptions made in deriving the model. Furthermore, in most cases, analytical solutions may not exist for a PDE constructed with more realistic constraints. As for construction projects, the maturity is always changing which is subjected to the actual operating environment and the option owner's decision. In this case, it is difficult to construct and solve PDEs. Thus, numerical approximation techniques are required, and discrete-time models (lattice model) are perhaps more practical in solving real options.

Another popular numerical procedure is the Monte Carlo simulation technique. The

basic idea is to simulate thousands of sample paths for a variable based on its stochastic process. For example, by taking random draws of ε in Equation 2.2, sample paths for variable V can be simulated by substituting Equation 2.2 into Equation 2.3 with a predetermined time-step Δt . Evaluation is especially simple for a European option, where exercise of the option is only feasible at maturity, as illustrated in McDonald (2002).

Real options, however, are often more akin to American options (or even compound options) in which optimal option exercise can happen before maturity. In other words, unlike the evaluation of a European option that resembles a forward induction procedure, values of real options in these situations often become path- and state-dependent, thus requiring a backward induction procedure. As with finite difference schemes, recent research has worked towards incorporating the features of backward induction in Monte Carlo simulation (Barraquand and Martineau, 1995; Broadie and Glasserman, 1997).

2.3.2.2 Discrete-time Models

Common forms of discrete-time models include the binomial model, the trinomial model and the lattice model. Many of these models have been developed with an intention to provide an approximation to the continuous-time models “in the limit” (i.e. when the time steps are increased indefinitely). For example, for a binomial model, Cox, Ross and Rubinstein (1979) have recommended parameters to represent the up and down movements of the underlying variable V in Equation 2.1, so that the volatility of the binomial tree matches that of the stochastic process. Thus, one can fairly comment that the underlying assumptions for this first category of discrete-time models and their continuous-time counterparts are essentially similar. They are conceptually equivalent – just that they are solved using different mathematical approaches.

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In the application of binomial approach, the solution can be obtained in one of two ways. The first is the use of market-replicating portfolios, and the second is the use of risk-neutral probabilities.

The predominant assumptions of market-replicating portfolios are: there are no arbitrage opportunities; and there exist a number of traded assets in the market that can be obtained to replicate the existing asset's payout profile. However, this assumption is argued to be hard to accept in real options where physical assets are being valued.

The risk-neutral probability approach does not depend directly on the investor's preferences/risk attitudes. In a world with risk-neutral investors, equilibrium requires that the expected returns on both the underlying assets and the payoffs are equal to risk-free returns. This risk-neutral valuation is also known as "equivalent measures" in probability theory (Harrison, 1985). It is akin to discounted cash flow models: one can "risk-adjust" the probabilities of specific cash flows occurring at specific times and then discount these cash flows at the risk-free rate. This is the essence of binomial approach in valuing options, and the result is identical to that of market-replicating portfolios approach. When evaluating the underlying asset value and the exercise price based on discounted cash flows, many authors and practitioners, such as Copeland and Antikarov (2001) adopt a same discount rate before and after the exercise date. The candidate hereby adopts a similar approach as well when evaluating these option parameters.

Nonetheless, discrete-time models need not be mere approximations of their continuous-time counterparts. This gives rise to what can be considered as the second category of discrete-time models that essentially represent "economically corrected" versions of decision-tree analysis so that the problems of payoff structure, risk characteristics and non-constant discount rates – all of which are primarily due to the flexibility and asymmetry embedded in the decision-making process – can be

overcome (Trigeorgis, 1999). More importantly, due to its resemblance to traditional decision-tree analysis, managerial flexibility can be modeled more explicitly in the tree structure. Thus, modeling real options as discrete-time models is more intuitive. This approach is especially valuable when the real option scenario cannot be represented simply by imposing stochastic processes on the underlying variables.

2.3.4 Application of Real Options in Different Industrial Contexts

An anticipative management may postpone or defer a project until market conditions are more favorable to achieve a higher return. Similarly, the decision to abandon a project during the life of the project may be necessary to cut losses. This flexibility of decision implies that management has the ability and influence to limit the downside risk of losses, but retain relatively unlimited upside potential for profits. Sustainable successes can be achieved by management's continuous learning in the marketplace and their ability to react correctly to changing dynamics. Performance is driven by a flexible and adaptive strategy that can be implemented rapidly.

In the real world that is full of uncertainty and competitive interactions, the realization of cash flows will probably differ from what the management has originally expected. As new information becomes available and uncertainty about future cash flows is gradually resolved, management may find that various projects carry varying degree of flexibility to depart from and revise the operating strategy that it originally anticipated.

Since the pioneering work of Black and Scholes (1973) and Merton (1973) in financial option pricing, tremendous progress has been made in the understanding and quantification of options. Moreover, with the increasing recognition that real assets can have option-like characteristics, literature on real options has now built up into a rich repertory. A general exposition to the subject can be found in Trigeorgis (1999),

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Amram and Kulatilaka (1999), Copeland and Antikarov (2001). Research studies have been extended to the application of real option evaluation in different industries (Busby and Pitts, 1998; Amram and Kulatilaka, 1999; Brennan and Trigeorgis, 2000).

These real options may be classified according to their nature:

- Timing option or the option to undertake, defer or abandon an investment (Titman, 1985; Williams, 1991; Capozza and Li, 1993; Grenadier, 1996). If market conditions decline severely, manager can defer, or even abandon current operations to avoid potential loss.
- Staging option or the option to undertake an investment in stages (Majd and Pindyck, 1987; Trigeorgis, 1996). Staging option is a series of outlays which create options to abandon if new information is unfavorable. Each stage can be viewed as an option on the value of subsequent stages and valued as a compound option.
- Scaling option or the option to expand or contract an investment (McDonald and Siegel, 1985; Pindyck, 1988; Capozza and Li, 1993). Manager can expand the scale of production or accelerate resource utilization if market conditions are more favorable than expected. Conversely, if conditions are less favorable than expected, the scale can be reduced.
- Growth option or the option to make a number of investments that may lead to greater opportunities (Myers and Majd, 1990; Faulkner, 1996; Brown, 1997, Grenadier and Weiss, 1997). An early investment such as in R & D, natural resources exploration is a prerequisite in a chain of interrelated projects. This will lead to future growth opportunities.
- Switching option or the option to change inputs or outputs in a production process (Fine and Freund, 1990; Kogut and Kulatilaka, 1994; Kutatilaka, 1995). During the operation of a project, if the prices or demand change,

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manager can change the output mix of the product. Similarly, if the costs of materials change, the same product can be produced by using alternate raw materials.

- Learning option. This is a more subjective type of option as it treats the entire project or business initiative as a learning ground or as part of a larger strategic plan to pursue future goals. For example, in its entirety, a pilot project in a politically unstable or less developed country is a learning option for a corporation to explore future business opportunities in the country.

Real option theory is not a new concept and has been applied to sectors and industries such as oil and gas, pharmaceutical, manufacturing, airlines, mining, and real estate. Though more commonly applied within other industries, the concept remains largely alien to the engineering, construction and infrastructure community. This represents an unfortunate drawback in view of the fact that multiple flexibilities are often structured within various stages of the lifecycle of many complex infrastructure projects.

An infrastructure project structured under the PFI arrangement often carries high risk. The importance of balancing risk and value has been highlighted in Cheah (2004). As a start, a major factor in all concession agreements is risk. When each party brings its own set of expectations and risk transfer or avoidance strategies to the negotiation table, the result would simply be a zero-sum game. To infuse a spirit of positive thinking, however, it is important not to overlook the part of value enhancement. Besides, value can also be created by structuring operating options and flexibilities during the course of design and execution of a project. Without proper evaluation of these elements, the matching of risk and value cannot proceed in a guided manner.

Recently, the concept of real option is also gradually gaining recognition in the field of construction engineering and management. For example, Leviäkangas and

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Lähesmaa (2002) consider the options approach as one of the useful evaluation methods for intelligent transport system investments. Garvin and Cheah (2004) used a simple binomial model to evaluate a deferment option in a toll road project. Ford et al. (2002) also used a similar approach to quantify the value of design flexibility in an engineering project; their method is closer to the framework of an ‘economically corrected’ decision-tree analysis – the second category of discrete-time models described previously. Ho and Liang (2002) developed a five-step option pricing based model to evaluate financial viability of a private finance infrastructure project, which adopted a discrete-time approximation to model the stochastic processes of two log-normally distributed variables, project value and construction cost, to subsequently solve for equity value using a lattice model. While Ho and Liang’s valuation is mathematically more elegant, Ford et al.’s application is a more intuitive and flexible model for specific construction scenarios. Other works include Ng et al. (2004), who set up a model to value a price cap and determine an optimal exercising policy in construction material procurement.

Apparently, there are many ways to model and evaluate real options. By broadly categorizing models into continuous-time and discrete-time (as similarly elaborated in the earlier sections of this chapter), Garvin and Cheah (2004) commented on the merits and challenges of applying each of them to the context of infrastructure projects. Borison (2003) also categorized the different real option approaches based on their assumptions made and the mechanics involved.

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Literature of RO in PPP/PFI	Summary of Content
Leviäkangas and Lähesmaa (2002)	Using options approach as one of the useful evaluation methods for intelligent transport system investments
Garvin and Cheah (2004)	Using binomial model to evaluate a deferment option in a toll road project
Ford et al. (2002)	Using binomial model to quantify the value of design flexibility in an engineering project;
Ho and Liang (2002)	Develop a five-step option pricing based model to evaluate financial viability of a private finance infrastructure project, which adopted a discrete-time approximation to model the stochastic processes of two log-normally distributed variables to subsequently solve for equity value using a lattice model
Ng et al. (2004)	Using option concept to evaluate a price cap and determine an optimal exercising policy in construction material procurement.
Missing Gaps	
1. Prior to jumping straight into option analysis, one should first answer the basic question of “what are the relevant types of options at different stages of an infrastructure projects?” 2. How can the real option concept be incorporated into risk management process? 3. How can real option be included in a negotiation setting between project participations?	

Table 2.3: Research on Real Option’s Application in Infrastructure projects

2.3.5 Limitations of Real Option’s Application in PPP/PFI Projects

Although as reviewed before, real option can be used in different industries and avoid the shortcomings of traditional evaluation methods, there are still downsides of its application in PPP/PFI projects. First, according to the classical formula of option, there are five parameters to determine. Oftentimes, however, these parameters are difficult to be identified and determined by great accuracy. For instance, one of the parameters, volatility (σ), is particularly difficult to derive due to the long project

duration and complication of qualitative risk factors such as political risk. Second, there are some who question the robustness of underlying assumptions of real option applications for certain cases. The classic approach makes use of the standard replicating-portfolio assumption of financial option pricing. Specifically, this approach assumes that a portfolio of traded investments can be constructed to replicate the returns of the option in question, and therefore the option can be valued based on the standard no-arbitrage arguments. As Amram and Kulatilaka (1999) has clearly stated: “Options are valued in a transparent, no-arbitrage manner.” However, there are many who do not agree with this perception – since PPP/PFI projects cannot be traded in a market, the validity of a “replicating portfolio” is difficult to accept.

2.4 Summary

PPP/PFI is increasingly an attractive delivery scheme in models such as BOT, BOT, BOOT and so on, which are accepted by many developing and developed countries. It is a win-win approach both to public and private sectors.

Generally, there are several parties such as government, shareholders, lenders, contractors, suppliers and operators involved in an infrastructure projects. Risks exist in a project should be assumed by a suitable party who is in the best position to absorb or handle them. The two typical methods of risk classification are developed by Li, et al. (2005) and Wang and Tiong (2000) which are suitable to conventional risk management strategies. The conventional strategies aim to transfer risks to other parties and avoid losses resulted from these risks. It has been pointed out that there are effectively four traditional risk management strategies: avoidance, reduction, transfer/shifting, and assumption.

The real option theory is reviewed, which is a new approach of project evaluation in the context of construction industry (although not new in other industries). Different

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from conventional DCF method, this theory considers managerial flexibility in a project which will enhance the value of a project. The review starts with basic concepts of option theory and various real option models, including continuous-time and discrete-time models. Subsequently, the challenge of applying these models to evaluate real options is discussed. Finally, the application of real option theory in general, and the limited research on real option in construction, is discussed.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

This chapter outlines the methodology used for this research, which aims to study real option evaluation and risk management strategies in privately financed infrastructure projects. As the goal and the nature of a research would determine its design and methodology, the main methods selected for the research include literature review, case studies and incremental development of a risk management framework that incorporates the real option concept.

3.1 Overview of Research Methodology

3.1.1 Selection of Research Methods

Most research works require decision-making in terms of the pattern and techniques of searching and investigating relevant subject materials throughout the voyage of discovery. Obviously, the selection of research methods plays an important part in determining the success of a research (Fellows and Liu, 1997).

Generally, there are five types of research methods, which include action research, ethnographic research, surveys, case studies, and experiments. Each of these research methods has its own advantages and disadvantages. Yin (1996) pointed out that the choice of the methods depends on three conditions: the type of research question, the amount of control that an investigator has over actual behavioral events, and the focus on contemporary as opposed to historical phenomena. Among these research methods, survey is a popular approach to conduct research in the forms of questionnaires and interviews. However, instead of using a survey, this research is conducted using the case study approach in view of the nature of the topic as explained below.

First, the study and application of real option theory require fairly detailed information about a project, such as background information, contractual arrangement and financial data, in order to derive the options that are embedded in the project and also to evaluate them. In contrast, a survey is usually meant to verify the respondents' beliefs in the validity of the statements put forth by the researcher — this obviously does not fit with the goal of examining the application of real options.

Second, although real option is not a new concept, its application in the context of construction and infrastructure is still in the stage of infancy. Most people in this industry are still not familiar with this concept. Given this industrial outlook, it is obviously not ideal to refer to these construction practitioners-at-large to impose upon

them questions that they may not be able to answer and extract information accordingly.

In contrast, case study, like an experiment, is a sound approach for collecting data. They allow for the identification of variables that cannot be identified in archival analysis. This alternative approach is regarded as more useful in achieving the purpose of this research.

In general, the analysis of data can be conducted using two popular catalogues of qualitative and quantitative methods. Although only one will be normally adopted due to resource constraints on the work, they are not usually mutually exclusive (Fellow and Liu, 1997). A qualitative method seeks to gain insights and to understand people's perception of the research. Simply stated, it can be considered as a method of data collection and analysis that are non-quantitative (Lofland and Lofland 1984). This method focuses on "quality", a term referring to the essence or ambience of something (Berg, 1989). A quantitative method seeks to gather factual data and to study relationships between facts and how such facts and relationships accord with theories and findings in the research executed. Analysis of the data yields quantified results and conclusions derived from the evaluation of results.

In this research, both qualitative and quantitative methods are applied in a way that is complementary to each other. In the case analysis, some options can be modeled and evaluated quantitatively, although there are also others that cannot be tagged with a concrete value based on data available (a good example is the "learning option" which is highly intangible). A combination of quantitative and qualitative methods can thus present a complete analysis of a project.

3.1.2 Data Collection

Since this research relies primarily on case studies, the data collection process naturally focuses on the cases selected. There are different sources of data for this research, including journal papers, press releases, conference papers, write-ups for business cases and also project/company websites. Although some projects were well publicized, there remained much information that could not be easily obtained since the details of the projects were kept confidential. In some cases, the data in fact originated from the bidding documents.

Data and information concerning the cases consist of two categories. The first category is qualitative descriptions of the projects, including background information and contractual arrangements. The other category of information is quantitative data, including components of cash flows. In this thesis, the analyses of short cases focus primarily on qualitative descriptions of the projects concerned. Analyses of the subsequent three major cases are more detailed, which include: background of projects; identification of embedded options; cash flow modeling; and evaluation of real options. The original categorization between short and major case studies was dictated by the amount of data gathered for each case.

3.1.3 Research Process

By and large, a typical research process consists of five stages: problem formulation, data collection or literature search, data evaluation, analysis and interpretation, and presentation of results (Cooper, 1998). This research study follows the general steps as shown in Figure 3.1. The first step is to put forward a problem statement and understand the significance of the research topic. Review of literature and theories forms the second step. The third step involves data collection of the cases selected and data analysis. By building on the findings from the third step, the final step represents

the ultimate objective of this research: to develop a framework of risk management strategies with the inclusion of the real option concept.

Figure 3.1 Components of the Research Process

3.2 Problem Formulation

At the very beginning, problem formulation requires a clear understanding of the background of research, the objectives that are targeted to achieve, and the significance of potential research findings. With the growth of economy in developing

countries, the need of infrastructure systems is increasing. In infrastructure project development, risk management is a very important aspect. However, traditional risk management strategies do not typically consider managerial flexibility during project execution which can enhance the value of a project. This thesis aims to illustrate how to incorporate real option thinking in the risk management of infrastructure projects. This will eventually lead to a risk management framework with a risk sharing setting.

3.3 Literature Review and Theoretical Foundation

The literature review aims to build a strong foundation of theories upon which the research is based. A good literature review will not only place the research in a scientific perspective, but also avoid duplication of efforts and help to identify relevant concepts, theories, research methods and analytical tools (Dane, 1990).

In this thesis, the review includes those literature that are related to real option theory and privately financed infrastructure (PFI) projects. The review of PFI centers on the development aspect of PFI and conventional strategies adopted in risk management of infrastructure projects. The review of real option focuses on the strength of real option evaluation over traditional discount cash flow (DCF) techniques, the basic features of options, the mechanics of option pricing and evaluation, the applications of real option in the general context and also the PPP/PFI context. These have already been discussed in Chapter 2.

3.4 Case Study Analyses

3.4.1 Short Cases

Since the 1980s, PFI and similar initiatives (e.g. BOT, BOOT, BTO etc.) have become a common approach to develop large-scale infrastructure systems. Despite some subtle differences in their contractual settings, the key issue for all parties concerned is still to assess risks and uncertainties inherent in a project. The risk factors studied and highlighted by past researchers are very diverse. The analysis of short cases embarks with an objective to compare the risk factors in different sectors of infrastructure systems, and subsequently categorize them into two kinds: general and specific risks. Following this classification, risk mitigation strategies should be adopted differently at the corporate and project levels. These short cases are then used to illustrate the flexible measures or “options” that project participants have designed to address some of these risks and uncertainties.

3.4.2 Major Case Study I — Dabhol Power Project in India

The multi-dimensional complexity of large-scale infrastructure projects is widely known. Although much research effort and publications exist in areas of contract administration, privatization and risk management, fundamentally sound evaluation approaches are generally lacking in quantifying flexibilities and options incorporated within the planning and execution stages of these projects. This may lead to distorted expectations in contractual dealings and design of inequitable terms in the agreements.

Dabhol Power Plant was a pilot project for India’s electricity reform. This project was developed by Enron and the project vehicle was known as the Dabhol Power Company (DPC). The project was designed to be implemented in two phases, with

each having a concession period of 20 years. In this project, conflicts existed among the government agencies, the investors and other parties during the planning stage, the construction stage and the operating stage. Results of subsequent negotiations between the parties had defined the characteristics of the project and its uncertainties. These uncertainties created values in the options for certain parties in the project. The qualitative data and background of the project are essential in giving a detailed understanding of the associated events.

By evaluating the options in this project, the differences between traditional DCF/NPV method and real option approach become evident. It is concluded that the latter approach better captures flexibility and option values, hence a valuable tool to align the interests of different parties and facilitate fairer negotiation.

3.4.3 Major Case Study II — Malaysia-Singapore Second Crossing

Host governments often grant various forms of support, which may include a subsidy, a guarantee or even a direct capital contribution to alleviate the concern of the private sector and attract long-term investors' participation in financing the project (Klein, 1997). However, as has been reported widely, some governments do not explicitly account for the contingent liabilities and implications associated with these support packages (Mody and Patro, 1995). Despite their prevalence, the cost of these financial incentives to governments and their value to private recipients are not well understood (Mason and Baldwin, 1988). Furthermore, unsolicited proposals for private participation in infrastructure projects are not uncommon (Hodges, 2003). All these factors create room for opportunists to capitalize on the lack of understanding of contingent liabilities and exploit the host country by proposing a lopsided deal. The situation is particularly exacerbated in the case of weak institutional and regulatory frameworks of the host country as in the first case of Dabhol Power Plant.

In the analysis of the Malaysia-Singapore Second Crossing, actual guarantee granted by the government is identified as a put option and a hypothetical repayment scheme from the sponsor to the government is modeled as a call option. Monte Carlo simulation, real option and sensitivity analyses are used collectively in the project analysis. In addition, the project features are also reviewed to illustrate the possibilities of introducing flexibility during the design and construction stage.

3.4.4 Major Case Study III — Wastewater Treatment Plant in Southern China

In the evaluation of infrastructure projects, certain parameters are naturally difficult to estimate. One such example is the volume of rain fall in a city. These parameters, however, are important to project stakeholders since they will affect the value of the project from individual's perspective. This wastewater treatment plant is a pilot project that took place during the reform of changing the capital structure of state-owned enterprises at the end of the 20th century in China. During such reforms, local governments often authorized affected public agencies to transfer operating rights of certain infrastructure systems to the private investors.

In the analysis of this project, the guarantee of the minimum treatment volume is analyzed as a put option granted by the local government. The “capped” tariff for treatment volume in excess of a predetermined level is modeled as a call option that is owned by the government. For the analysis of these two options, Monte Carlo simulation and sensitivity analyses are applied. Based on the analysis, this case not only illustrates the value of options, but also proposes a proper negotiation model to align the interests of both the local government and the concessionaire.

3.5 Conclusion of the Research

In a privately financed infrastructure project, risk management represents an important aspect. As illustrated in the literature review, the traditional strategies of risk management are based on conventional evaluation methods which generally overlook the value of managerial flexibility. Due to the significance of this managerial flexibility, it would only be proper to design a risk management framework that incorporates the real option concept.

The construction of this framework follows an intuitive procedure. First, the identification of risks still forms the most basic step. In addition, the framework demonstrates risk management strategies together with option design, structuring and modeling, which will lead to a risk sharing setting that can potentially enhance the project value from different parties' viewpoints.

As reviewed in Chapter 2, risks are classified in the form of a check list, which includes critical success factors (CSFs). Although the classification is built based on the relationship between the risks and the project itself, the timing of these risks is not generally explored, which could be an important factor in real option theory. Therefore, this framework also identifies risks in a project according to the timing and nature of risks in the form of a checklist.

The design of risk management strategies and the structuring of option form the core of the framework. However, it should be emphasized that traditional risk management strategies are far from being discarded — they still have an important role to play in the holistic framework.

3.6 Summary

Literature review, quantitative model building and qualitative analysis of case studies and are the key components in this research.

The literature review aims to build a theoretical foundation upon which the research is based. The scope of the literature review includes real option theory and PFI. To achieve the purposes of this research, the analyses of short cases and three major case studies are conducted with both quantitative and qualitative methods. Finally, this research developed a risk management framework that incorporates the concept of real option.

CHAPTER 4

OPTION DESIGN STRATEGIES FOR INFRASTRUCTURE PROJECTS

In this chapter, risks involved in infrastructure projects are classified in a new manner: general risks and specific risks. Accordingly, mitigation measures are defined on the basis of this new method of classification. The analyses of the short cases demonstrate that risks can be mitigated by incorporating flexible strategies, which will create real options. At the end of this chapter, these flexible strategies are summarized. The information of the cases is collected from various sources such as journal papers, publications, conference papers, internet websites, and write-ups on business cases.

4.1 Interpreting Risks in an Alternative Manner

Since the 1980s, privatization has become a common approach to develop large-scale infrastructure projects. This has come in different forms of private sector participation models such as the build-operate-transfer (BOT), build-own-operate (BOO) and build-own-operate-transfer (BOOT) type of concessions (Thomas and Ananthanarayanan, 2003). These infrastructure projects would involve the participation of many parties, a huge amount of investments and a lengthy contractual period. As a result, they are more risky than most projects that are delivered using the “conventional” mode of Design-Bid-Build.

Generally, all infrastructure projects can be related to either the provision of product or the provision of services. Among the common types of infrastructure projects, the former would include power plants, water and wastewater treatment plants; the latter would include toll roads and telecommunication networks. It is suggested that the distinction between provisions of product and services helps to examine the source of risk from a different angle. It also follows that the risks associated with different infrastructural sectors can be categorized into two kinds based on their nature – general risks that are applicable across all infrastructural sectors, and specific risks that are only relevant to one or few specific sectors. This concept is depicted in Figure 4.1.

Figure 4.1: Conceptualization of General and Specific Risks

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Based on the risk categorization model of Wang and Tiong (2000) (see Pg 22 in Chapter 2) and the analysis of short cases presented in this chapter, Table 4.1, 4.2, 4.3 and 4.4 are derived to categorized risks into general and specific types with respect to portfolio theory. General risks are common risks which are embedded in all sectors, as represented in Table 4.1. When an infrastructure project is undergoing development, there are always some common risks that are faced by the project sponsor, such as changes in government monetary and fiscal policies, economic uncertainty, etc. All these would be experienced regardless of the type of infrastructure developments that the sponsor is currently promoting – be it power, transportation or wastewater treatment. On the other hand, specific risks are those that are uniquely framed within one or few specific sectors (as shown in Table 4.2, 4.3 and 4.4). For instance, a toll road project is not directly exposed to the supply risk of fuel source, unlike the case of a power plant project. This suggests that there are certain risks that differ between a toll road project and a power plant project. These differences belong to specific risks, which are mostly made up of political, construction, operating, market and revenue risks that are unique to the corresponding sectors. At the meantime, they are both exposed to general risks.

The categorization of general risks and specific risks will lead to risk management strategies at different levels. As reviewed in Chapter 2, there are two insightful risk management models (Li, et al; 2005 and Wang and Tiong, 2000) – these risk management models and strategies are designed for individual projects in isolation. In recent years, given the aggressive growth and expansion of large engineering and construction firms such as Skanska (Sweden), Vinci (France), Hochtief (Germany) and Ferrovial (Spain), these firms often have direct equity participations in a number of projects concurrently. Therefore, it would be relevant to develop a risk management model on the basis of portfolio theory at the company level. The categorization of general and specific risks would help managers to recognize that systematic risks are non-diversifiable and is best hedged away, whereas unique or specific risks are partly diversified at the company level. General risks are effectively risks subject to the

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general business and market environment that are uncontrollable by project parties; specific risks on the other hand arise due to the unique features of the project that are not common to other types of projects. Based on the above concepts, the two risk management models of Li et al. and Wang and Tiong, and also the insights gained in the short and major case studies, classification of risks are sought in Table 4.1 – 4.4. The principle is nonetheless similar to the portfolio theory in corporate finance (Markowitz, 1952).

Categories	General Risks for All Types of Infrastructure Projects
Political risks	<ul style="list-style-type: none"> • Expropriation/sequestration of assets • Change in law (general effect on all sectors) • Development approval • Adverse government actions or inactions • Increase in taxes (general effect on all sectors) • Force majeure events • Termination of concession by Government/Revocation
Operating risks	<ul style="list-style-type: none"> • Government department default • Concession company default • Environmental damages
Market and revenue	<ul style="list-style-type: none"> • Government restriction on profits/tariffs/charges • Competition
Financial risks	<ul style="list-style-type: none"> • Inflation • Interest rate • Foreign currency exchange rates • Foreign currency convertibility
Legal risks	<ul style="list-style-type: none"> • Ownership assets • Security structure • Breach of contract • Enforcement of security • Documentation risk

Table 4.1: Categories of General Risks (from a Concessionaire's Viewpoint)

Source: Developed by Author

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Categories	Specific to Power
Political risks	<ul style="list-style-type: none"> • Change of law Land acquisition and compensation • Payment failure by Government/ offtaker in Take-or-pay contract
Construction risks	<ul style="list-style-type: none"> • Restriction on import of equipment/ materials specific to power project • Land acquisition and compensation • Nature of cost overrun • Sensitivity to an increase in financing cost • Time and quality • Contractor default • Variation in scope • Environmental damages
Operating risks	<ul style="list-style-type: none"> • Power theft • Labor risk • Technology risk • Condition of facility • Transmission failure/Distribution Failure • Supply risk of materials/fuels
Market and revenue	<ul style="list-style-type: none"> • Fluctuating demand of power generated (e.g. Merchant plants; except in take-or-pay contract) • Offtake risk(quantity, timely payment) • Fluctuation of cost • Supply of fuel source

Table 4.2: Categories of Risks Specific to Power Projects

Source: Developed by Author

Categories	Specific to Transportation
Political risks	---
Construction risks	<ul style="list-style-type: none"> • Nature of cost overrun • Sensitivity to an increase in financing cost • Time and quality • Contractor default • Variation in scope • Environmental damage
Operating risks	<ul style="list-style-type: none"> • Delay in other projects connecting to the project • Labor risk • Construction of competing routes
Market and revenue	<ul style="list-style-type: none"> • Inadequate traffic volume

Table 4.3: Categories of Risks Specific to Transportation Projects

Source: Developed by Author

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Categories	Specific for Wastewater Plant
Political risks	<ul style="list-style-type: none"> • Payment failure by government agencies
Construction risks	<ul style="list-style-type: none"> • Restriction on import equipment/ materials specific to plant facility • Nature of cost overrun • Sensitivity to an increase in financing cost • Time and quality • Contractor default • Variation in scope • Environmental damages
Operating risks	<ul style="list-style-type: none"> • Quality of Influent and Effluent (BOD etc) • Labor risk • Technology risk • Condition of facilities (esp. in TOT contracts) • Fluctuation of cost
Market and revenue	<ul style="list-style-type: none"> • Volume of Influent • Offtake risk (quantity, timely payment) • Fluctuation of price

Table 4.4: Categories of Risks Specific to Water/Wastewater Treatment Plants

Source: Developed by Author

Obviously, there are situations where general and specific risks cannot be demarcated clearly. For example, government restrictions on profits and tariff levels may follow certain sectoral or industrial policies, thereby converting an otherwise general risk into one that is more of a specific nature.

Moving along with the above categorization, general risks, to a large extent, would be subject to external uncontrollable conditions that a project is confronted with. For instance, inflation, which can be classified as a type of general risks under the category of financial risks, cannot be controlled by the project participants. On the other hand, specific risks are unique to individual projects; the exposure to some, but not all, of these risks may be limited or even “molded” by a project participant. For instance, through proper structuring of the contractual arrangement, the concessionaire in a power project may potentially mitigate the supply risk of fuel source (which is a specific risk) by entering into a long-term fixed-price supply contract.

4.2 Risk Management Strategies at Firm and Independent Project Levels

4.2.1 Strategies at the Firm Level

The differentiation between general and specific risks can be extended further. From a firm's viewpoint, the differentiation is related to the concept of portfolio theory in corporate finance (Markowitz, 1952) and applied to risk management when investing in a collection of infrastructure projects. At any point in time, a sponsor or an investor may have made investments in several infrastructure projects or concessions. This is a common strategy among institutional investors. In fact, large engineering and construction firms, such as Vinci from France and Hochtief from Germany, have also become strategic players in the worldwide concession market. Other than limiting their roles in the traditional areas of feasibility planning, design and construction, these firms have also taken the lead in financing the project by taking up long-term equity stakes. Again, at any point in time, the firms may be having stakes in multiple infrastructure concessions, which are undergoing different stages of project life cycles.

According to portfolio theory, diversification helps to reduce the overall variability of return, which reflects the risks of investing in a portfolio of infrastructure concessions. Moreover, even a little diversification can provide a substantial reduction in variability, although some residual risks still exist (as shown in Figure 4.2). Following the context of Section 4.1, general risks cannot be eliminated by diversification, since they stem from economy-wide perils that would threaten all types of infrastructure projects. In the contrary, specific risks would be reduced through diversification when a firm is invested in a larger number of projects. This stems from the fact that specific risks are peculiar to individual infrastructural sectors, thus it is unlikely that the same source of specific risk will affect two projects of different sectors at the same time.

Operationally, specific risks can also be diversified by, for example, transferring profits or cash flows from well-operating projects to cover temporal shortfall in other projects. From a portfolio standpoint, the volatility of return of the overall collection of infrastructure investments is thus reduced. This helps to reduce the risk of financial distress or bankruptcy of a firm that is actively involved in infrastructure concessions.

Figure 4.2: Collective Risks in a Portfolio of Infrastructure Projects

4.2.2 Strategies at the Independent Project Level

Section 4.2.1 analyzes risk management from a firm's viewpoint based on the portfolio theory. Creation of a portfolio would not reduce general risks. For an independent project, all the risks are not reduced in the process of diversification. As a matter of fact, as a project participant, the sponsor holds the position of developing and shaping the project and it could take actions to mitigate some of the risks. For instance, in a power project, to protect from the shortfall in energy demand, the sponsor could find ways to sell surplus electricity to other customers, encourage consumption by lowering prices, or simply negotiating for a "take-or-pay" contract at the outset.

There has been a decent amount of research conducted on risk management of infrastructure projects. However, many of these covered the idea of risk management following the conventional process of identification, measurement, control and mitigation. It also follows that four general methods of risk mitigation are commonly adopted: avoidance, reduction, shifting or transfer, and assumption (CII, 1989). Although these four methods are applicable to avoiding potential losses due to risks, it is easy to overlook the fact that certain risks can be managed or restructured by “shaping” the plan of execution of the project. This ultimately enhances the value of a project. Among others, Lessard and Miller (2001) recommended, with general descriptions, for developing a real option framework to manage risks in large engineering projects. Throughout the life cycle of a project, risks are expected to result in either gains or losses. Real option thinking argues that managers can take advantage of the upside scenarios (gains) and avoid the downside scenarios (losses) by incorporating flexibility in risk management of a project (Miller and Waller, 2003).

Through the descriptions of a few short case studies, the next section will illustrate how flexibility or options may be introduced into a project so as to address some of the general and specific risks.

4.3 Short Case Studies on Flexibility and Options

4.3.1 Texas High-Speed Rail Corporation

4.3.1.1 Background

The Texas cities of Dallas, Fort Worth, Houston, Austin, and San Antonio, through an unusual combination of geography and demographics, represent a promising market in the United States for an inter-city high-speed passenger rail network. They are situated on a rough triangle with 250-mile-long legs (Figure 4.3). Residents and

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visitors traveled frequently between these cities. In one study, the volume was projected to reach about 20 million person-trips per year by 2000, of which 12 million would be by air. Most of the air travel within the state was to and from Dallas-Fort Worth, a major air traffic hub, and most of it consisted of business trips. The Texas High-Speed Rail Corporation (THSRC) was formed by the Texas TGV ("Train à Grande Vitesse") Consortium, a group of private investors, to construct and operate a rail network. In 1991, the Consortium was awarded an exclusive franchise for such a system by the State of Texas. Although the project was eventually cancelled in August 1994, the original execution plan is worth studying here.

Figure 4.3: Route Alignment of the “Texas Triangle”

The THSRC project was planned to pass through five phases, each characterized by a different set of activities, uncertainties, and funding needs. A preliminary phase of relatively low expenditure lasted until sometime in 1993. A two-year development phase would then mark the beginning of large expenditures and involved some irreversible investment. The construction phase would last for five years and involve heavy expenditure in many locations. A startup phase was then planned to begin in 1998 and would last for two years as the systems swung into full operation, so that THSRC could make adjustments to operating policies and systems. Finally, in time to come, the high-speed rail system was expected to arrive at a steady state characterized

by stable operations and a new equilibrium in the Texas inter-city transportation market.

THSRC planned to operate trains along the eastern leg of the triangle beginning in 1998, and offer door-to-door travel times comparable to existing air service at prices comparative with airfare. Following this, by the end of 1999, services would commence along the western corridor from San Antonio to Austin and Dallas-Fort Worth. A southern corridor, connecting Houston and San Antonio, would be added later if sufficient demand materialized.

One problem predicted was that the high-speed line between Dallas-Fort Worth and Houston was unsubsidized and it was difficult to project whether it could match competing airfares and realize high enough load factors to produce an adequate return on investment.

Based on the construction of the facility, THSRC could provide several other potential services such as parking, package delivery, and advertising. In addition, some of THSRC's right-of-way and station sites would create opportunities for real estate development, though none of THSRC's current projections included costs or revenues from such projects. THSRC also planned to lay fiber-optic cables along its right-of-way.

4.3.1.2 Options Identified from the Case

(1) Abandonment option along the five phases

As mentioned, THSRC would implement the project on a phased schedule. Based on the phased schedule, THSRC could make a projection of the facility's prospect according to information collected in each stage. If the prospect turned out to be favorable, the project would be continued; otherwise, it would be abandoned to avoid

larger losses, just as what indeed actually happened. This strategy gave THSRC a series of abandonment options during each of the five phases. Since a put option implies a right to sell an asset at a predetermined exercise price when the value of the underlying drops below this price, the abandonment options can be modeled as a form of put options (Trigeorgis, 1999).

(2) Expansion option

THSRC initially planned to operate the eastern and western legs of the triangle. From the viewpoint of THSRC, the construction of the southern corridor is an expansion option based on the execution plan. The decision to construct the southern corridor is subjected to its value and cost. According to real option theory, the uncertainty of traffic volume is a key factor, which would lead to an uncertain asset value but a positive option value. If the present value of asset is greater than the present value of cost, it would be valuable to construct the southern corridor; otherwise, the decision can be postponed.

(3) Growth option from air traffic handling

There were two approaches to tackle the previously mentioned problem of the high-speed line between Dallas-Fort Worth and Houston. One was to compete head-on against the airline; the other was to cooperate with it. As the high-speed line was unsubsidized, it is difficult to realize a good return of investment when there is a substitute transportation means. In this case, THSRC developed an idea of increasing rail traffic by cooperating with airlines to deliver air passengers from outlying parts of Texas to the DFW hub. This seemed to be more feasible at that time. The feasibility of the high-speed line would then be subjected to the income negotiated for delivering air passengers and the cost of cooperating with the airline. In this strategic arrangement, cooperating with the airline would represent a form of growth option to THSRC.

(4) Call options from other revenue sources

The potential services from parking, package delivery, advertisement, real estate development and so on could form ancillary sources of revenue and it could generate stable, if modest, cash flows. Laying fiber-optic cables along its right-of-way would involve low incremental costs during the system's construction phase, and create some immediate cash flow when the resulting telecommunications capacity was sold or leased. All these potential opportunities provided some call options for THSRC to capture additional revenue.

4.3.2 Poland's A2 Motorway

4.3.2.1 Background

After some great political and social changes, Poland, an Eastern European country, turned its focus on its development in the early 1990s. Besides reforming the economy, the government recognized the need to upgrade and expand the country's transportation infrastructure. In September 1993, the government approved the construction of a 2,600-kilometer tolled motorway system, which consisted of four main routes: two running east-west (A2 and A4) and two running north-south (A1 and A3) (as shown in Figure 4.4). The government hoped that private enterprises would provide a substantial fraction of the estimated US\$ 10 billion cost under the BOT model used for many infrastructure projects around the world.

The government selected the A2 Motorway as the first concession. Once it was completed, it would be part of Paris-Berlin-Warsaw-Moscow transit corridor, a modern transportation system linking EU member countries. The challenge of this project was its size, setting, and lack of precedents.

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Figure 4.4: The Polish Motorway Program

Autostrada Wielkopolska, S.A. (AWSA), a consortium of Polish and Western European firms, won the exclusive concession to build and operate a major segment of the proposed A2 Motorway, the first private toll road in Poland. The concession authorized AWSA to design, finance, build and operate the western third of the A2 Motorway, a distance of 254 km. The concession application specified a phased plan of construction beginning at Konio and proceeding westward to Swiecko. Phase I contained three roughly equal sections with sequential completion deadlines. AWSA was obligated to finish Phase I within 6.5 years after financial closing, and had until December 2007 to finalize financing for Phase II; otherwise the government could

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reassign the concession to another firm.

Development Company (DC), a new special-purpose joint venture company with extensive construction experience owned by several AWSA shareholders, was expected to sign a fixed-price Design-and-Build contract for Phase I with AWSA. DC needed to pay AWSA liquidated damages for each day of delay, but the maximum damages were set at 5% of the contract price for each segment. In case the maximum damages were reached, AWSA would have the right to terminate the contract and replace DC with another contractor.

According to the concession, the government was entitled to receive 20% of distributable cash flow once the shareholders had received a cumulative real return of 10% or more on their invested capital, and 50% once they had received a return of 15% or more.

If a force majeure event or government action caused a delay, either an insurance policy or the government would compensate AWSA subject to a maximum annual loss of 650,000 Euro. The government also agreed to compensate AWSA for delays or increased costs caused by the discovery of archaeological or hazardous materials.

The government agreed not to build or improve any competing road, not to impose tolls on any feeder roads, and to maintain the feeder roads. These commitments were backed by specific compensation provisions for losses suffered by AWSA.

The concession gave AWSA the right to set tolls in zloty (the Polish currency), but limited both initial and life-of-concession maximum tolls by class of vehicle. AWSA could reset the actual tolls every six month, and there was a provision to adjust the maximum tolls to account for changes in Polish inflation and exchange rates. AWSA also had been guaranteed that it could adjust the toll rates according to the actual traffic situation of the facility and economy.

4.3.2.2. Options Identified from the Case

(1) Learning option

The size of this project, setting, and lack of precedents led to challenges to all parties involved. Since the A2 Motorway was the first toll road in Poland, none of the principal parties, including the government, had any significant experience in structuring projects of this size. As such, the construction of A2 can be viewed as a complicated learning option to either party as each can learn how to structure a deal that meets international standards for financing and construction. The cost of this learning option would be their respective investments (both direct and indirect) in the A2 Motorway.

(2) Abandonment and switching option from phased construction

In the phased A2 Motorway, AWSA was obligated to finish Phase I and finalize financing for Phase II; otherwise the government could reassign the concession to another firm. This implies that the government held the option to withdraw participation of AWSA in Phase II to avoid greater losses resulting from construction delay. Of course, the government must incur some cost to engage another firm to continue with the project, which is the cost of the option to switch to an alternative project promoter.

(3) Repayment as a call option

According to the concession, the government was entitled to receive certain percentage of distributable cash flow once the shareholders had received beyond 10% and 15% cumulative real return on their invested capital. The right offered the government a call option to get repayment from the concessionaire. As it is a public facility, the government hence held the right to limit the benefit of AWSA by terms like these to reclaim part of the distributable cash flows.

(4) Learning and expansion option from a phased approach

According to the concession, the A2 Motorway would be built in two phases. Although the phased approach extended the overall construction period, it was critical to the design of the project. The usage of Phase I would demonstrate the reliability of initial traffic projections, which would lead to better traffic prediction for Phase II and also a much better position to negotiate the financing for Phase II. From the viewpoint of AWSA, it is a learning plus an expansion option.

(5) Put option

The contractor, Development Company (DC) for Phase I, needed to pay AWSA liquidated damages for each day of delay, but maximum damages were set for each segment. In case the maximum damages were reached, AWSA would have the right to terminate the contract and replace DC. AWSA could then find a new company to continue with construction. This option entitled AWSA to control the construction process. The additional cost and time involved effectively represents the cost of this put option available to AWSA in order to terminate its engagement with DC.

(6) Guarantees written by the government

First, the government wrote a guarantee to AWSA against force majeure event and government action that would result in loss to AWSA. Under this guarantee, AWSA would not need to worry about risks of force majeure. Second, the government guaranteed that there would be no competing road, which provided some security to the revenue of AWSA. Third, the concession gave AWSA the right to set tolls according to changes in Polish inflation and exchange rates and AWSA could adjust toll rate according to the actual traffic situation of the facility and economy. All these guarantees, in the form of put options, provided a downside protection to AWSA, which offered AWSA the flexibility to manage the project and some commercial terms during operation.

4.3.3 Rocksavage Power Plant

4.3.3.1 Background

In the U.K., the first wave of private power was politically motivated, the driving force being a desire for low cost, non-polluting electricity production. New technology constantly plays an important part in achieving this goal. The plant being built at Rocksavage is a good example of this.

The Rocksavage independent power project involved a 770 MW combined cycle power plant built for the chemical company ICI (Imperial Chemical Industries). The developer was InterGen, a U.S. power plant developer jointly set up by Bechtel and Pacific Gas & Electric in 1995. The Rocksavage plant was designed to provide 300 MW to ICI's adjacent Runcorn chloro-alkali facility, 400 MW to Scottish Hydro Electric, with the remainder transmitted to the national grid.

In the Rocksavage IPP project, fuel was supplied to the plant on a "tolling" basis. Gas was procured and provided to the plant by the users – ICI and Scottish Hydro, and processed through the power plant which then provided them with electricity. Whether the plant operates or not would depend on whether the two main customers need the electricity and also whether it is to be their cheapest option.

Rocksavage was InterGen's first exclusively developed and owned international project. The entry into commercial operation of Rocksavage was a milestone for InterGen. The first kWh generated by Rocksavage was also the first product generated by a wholly InterGen-owned plant, which marked the company's transition from a developer to an operator of power plants.

4.3.3.2 Options Identified from the Case

(1) Switching option of altering operation (shutdown and restart)

Gas-fired plants built in the early 1990s were sometimes criticized because they operate predominantly in a baseload mode. They gave no thought to flexibility, load following, frequency response, security and the greater good of the whole electricity system. The Rocksavage IPP plant was not a baseload plant that runs regardless of pool price. It was the first U.K. IPP-developed and was not designed to just be switched on and run continuously. This flexibility was built in from the outset. In fact, the design basis of the plant assumed around 200 stop/start sequences per year. InterGen could provide power according to the actual energy demand. This option helps to avoid losses that would have resulted from a baseload model.

(2) Growth option

As Rocksavage is InterGen's first exclusively developed and owned international project, it could be seen as a flagship plant launching what it hoped would become "a national energy company in the U.K." The setting up of what it called national energy companies, which handled all aspects of electricity production, from power project financing to electricity marketing, was a key element of the InterGen strategy. So the development of Rocksavage gave InterGen a growth option from the level of company strategy. Indeed, InterGen continued to look for opportunities in the U.K. and had further constructed two combined cycle gas-fired plants at Coryton and Spalding.

4.3.4 Indiantown Cogeneration Project

4.3.4.1. Background

This project involved the construction and operation of a coal-fired cogeneration

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facility in Southwestern Martin County, Florida, U.S.A. The cogeneration facility, with an electric generating capacity of 330 MW and a steam export capability of 175,000 pounds per hour, was certified as a “qualifying cogeneration facility” under the Public Utilities Regulatory Policy Act of 1978 (PURPA). A project partnership, which was formed among Toyon Enterprises, Palm Power Corporation, and TIFD III-Y Inc., sold electric power to the Florida Power & Light Company (FPL) under a 30-year Power Purchase Agreement and sold steam to the Caulkins Indiantown Citrus Company under a 15-year energy services agreement. Bechtel Power Corporation was responsible for constructing the cogeneration facility pursuant to a fixed-price turnkey contract. Bechtel Power’s responsibilities included design, engineering, procurement, construction services, plant start-up, training of personnel, and performance testing.

Construction began in October 1992. The guaranteed date for substantial completion of the cogeneration facility under the construction contract was January 21, 1996. If the facility failed to achieve substantial completion by the guaranteed completion date, Bechtel Power would have to pay substantial liquidated damages. However, Bechtel Power’s total liability for delay and performance liquidated damages was subject to a cap of US\$100 million (in addition to any delayed completion insurance payments).

The Power Purchase Agreement gave FPL broad control over power dispatch levels. For example, FPL could suspend its receipt of energy for specific reasons, including safety reasons or system emergencies.

The Steam Purchase Agreement had a term of 15 years following the commercial operation date. Either party can renew the agreement for five additional years. The agreement can be extended for two additional terms of five years each, if Caulkins and the partnership both agree.

The partnership and a company known as U.S. Operating entered into an Operating Agreement. Under this agreement, U.S. Operating was responsible for operating and

maintaining the cogeneration facility. The term of the Operating Agreement is 30 years with automatic renewal for successive 5-year periods, unless terminated by either party.

4.3.4.2 Options Identified from the Case

(1) Cap/written call option

Although Bechtel would pay liquidated damages in case of delay, the contract had set a cap to the total liability. From the partnership's standpoint, the payoff foregone due to this cap represents a "written call" (i.e. a call option granted to Bechtel).

(2) Switching option of altering procurement sources

This contract feature of the PPA gave FPL the flexibility to adjust its energy purchases from the cogeneration facility based on FPL's relative costs of procuring power from its alternative sources (such as the other merchant plants connected to the same transmission grid). This arrangement helped FDL to control the uncertainty caused by the cost of power in the form of a switching option.

(3) Extension /call option

The Steam Purchase Agreement offered an extension option to either party. At the end of term, both parties could renew it and extend for a new term if it turns out to be worthy; otherwise, the term could be ended. This clause offered each party the right to benefit from a new term under an optimistic scenario, which presented a call option.

(4) Abandonment option

Although the Operating Agreement also offered an opportunity to extend the term as in the case of the Steam Purchase Agreement, it was expressed differently from an option standpoint. By default, the term would be automatically extended for five years if either party was satisfied with it. However, either party would have the right to

terminate the contract before the end of the successive terms, which represents a form of abandonment option (i.e. a put option to terminate, rather than a call option to extend as in the case of the Steam Purchase Agreement).

4.3.5 Learning Option in Plant Design/ Construction of Merchant

Power Plants

With capital for the construction and upgrading of power plants becoming more elusive and expensive, reducing the cost of design, construction and upgrading of power plants is all the more critical. With today's competitive electricity power market, power plant developers are demanding reliable and short construction and startup times. Shortening the construction time and up-front costs is possible by utilizing new concepts and techniques, such as parallel design and field erection, partnering between owners, suppliers, engineering and construction companies, and using enhanced computer-aided design.

These new techniques and design approach offer developers valuable learning options during the construction phase of a power plant. A good example can be given in the case of InterGen. InterGen, a joint venture between Bechtel Enterprises and Shell, constructed three almost identical power plants: Cottonwood in Texas, Magnolia in Mississippi, and Redbud in Oklahoma. All three plants are natural gas combined-cycle plants with supplemental firing. With three identical plant designs, and by staggering the start of construction, the engineering design for the second and third plants would be progressively carried through and the time will be shortened greatly. In addition, the staggered arrangement could facilitate information exchange among the plant and also make it possible to allocate manpower flexibly.

Following the requirements for an option, there are five parameters of concern: the

value of underlying asset in this option would be the economic value (arising from operations) of the subsequent plants; the volatility of option is driven by all factors of uncertainties in the construction of the subsequent plants; the cost to redesign the scheme of construction and to implement the modified scheme will be the exercise price of the option; the time difference between construction of a former plant and a latter one is the maturity period of this option; and finally, the difference between the value of this staggered arrangement (sequential construction) and the one without (concurrent construction) will be the value of this option.

In some cases, learning options during the construction phase can also give rise to switching option by using a new design or technology. For instance, during the construction of the three power plants, Bechtel switched to use pre-cast concrete pipes with special end fittings for the circulating water piping systems, rather than using steel piping. The new design was more technically challenging in fitting and assembling the pre-cast piping and fittings, but the installation was faster than using steel piping. When it was applied in one plant, the new design generated a switching option, i.e., a switch of materials. Following the nature of a learning option, the new design was also used in the other two plants, which were originally designed using steel piping.

4.4 Option Design Strategies and their Relevance to Risks

Infrastructure projects tend to have lengthy construction periods and are generally long-lived, with the entire project life-cycle often spanning several decades. It is tough to predict the actual consequence of each risk for a project with such a long tenure. However, as observed from the cases in Section 4.3, innovative strategies can be designed and introduced to all stages of an infrastructure project regardless of the delivery scheme of the project. These strategies create flexibility for managing the risks of the project. Sometimes, such flexibility would even represent a form of value

enhancement (Cheah, 2004).

First, the splitting of a project into two or more phases was verified as an effective strategy given the right circumstances (e.g. the Texas High-Speed Rail Corporation case). Generally, a project can be phased into different forms depending on the type of sectors. For a product-providing project, it can be phased into several independent units of a smaller scale, which would collectively generate and furnish the same product to clients in the required quantity or volume. For example, a huge power plant or a wastewater treatment plant may be decomposed into smaller units that would be constructed over several phases in order to address demand uncertainty and even technological risks. Whether the subsequent units are built would be determined by the operation of the forgoing phases and the realized demand. A service-providing project, similarly, may be broken into phases, albeit in a slightly different manner in terms of design. A toll road facility can be divided into sections or lanes. Again, the construction of additional sections or lanes would be subjected to the realized traffic demand after the opening of the toll road.

The division of a project into phases will create valuable flexibility. Whether it is a product- or service-providing project, the operation of the forgoing units/sections/lanes would provide information for the execution of later stages. This strategy of phasing offers the manager a right to enter into the subsequent phase or simply give up the opportunity, thus essentially creating a combination of expansion, abandonment and learning options. In the THSRC project, this strategy led to an expansion option and an abandonment option for the developer.

Second, if governmental support is negotiated for, it would represent a form of option strategy for the concessionaire but a form of contingent liabilities for the government (Cheah, 2004). Given that a privately financed infrastructure project often involves high risks, unless the financial viability of the project over its entire lifespan can be clearly demonstrated, potential sponsors will be unwilling to take part in the project.

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To attract private sector investors, the host government often provides supports against risks, such as demand risk, foreign exchange risk and default risk of a lower level governmental agency. These supports may come as a direct guarantee, capital contribution (equity/debt/subordinated debt participation), preferential tax treatment, grant or subsidy. The supports will help the sponsors to mitigate losses under a pessimistic scenario, and therefore the associated payoff would resemble the payoff of a put option.

Third, a cap can be placed on the level of profit or penalty payment. Generally, it is difficult to estimate the actual demand and revenue of a project. If the return derived from the project is too high, the sponsor may be perceived as exploiting the host country by structuring a lopsided deal. Politically, the host government may also be projected as having failed to protect the interest of its people. Consequently, the host government sometimes places a cap on the maximum rate of return or the maximum rate of tariff. Objectively, the government is introducing a call option for itself in the deal – to “call upon” any excess return beyond a certain level. A separate scenario is a cap that is placed on liquidated damages due to construction delay, as in the case of the Indiantown Cogeneration Project. The contractor has in fact been granted a call option by having a cap on its liability.

Fourth, an innovative use of advanced technology would help to introduce switching options for the operation of a project. The new technology may allow changes in the input/output of a project during the course of operation. In the Rocksavage case, the technology that was designed based on a stop/start model instead of the baseload model essentially changed the operational strategy of the project, thereby creating a switching option.

Fifth, a properly structured supply agreement could be used as an effective strategy against supply risks. If the concessionaire is concerned with the fluctuation of the cost of an input, it can negotiate for a long-term fixed-price contract with the supplier or

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even enter into a swap if the input is a widely traded commodity. Technically, it has been shown that a swap is equivalent to a combination of options (Chance, 2003). Alternatively, if a party is concerned with a decrease in demand of its output which would warrant a downscale of its operation, this party can negotiate for a flexible term with its supplier to match the demand level, as opposed to constraining itself with a fixed off-take contract. This strategy was implemented by ICI, Scottish Hydro and FPL in those two cases. Obviously, this option will not come free, as it is expected that the supplier would command for a higher unit rate or compensation in other means.

Sixth, the option to extend a contractual term can be a valuable strategy. Generally, the concession period of a BOT project is limited to a certain number of years. A party may introduce a clause to have the right to extend for a new term (either unilaterally or bilaterally). This arrangement would offer the party an opportunity to continue with the operation of the project if this is economically beneficial given the circumstances at the end of the concession period.

Seventh, revenue derived from ancillary sources would represent a form of call option and a growth strategy. In some cases, the project could provide a byproduct or the completed establishment could serve as an infrastructure to bring in extra revenue. In the THSRC project, the potential revenue from parking, package delivery, advertisement, real estate development and telecommunication services all represent call options and a growth strategy to THSRC.

Finally, investment in a pilot project provides a valuable learning option to understand the business environment in a foreign country. Not only that this is important in terms of exploring future opportunities in the context of internationalization strategy, it is also a risk management strategy. In developing countries such as China and India, the market for large-scale infrastructure projects is great, but the level of risk and uncertainty is also very high. Foreign sponsors usually explore the market by

moderating their investment budget across one or more pilot projects. Other than serving as a learning platform, these pilot projects provide growth opportunities in the form of a call option, as evident in InterGen's stance in the Rocksavage case.

4.5 Summary

This chapter introduced the notion of classifying risks in an infrastructure project into general and specific risks. At the firm level, the portfolio theory is considered as relevant to risk management; at the level of independent project, strategies are put forward in the form of real options to incorporate flexibility into the project. The short cases clearly support the claim that option strategies can be designed to enhance asset value and mitigate risks. These strategies should be designed on the basis of the risk classification adopted in this chapter. Due to the commonality of general risks to all infrastructure projects, strategies designed to control this type of risks should be implemented at the corporate level. These include efforts to negotiate for guarantees from the host government or to address foreign exchange risk at the aggregate level. On the other hand, option strategies of a more specific form should be schemed out according to the risks of individual projects. These include dividing a project into phases, applying new technology, structuring supply agreements, and seeking revenue from ancillary sources.

CHAPTER 5

MAJOR CASE STUDY ONE: DABHOL POWER PROJECT IN INDIA

This chapter identified the options embedded in an infrastructure project – the Dabhol Power Plant in India, based on contract arrangement and features of the project. Discrete-time models are used to evaluate several options found in the project. Comparing the values derived from the conventional NPV method and the real option approach, the findings illustrate that the real option approach better captures the value of flexibility and the differences can in fact be substantial.

5.1 Background of the Dabhol Power Project

India maintained as a self-sufficient economy since independence in 1947 until the early 1990s. During this period, the country's neighbor, China, took a more open policy and achieved great progress in its economy. In 1991, to reduce the gap between India and other countries and to enhance economic condition, the Indian government decided to launch several reform measures in conjunction with International Monetary Fund's assistance (Ramkishan and Rahul, 2002). Infrastructure projects are often the key to economic development in developing countries. India's industrial growth was (and still is) highly dependent on adequate and reliable supply of electrical power. Nonetheless, it was estimated that many of India's industries were only able to operate at half their capacities due to a lack of electricity supply. Huge capital injection was required to build new and large scale infrastructures. In the early 1990s, India was trapped by financial constraints – its foreign exchange reserves were sufficient for only three months of imports (Nair, 2003).

To alleviate the difficult situation, the central government subsequently amended the Electricity Act in October 1991 and early 1992 to permit foreign investments to take part in the construction of India's infrastructures (Mehta, 2000). In May 1992, a delegation of Indian central government visited the United States in order to seek investments from interested parties. In the following month, Enron's officials visited India at the government's invitation to investigate power plant development opportunities. They identified a potential site for a gas-fired power plant on the western coast of Mumbai in Maharashtra, a state of potential trading center in India. Enron signed a Memorandum of Understanding with the Maharashtra State Electricity Board (MSEB) in that month and a new company, Dabhol Power Company (DPC) was formed. 80% of the equity stake of DPC was held by Enron, with General Electric (GE) and Bechtel each held the remaining 10%. GE and Bechtel also served as contractors and main equipment suppliers for the project (Committee on Government Reform, 2002).

After a complex negotiation process, MSEB finally signed a power purchase agreement (PPA) with DPC in December 1993 on a Build-Own-Operate basis for a period of 20 years. Estimated to cost US\$920 million for Phase I and US\$1,920

million for Phase II, the project was broken into two phases and the initially planned total capacity was 2015 MW (subsequently increased to 2184 MW). DPC was responsible for making financial arrangement for the project, which was scheduled to commence construction in 1993 and operation in 1996. However, due to changes of political landscape in India, the project was reviewed, delayed and cancelled in 1995. The tariff of the project was deemed too high as compared to other power plants in India and allegation of corruption was widely claimed pertaining to initial award of the contract. After some renegotiation between Enron and its Indian counterparts, the PPA was amended, leading to an increased capacity, a reduced “levelized” tariff, a change in the source of fuel for Phase I, and a change in equity ownership with MSEB now holding a 30% stake in DPC. Construction was soon resumed and Phase I was commissioned in May 1999. Still, in December 1999, the state of Maharashtra was facing a power deficit. It then failed to make payments to DPC since December 2001. Meanwhile, Enron was also declared bankrupt in New York in December 2001. Since then, as of the date of this writing, there were no companies submitting any formal plans to the central government or financial institutions to take over the project’s affairs.

5.2 Real Options Embedded in the Project

The complex and uncertain nature of the project had led to the incorporation of various risk mitigation measures and flexibilities into the project setting. These measures were structured from the viewpoint of major parties, including: the equity investors of DPC (Enron, GE, Bechtel, and subsequently MSEB); the contractors (Bechtel, GE); MSEB; the Indian state and central government. Some parties were having multiple stakes in the project. Table 5.1 compiles several options derived from the descriptions of the project. The options identified in Table 5.1 will now be explained in a qualitative sense. The last four options will also be evaluated using discrete-time real option models in Section 5.3.2 subsequently.

CHAPTER 5 CASE ONE: DABHOL POWER PROJECT

Descriptions of Events	Type of Options	Option Owner	Exercise Price (K)	Uncertainty of Underlying (σ)	Maturity (T)
Sale of surplus power to other states	Call option	MSEB	Cost of additional transmission & distribution facilities	Selling price of surplus power	Technically, there is no maturity period for this option, subjected to economic conditions that affect the buyers' behavior for the surplus power. The second limiting factor would be the end of concession period.
Guarantees granted by the state and the central government	Put option	DPC	Earnings from the project (IRR with a floor of 16%)	Factors which will affect the revenues of DPC investment	The end of the concession period.
Excess capacity of the LNG terminal	Call option	DPC/MSEB	Extra capital cost of the LNG terminal	Selling price of LNG	Technically, there is no maturity period for this option, subjected to economic conditions that affect the buyers' behavior for LNG. The second limiting factor would be the end of concession period.
Internationalization strategy: 1. Project establishment in 1992 2. Pursuit of other projects in India	Growth options	Enron, Bechtel, GE	1. Initial cost of setting up DPC; 2. Costs of other new projects/expansion of operations	Factors which generally affect the benefits of energy business of Enron growing in India and other South Asian countries.	Technically, there is no maturity period for this option, subjected to the budget available for expansion plan.

Table 5.1: Real Options Inherent in the Dabhol Power Project

CHAPTER 5 CASE ONE: DABHOL POWER PROJECT

Descriptions of Events	Type of Options	Option Owner	Exercise Price (K)	Uncertainty of Underlying (σ)	Maturity (T)
Splitting of the project into two phases	Expansion option	DPC/ MSEB	Capital cost for Phase II	Price of natural gas and naphtha	Time maturity is subject to commitment in contract for the latest date to construct Phase II.
Sale of assets / equity stakes in the project	Abandonment option	DPC	Sale value of assets / equity stakes	Factors (e.g. oil and naphtha prices) occurring during the concession	1) The end of the concession period. 2) Breach of the contract by MSEB
Extension of PPA by 5/10 years or purchase of the plant at 50% of depreciated replacement value	Call option	MSEB	Cost of power (as per PPA) or cost of plant valued at 50% depreciated value	Price of power during the extension period	The end of the concession period.
Change of fuel source between distillate/naphtha/gas	Switching option	DPC/ MSEB	Switching cost, if any	Price of LNG, distillate or naphtha	Commencement of Construction of Phase II.

Table 5.1: Real Options Inherent in the Dabhol Power Project (Con't)

5.2.1 Sale of Surplus Power to Other States

There was always a possibility that the capacity of the project would exceed the demand in Maharashtra. MSEB could consider selling the surplus power to adjacent states and this represents a form of call option. However, if MSEB decided to sell the surplus power, construction of additional transmission and distribution facilities would become necessary and the costs involved would represent the exercise price of this call option. In short, if earnings derived from selling the excess power exceeded this cost, MSEB would exercise the option.

5.2.2 Guarantees Granted by the State and Central Government

At the time of the project, India was just opened to foreign investors. Since investment risks were deemed to be very high, the state and central government signed agreements to provide financial guarantees in February 1994 and September 1994 respectively. The guarantees provided financial protection for DPC in the event that MSEB was unable to make its payments. If MSEB could pay DPC according to the PPA, the value of the guarantee would be zero since the government would not need to compensate DPC. Conversely, the government would make up for any payment shortfall required to generate an IRR of equity of 16%. This payoff structure resembles that of a put option, since the government's compensations are paid when asset value is reduced (due to MSEB's failure to fulfill its commitment). The guarantees effectively provided DPC with a put option that has an exercise price equivalent to earnings commensurate with the specified floor rate for the IRR.

5.2.3 Excess Capacity of the LNG Terminal

All LNG-related facilities had significant alternative uses. The Dabhol Power Project required only 2.1 million metric tons of LNG, whereas the re-gasification facility could handle up to 5 million metric tons. This extra capacity could be marketed to other buyers of gas. Likewise, the harbor facility could also be used as a common

facility by other importers of LNG as its capacity was above what was required by Dabhol's operation. All these provided future business opportunities to DPC and MSEB who were stakeholders of the project. The cost of the terminal, over and above the requirement to support Dabhol alone, effectively represents the exercise price of this call option.

5.2.4 Internationalization Strategy

Enron Corporation was a diversified provider of services in the natural gas industry. It was positioned as the first "natural gas major" that would focus on various growth opportunities created by the deregulation of the gas industry in the United States and the growth of natural gas usage worldwide. Enron intended to become the world's leading energy firm. At the same time, India was an unplowed field for foreign investments in the early 1990s. The reform in the power sector in India provided an opportunity for Enron to realize its international strategy. The establishment of DPC was hence a growth opportunity for Enron. Through this project, Enron could not only further develop its gas power service in India by building up relationships with major parties in India, but also enter other South Asian countries' energy markets. Even if this project failed, it would help Enron develop other business models (an additional learning option). In short, this project was just a starting point for Enron to realize its internationalization strategy. It can be said that the same principle applies to the case of Bechtel and GE.

Despite the complexity of the Dabhol Power Project, Enron also kept its strategy of diversification intact. It began to pursue non-power projects regardless of its specialty and commitment in DPC. In November 1999, it signed an MOU with an undersea cable operator and negotiated for a venture to build a fiber-optic telecommunications network in India. This strategy provided a chance for Enron's excursion into other profitable industries in India.

5.2.5 Splitting of the Project into Two Phases

The DPC project was broken into two phases. Phase II would be built after construction of Phase I was completed, which spent 33 months. During this long period, new information would arrive and the condition about Phase I would be helpful for the economic evaluation of Phase II. To certain extent, construction of Phase II would depend on successful operation of Phase I and is a call option by itself.

On the flipped side, it is an expansion/compound option to MSEB, too. MSEB would observe the operation of Phase I. If the cost of Phase I seemed to be reasonable and the power capacity was not large enough to meet the development of the state, MSEB would initiate the construction of Phase II. Otherwise, sole operation of Phase I would be sufficient to meet the demand.

5.2.6 Sale of Assets/equity Stakes in the Project

Even though the state and central governments guaranteed the payments made by MSEB, there were always possibilities that something unexpected would occur. Under this condition, Enron had the option to sell the plant for its salvage value. In this case, the sale price would become the exercise price of the option.

5.2.7 Extension of PPA or Purchase of the Plant

According to the PPA, MSEB has the option of either extending the PPA for another 5 or 10 years or buying the plant from DPC. This is a type of call option maturing after 20 years. The cost of purchase is the exercise price of this option if MSEB chooses to buy the plant. If the cumulative savings from operating the plant by MSEB itself (as compared to purchasing power according to the terms of PPA) surpasses the cost of purchase, MSEB would buy the plant; otherwise, MSEB would simply let DPC continue operating the plant.

5.2.8 Change of Fuel Source

Although the original PPA was planned for a 2015MW project, the capacity was enlarged to 2184MW later. Phase I would be a 740MW project fueled with naphtha instead of 695MW fueled with distillate. Phase II was changed from 1320MW to 1444MW. When the evaluation was set at the beginning of the establishment, the capacity change provided an expansion option and the fuel change provided a switching option for DPC. So DPC could evaluate the project with two different plans.

Liquefied natural gas (LNG) is more environmental friendly and has less damage than using distillate or naphtha to fuel the plant. Nonetheless, oil and coal are abundant in India and the project was under pressure to use local resources. MSEB could consider the benefits among the types of fuels based on each respective cost and other factors such as political conditions. The choice of fuel in Phase II's operation, if different from Phase I's, would create a switching option as power can be generated by the facilities constructed in two phases which rely on different types of fuel.

5.3 Quantitative Analysis of the Project

The data for this case study is gathered from various public sources, which include: Enron's original proposal for the project; the initial PPA and its subsequent amendment; commission reports; academic publications and press releases. Obviously, discrepancies in certain facts reported by different sources are inevitable. For example, according to the amended Act, the central government would guarantee a 16% rate of return to the equity holders. Elsewhere, the "true" IRR of the project reported had ranged from 18.9% to 26% or even higher, depending on the scenario assumed. For the purpose of this case analysis, what is really needed is a basic cash flow model to illustrate the use of the RO concept. Therefore, while efforts are devoted to reconcile some of these discrepancies, Free Cash Flows to Equity (FCFE) are reconstructed using the following assumptions established from the information gathered:

- (i) Debt service and capital recovery charges escalate at 4% annually;

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- (ii) Fixed and variable O&M charges escalate on the basis of the Consumer Price Index (CPI), which usually averages about 4%;
- (iii) Fuel management fee escalates at 4% per annually;
- (iv) Fuel charge has a 3.5% escalation rate;
- (v) Components of the tariff in 1996 were as follows: fixed O&M (7.9%), debt service (5.2%), capital recovery charge (36.2%), variable O&M fee (0.3%), fuel management fee (1.4%), fuel charge (48.9%);
- (vi) The plant is run 8760 hours a year;
- (vii) The project is exempted from tax for the first ten years; subsequently the tax rate would drop from 57.5% to 46%.

Table 5.2 shows a snapshot of one of the cash flow models constructed. The details and other cash flow models are compiled in Appendix I of this thesis.

	1993	1994	1995	1996	1997	1998	1999	2000	...	2015
Gross revenue	0.0	0.0	0.0	407.5	422.8	438.8	455.3	472.5	...	823.7
Cost	0.0	0.0	0.0	210.0	217.4	225.0	232.9	241.0	...	403.8
Depreciation	0.0	0.0	0.0	23.1	23.1	23.1	23.1	23.1	...	23.1
Operation										
Expenses	0.0	0.0	0.0	35.3	36.7	38.2	39.7	41.3	...	74.4
EBIT	0.0	0.0	0.0	139.1	145.7	152.5	159.7	167.1	...	322.4
Tax	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	148.3
Capital										
Expenditure	83.7	111.6	83.7	0.0	0.0	0.0	0.0	0.0	...	0.0
Debt Service	0.0	0.0	0.0	116.7	116.7	116.7	116.7	116.7	...	0.0
Salvage Value									...	461.0
FCFE	(83.7)	(111.6)	(83.7)	45.4	52.0	58.8	66.0	73.4	...	658.1

Notes: 1. All figures shown are in US\$ millions.
2. This table is extracted from Appendix I-03.

Table 5.2: Cash Flow Model for Phase I – Before Renegotiation

5.3.1 Financial Analysis Using NPV

5.3.1.1 Estimation of basic parameters of NPV

Simple NPV evaluation requires the selection of a discount rate to discount pro forma cash flows. Since the project is to be evaluated from DPC equity investors' viewpoint, the discount rate is in fact the required rate of return-on-equity, which can be estimated by the use of the Capital Asset Pricing Model (CAPM):

$$r_e = r_f + \beta_e (r_m - r_f) \quad (5.1)$$

In Equation (5.1), r_f is taken as the rate of U.S. 10-year Treasury bond yield in 1996, estimated at 6.5%. The risk premium ($r_m - r_f$) traditionally falls within the range of 6% to 8% (Brealey and Myers, 2000), and a value of 6% is selected. β_e , a risk measure commensurate with this investment, can be determined using 16 selected international energy companies as proxies (Table 5.3). However, since debt-equity ratios typically differ among the proxies, an average equity beta needs to be estimated in three steps:

Step 1: Let β_{ei} and β_{Ai} be the equity beta and asset beta of company i respectively. Assuming that the debt beta is approximately 0, then:

$$\beta_{Ai} = \beta_{ei} \times \frac{E}{E + D} \quad (5.2)$$

Step 2: Compute the average asset beta of the proxies:

$$\overline{\beta_A} = \frac{1}{16} \sum_{i=1}^{16} \beta_{Ai} \quad (5.3)$$

Step 3: "Re-lever" the average asset beta to take into consideration the capital structure of this project (which has a debt-equity ratio of approximately 2.8):

$$\beta_e = \frac{E + D}{E} \overline{\beta_A} \quad (5.4)$$

Following the above steps, β_e is estimated as 1.61. Together with other parameters, Equation (5.1) yields a required rate of return of 16.2%. This figure is within the ballpark of those stated in other reports.

	Corporation	Beta	D/E
1	Amerada Hess Corporation	0.47	1.01
2	BP p.l.c. (ADR)	0.58	0.26
3	ConocoPhillips	0.61	0.60
4	Eni S.p.A. (ADR)	0.41	0.59
5	Exxon Mobil Corporation	0.33	0.13
6	Repsol YPF, S.A. (ADR)	0.62	0.81
7	Royal Dutch Petroleum Com	0.77	0.24
8	Shell Transport & Trading	0.78	0.24
9	TOTAL S.A. (ADR)	0.60	0.47
10	Apache Corporation	0.49	0.34
11	British Energy plc (ADR)	0.70	7.00
12	Duke Energy Corporation	0.31	1.51
13	Endesa S.A. (ADR)	0.99	2.31
14	Enersis S.A. (ADR)	1.14	1.72
15	International Power plc	1.91	0.34
16	National Grid Transco plc	0.24	12.37
Source: finance.yahoo.com			

Table 5.3: Equity Beta and D/E Ratio of Selected International Energy Companies

5.3.1.2 Simple NPV of the Project

To obtain a complete picture, net present values for both phases of the project – before and after renegotiation, are calculated. For Phase I, the base year is taken as 1993 when the MOU was signed; for Phase II, this is taken as 1996 when it was scheduled to commence. The results are presented in Table 5.4. In Table 5.4, S is the present value of net cash flows during operation and K represents the present value of capital expenditure and construction costs. In real option's parlance, S can be considered as the value of the underlying asset while K represents the exercise price of the option to secure the underlying. It can be seen that when valued at 1993, the difference between S and K is simply equal to the net present value – since this implies immediate exercising of the call option (while forgoing the value of other options such as deferment).

	Before Renegotiation			After Renegotiation		
	Phase I ⁽¹⁾	Phase II ⁽²⁾		Phase I ⁽³⁾	Phase II ⁽⁴⁾	
NPV	174.9	353.9 (1993)	555.1 (1996)	110.3	103.7 (1993)	164.3 (1996)
S_{1993}	416.7	603.6		352.1	353.4	
K_{1993}	241.7	249.7		241.8	249.7	
(All figures shown are in US\$ millions)						
Notes: (1) Refer to Appendix I – 03						
(2) Refer to Appendix I – 06						
(3) Refer to Appendix I – 09						
(4) Refer to Appendix I - 12						

Table 5.4: Net Present Values of Different Scenarios

5.3.2 Financial Analysis using Real Option Approach

5.3.2.1 Volatility of Cash Flows

The cash flows of the project are sensitive to many risk factors such as politics and fuel prices. Uncertainties in these factors drive the option values of the project. In real option evaluation, volatility is the most difficult parameter to estimate. In this case, volatilities of fuel prices – naphtha and natural gas, are taken as proxies for the volatility of the underlying asset. The volatility of natural gas prices is estimated from three sources: the U.S. natural gas prices (Figure 5.1), the Henry Hub series (Figure 5.2), and the London Natural Gas Index (Figure 5.3). The estimation periods adopted (which differ slightly for each series) start from the early 1990s to 2003 using monthly observations. The volatility of naphtha prices is estimated from two sources: the Singapore Spot FOB series (Figure 5.4) and the Europe CIF series (Figure 5.5).

Figure 5.1: U.S. Natural Gas Prices

Figure 5.2: Henry Hub Series

Figure 5.3: London Natural Index P/Therm – Price Index

Figure 5.4: Naphtha-Singapore Spot FOB

Figure 5.5: Naphtha-Europe CIF

The volatility of natural gas (or naphtha) prices is computed with the following steps:

1. The natural gas (or naphtha) price was observed every month, here we define:

$N+1$: Number of observations (12 per year)

S_i : Natural gas (or naphtha) price every month

τ : Length of time interval in years. For monthly observations, this is = 1/12

2. Let

$$u_i = \ln\left(\frac{S_i}{S_{i-1}}\right)$$

An estimate, s , of the standard deviation of u_i is then

$$s = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (u_i - \bar{u})^2}$$

where $\bar{u}$ is the mean of the u_i .

3. The volatility per annum can finally be computed as

$$\sigma = \frac{s}{\sqrt{\tau}}$$

Following these steps, the average value of the volatility of natural gas prices is estimated as 45.32%; this will be denoted as σ_1 in the binomial model. The average value computed is 37.30%, which will be denoted as σ_2 . These are two critical inputs for calculating the parameters of the binomial model in the next section.

5.3.2.2 Parameters of Real Option Analysis

The binomial approach essentially models the up and down movements of the underlying asset. Following Cox *et al*'s (1979) approach, the up- and down- factors (denoted as “u” and “d”) and the associated risk-neutral probabilities (denoted as Π_u and Π_d) can be computed as follows:

For the case of natural gas:

$$u_1 = e^{\sigma_1 \sqrt{t}} = e^{0.4532 \times \sqrt{1}} = 1.5733$$

$$d_1 = e^{-\sigma_1 \sqrt{t}} = e^{-0.4532 \times \sqrt{1}} = 0.6356$$

$$\Pi_{u_1} = \frac{e^{rf} - d_1}{u_1 - d_1} = \frac{e^{0.0633} - 0.6356}{1.5733 - 0.6356} = 0.4583$$

$$\Pi_{d_1} = \frac{-e^{rf} + u_1}{u_1 - d_1} = \frac{-e^{0.0633} + 1.5733}{1.5733 - 0.6356} = 0.5417$$

For the case of naphtha:

$$u_2 = e^{\sigma_2 \sqrt{t}} = e^{0.3730 \times \sqrt{1}} = 1.4521$$

$$d_2 = e^{-\sigma_2 \sqrt{t}} = e^{-0.3730 \times \sqrt{1}} = 0.6887$$

$$\Pi_{u_2} = \frac{e^{rf} - d_2}{u_2 - d_2} = \frac{e^{0.0633} - 0.6887}{1.4521 - 0.6887} = 0.4934$$

$$\Pi_{d_2} = \frac{-e^{rf} + u_2}{u_2 - d_2} = \frac{-e^{0.0633} + 1.4521}{1.4521 - 0.6887} = 0.5066$$

To avoid confusion, subscripts ‘1’ and ‘2’ differentiate between parameters used for the case of natural gas and naphtha respectively. Exactly which parameters to use would depend on the type of options or scenarios. For example, to evaluate Phase II expansion option, parameters for natural gas are appropriate since this is the type of fuel used in Phase II. On the other hand, to evaluate the switching option, both types of parameters need to be used in the model.

5.3.2.3 Value of the Expansion Option: Splitting of the Project into two Phases

The breaking of the Dabhol Power Project into two phases effectively created an expansion option for DPC and even MSEB – both parties could decide whether to launch Phase II based on the progress of Phase I and the economic projection at that time. In Table 5.4, prior to renegotiation, the present value of net cash flows expected from Phase II is computed as $S_2 = \$603.6$ million (in 1993 dollars), whereas the present value of capital expenditure of Phase II is $K_2 = \$249.7$ million. The fuel price is uncertain and would cause S_2 to fluctuate as depicted in Figure 5.6.

The expansion option would expire in 1996 – when decision has to be made on whether to launch Phase II. With a maturity period of 3 years, the value of capital expenditure of Phase II in 1996 would be: $K_2 = 249.7 \times e^{0.0633 \times 3} = \301.7 million. This is evaluated in a “risk-neutral” setting, which assumes that all prices would appreciate at the risk-free rate (Hull, 2002).

Figure 5.6: Binomial Tree of the Underlying Asset Value

Figure 5.7: Binomial Tree of Project Value with Embedded Expansion Option

Referring to Figure 5.7, Year 3 (i.e. 1996), the party concerned could acquire asset S_2 by paying an exercise price of \$301.7 million. Logically, if the value of the asset is less than the acquisition cost, the option would not be exercised. Values in earlier years/nodes are then calculated by using the risk-neutral probabilities computed previously and discounted at the risk-free rate. For instance,

$$\begin{aligned} V_{2,uu} &= e^{-rf} (\Pi_{u1} \times V_{2,uuu} + \Pi_{d1} \times V_{2,uud}) \\ &= e^{-0.0633} (0.4583 \times 2049.0 + 0.5417 \times 648.0) \\ &= \$1210.9 \text{ million} \end{aligned}$$

Following the same procedure of backward induction, $V_{2,opt}$ – the value of Phase II after considering the expansion option, can be derived as \$379.1 million. The total value of project inclusive of Phase I is simply:

$$V = V_1 + V_{2,opt} = 174.9 + 379.1 = \$554.0 \text{ million}$$

In Table 5.4, total NPV of both phases (before renegotiation) is \$528.8 million (\$174.9 million + \$353.9 million). It thus follows that the value of expansion option itself is \$25.3 million. The total value of the project is really the sum of a “static” NPV value and the value of the expansion option. Similarly, the value of expansion option following the terms after renegotiation can be obtained. All results are summarized in Table 5.5.

	Before Renegotiation	After Renegotiation
NPV _I (in 1993)	174.9	110.3
NPV _{II} (in 1993)	353.9	103.7
NPV _{I+II} of both phases (in 1993)	528.8	214.0
V _{2,opt}	379.1	160.2
Total value of project with embedded option (=NPV _I + V _{2,opt})	554.0	270.5
Value of Option	25.3	56.5

(All figures shown are in US\$ millions)

Table 5.5: Value of Embedded Expansion Option

5.3.2.4 Value of the Abandonment Option: Sale of Assets / equity Stakes in the Project

Even though the state and central government guaranteed the payments to be made by MSEB, there could always be unforeseen circumstances (e.g. politics) rendering the PPA not honorable. If this occurred prior to the end of concession period, DPC might be able to sell the plant to other investors at its salvage value. In this case, the sale price becomes the exercise price of this put/abandonment option. For illustration, it is assumed that DPC would only sell the plant in the last 5 years before the end of the concession. Rightfully, this represent a form of “American options”, since it can be exercised in any of the 5 years before maturity.

Again, binomial trees with yearly time steps are constructed. The underlying asset in this case would be the NPV of the project – this is the real net worth of the project. If the salvage value in any particular year is larger than the NPV, the project should be sold; otherwise, it is wiser to continue to run the plant that is worth at least the NPV. The model for this option can thus be represented as follows:

Figure 5.8: Model for Abandonment Option of Selling Assets/Equity Stakes

In the model, the NPV of the project would appreciate at the risk-free rate as governed by the risk-neutral setting. To be consistent, however, the salvage value needs to be discounted back to the base year (1993 for Phase I; 1996 for Phase II) at the required rate of return-on-equity (16.2%) before compounding at the risk-free rate in the binomial tree. The evaluation results are summarized in Table 5.6:

	Before Renegotiation	After Renegotiation
NPV	174.9	110.3
Phase I V_{opt}	189.5	122.8
Value of Option	14.5	12.5
NPV(in 1996)	555.1	164.3
Phase II V_{opt}	573.0	202.5
Value of Option	17.9	38.2

(All figures shown are in US\$ millions)

Table 5.6: Value of Abandonment Option to Sell Assets/Equity Stakes

5.3.2.5 Value of the Option to Extend PPA for 5/10 Years or Buy the Plant

According to the PPA, MSEB had the option to either extend the PPA for another 5 or 10 years or buy the plant at half of the salvage value. This is a type of call option maturing after 20 years at the expiration of the PPA. From MSEB's standpoint, if it

could operate the plant at a lower cost as compared to fulfilling its obligations under the PPA, it would buy the plant; otherwise, it would be wiser to extend the PPA and allow DPC to continue operating the plant.

Cash flows must be reconstructed from the viewpoint of MSEB. According to the original PPA (prior to renegotiation), MSEB did not hold any equity stakes in DPC, so the value of the plant to MSEB is technically zero in the model. This argument equally holds if MSEB chooses to extend the PPA for another 5 or 10 years. On the other hand, if MSEB subsequently chooses to buy the plant, the value to MSEB would then become the value of the plant (i.e. value of cash flows for the extended period) minus the cost of purchase (i.e. half of salvage value). The present value of cash flows for the extended period is hereby denoted as “ NPV_e ”. This scenario can be represented by the model below:

Figure 5.9: Model of Option to Extend PPA/Buy Plant (Before Renegotiation)

In the case of the amended PPA (after renegotiation), the model in Figure 5.9 needs to be modified slightly since MSEB now carries 30% stake of DPC. During the initial concession period, MSEB would be entitled to 30% of the project cash flows, the present value of which is hereby denoted as “ NPV_i ”. If the PPA is extended thereafter, MSEB would continue to get 30% of the extended cash flows (value being 30% of NPV_e). If, however, MSEB decides to buy the plant at the end of the initial concession period, it would secure 100% of cash flows from the extended period, minus the cost of half the salvage value (the exercise price). The model for the option in this scenario is represented as follows:

Figure 5.10: Model of Option to Extend PPA/Buy Plant (After Renegotiation)

Based on the above two models, the analytical results of the analysis are summarized in Table 5.7.

		Before Renegotiation	After Renegotiation
Phase I	NPV_e (in 1993)	43.1	39.9
	NPV_i (in 1993)	0	110.3
	V_{opt}	38.4	67.7
	Value of Option	38.4	34.6
Phase II	NPV_e (in 1996)	95.7	76.1
	NPV_i (in 1996)	0	164.3
	V_{opt}	86.0	117.3
	Value of Option	86.0	68.0

(All figures shown are in US\$ millions)

Table 5.7: Value of Option to Extend PPA or Buy Plant

5.3.2.6 Value of the Switching Option: Changing of Fuel Source

One of the main issues raised during renegotiation in 1996 was fuel flexibility. The noble intention was to have the entire plant eventually operating with liquefied natural gas (LNG) to limit adverse environmental impact. The plant was subsequently converted into a multi-fuel facility to encourage the use of indigenous fuel sources and limit potential damages in the case of interruption in supply of LNG. This created a switching option in terms of technology and fuel (between gas, distillate and naphtha).

To illustrate the evaluation of a switching option, the operating mode fueled by gas will be set as the default mode. An alternative fuel (chosen as naphtha in this illustration) will be selected whenever it can produce a larger cash flow. The relative costs of fuels change over time and they have a great influence on the cash flows. In Figure 5.11, prices of fuels are assumed to change yearly, with “G” and “N” denoting prices of gas and naphtha respectively. Spot prices in Figure 5.11 are associated with probabilities that can be derived from the historical volatility of fuel prices. Notations for each probability tree are shown in Figure 5.12. The gas and naphtha prices in Figure 5.11 can be entered into cash flow models (similar to the one shown in Table 5.2) in order to generate “cash flow trees” (see Figure 5.13). Finally, based on Figure 5.12 and 5.13, two inverted pyramids (Figure 5.14 and 5.15) are constructed to represent various up- and down- scenarios of cash flows and probabilities – the combinations of which would reflect the movements of the two types of fuels.

Figure 5.11: Binomial Trees for Fuel Prices

Figure 5.12: Probability Trees for Gas and Naphtha Prices

Figure 5.13: Binomial Trees for Cash Flows

Figure 5.14: Inverted Pyramid Representing Joint Cash Flow Scenarios

Figure 5.15: Inverted Pyramid of Joint Probabilities

For each node of Figure 5.14, when the cash flow produced by the use of naphtha is more than that produced by gas, the former would be selected as the preferred source of fuel. For example, the difference in cash flows (DOCF) at node **A** arising from this switching option is represented by:

$$\text{DOCF} = \text{Max} [(\text{CFN}_{(d2)} - \text{CFG}_{(d1)}) , 0] \quad (5.5)$$

DOCFs in each year i are in turn weighted by the corresponding probabilities P derived in Figure 5.15 (e.g. P for node **A** is $\Pi_{d1}\Pi_{d2}$). Following this procedure, an expected value of DOCF for each year i can be generated:

$$E(\text{DOCF})_i = \sum_i \text{DOCF} \times P \quad (5.6)$$

Finally, the value of the switching option is computed as:

$$V_{opt} = \sum_{i=1}^{20} \frac{E(\text{DOCF})_i}{(1 + r_f)^i} \quad (5.7)$$

A complete framework is complex, as the number of nodes increases quickly with the number of years projected out into the future. When the boundary is set at the fifth hierarchy (whereby it is assumed that the option can only be exercised up till 2000), the value of the option is computed as \$9.0 million. If maturity of the option is extended all the way to 2015, the value will obviously be even larger.

5.3.3 Implications of Evaluation Results and Further Discussions

In the previous Section 5.3.2.3 to 5.3.2.6, four options have been evaluated using the discrete-time models – three from DPC's equity holders' viewpoint, and one from MSEB's viewpoint. The results show that the values of these options can be quite considerable. Using cash flows for the case before renegotiation, the expansion option and put option amount to 4.8% and 3.4% of the basic Net Present Value. After renegotiation, these percentages increase to 26% and 18% respectively. Technically speaking, the switching option was “created” only after renegotiation had taken place – this value amounts to 4.2% of the basic NPV. In the case of a large infrastructure project that is structured to be economically viable (hence a positive NPV), these

options would augment the value of the bottom line. Likewise, as shown in Table 5.7, MSEB's options to extend the PPA or buy the plant at the end of the concession period have high absolute values.

Apparently, the true value of the project to each party would be grossly undervalued if these options are not taken into consideration. The value of the project will also vary depending on the party concerned. For example, from MSEB's standpoint, omission of the value of DPC's options during the process of negotiation would lead to too lucrative a deal for Enron. On paper, the IRR of the project presented during the negotiation stage might be indicated as 26%. However, once the value of DPC's embedded options were considered, MSEB would have a better ground to negotiate for a lower level of tariff – since the “real” IRR was in fact higher than 26%. This is particularly true for the financial guarantees that the state and central government granted to DPC. Mason and Baldwin (1988) commented that if the value of a guarantee exceeds the minimum necessary subsidy to keep a project alive, the government may be overcompensating the project's sponsor. In the case of Dabhol, not only that the project has a positive NPV (hence no subsidy should be necessary to start with), the value of guarantee is in nowhere captured by a basic NPV model.

Note that it is technically incorrect to simply sum up all the option values together due to two reasons. First, interactions exist among these options. For instance, once the abandonment option of selling the plant is exercised, the expansion option would no longer exist. On the other hand, the combined value of two interacted call options may be less than the sum of separate option values (Trigeorgis, 1993). Second, different options are “owned” by different parties, therefore options should be assessed and consolidated only if they belong to the same party concerned.

5.4 Summary

Infrastructure projects may possess many flexible features and embedded options, as illustrated in the case of Dabhol Power. The value of these options is largely omitted by standard valuation techniques such as the simple NPV approach, which serves well only in static conditions with minimum uncertainties. This chapter demonstrates that

the real option approach are more effective in modeling flexibilities, although the NPV method still has a role to play in estimating the underlying asset value and the exercise price of the options. As the results from the Dabhol case show, the value of the options can be quite significant. By properly capturing these values during the initial evaluation stage, a more equitable contractual and risk-sharing arrangement can be established. This issue is particularly important for developing countries that rely substantially on private and foreign sector investments. These countries, with limited financial resources to propel economic growth, need to carefully assess the risks and value of those concessions that they grant to the private and foreign investors.

CHAPTER 6

MAJOR CASE STUDY TWO: THE MALAYSIA-SINGAPORE SECOND CROSSING

The second case, the Malaysia-Singapore Second Crossing, is analyzed in this chapter. This case study analyzes Malaysian government's "guarantee" on toll revenue as a put option. A hypothesized scenario is also constructed to include a concessionaire's "repayment" obligation to the government as a call option – the intention is to examine a balance of value to both parties. In the evaluation of options, Monte Carlo simulation is applied. To demonstrate the effect of variables in the model, sensitivity of the two options to standard deviations of traffic volume and growth rate is presented. At the end of case study, the advantage of introducing real option thinking into design and construction of the bridge is discussed.

6.1 Project Background

Peninsular Malaysia (West Malaysia) is bordered on the south by Singapore, which has a close relationship in foreign trade with Malaysia. For more than 70 years, a causeway that was built in the 1920s served as the only physical connection between the two countries. With fast economic growth in the past two decades, the scale of transportation between the two countries increased quickly – up to 55,000 vehicles use the causeway daily and severe congestion is observed even today. In the early 1990s, the government of Singapore and Malaysia recognized the need for a second connection. A new bridge was then proposed to improve land-based transportation service and serve as the second crossing for inter-country travelers. With its spacious three-lane dual carriageway, the new bridge has a capacity of 200,000 vehicles a day (or 73 million vehicles per year), which is four times the load on the old causeway.

Figure 6.1 shows the contractual structure of the project. UEM, a leading Malaysian construction group, was successful in securing the mandate from the Malaysian government and setting up a special purpose vehicle (which was named as “LINK”) to implement this project. In July 1993, a concession agreement was signed between the Malaysian federal government and UEM. UEM then seconded to LINK all rights, liabilities and obligations under the agreement to receive tolls in return for designing, constructing, operating and maintaining the Malaysian side of the second crossing (approximately 1.7 km) and the expressways that connect to other parts of the neighborhood. The Singapore government will be responsible for constructing the Singapore side of the crossing (approximately 0.3 km).

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Figure 6.1 Contractual Structure of the Second Crossing

Figure 6.2: Location of Second Link

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As shown in Figure 6.2, the bridge is linked to a 44 km new Second Link Expressway leading to the North-South Expressway, the Senai Airport and Johor Bahru. The adjoining expressway, which comprises the dual two-lane, 21.5 km long Northern Link and the dual three-lane, 14 km long Southern Link, also includes the dual two-lane Johor Bahru Parkway which runs from the proposed Kulai Interchange to the Johor Bahru city as well as the port and industrial area of Pasir Gudang. One interchange will be constructed in the south of Gelang Patah which is approximately 10 km from the crosslink to provide access to the new town development area.

A 2-meter wide paved shoulder will be provided along each carriageway for emergency stops of breakdown of vehicles. In addition, there will also be an emergency U-turn facility at the centre of the Malaysian main navigational span, an emergency telephone system, street lighting, 3 toll plazas, rest/service areas and the Customs, Immigration and Quarantine (CIQ) facilities at both ends of the bridge.

LINK had estimated the total cost of the project to be RM (Ringgit Malaysia) 1.4 billion. 30% of this cost was provided by UEM in ordinary equity and 70% was obtained from a syndicate of Malaysian banks in a form of fixed interest rate term loan facility, which would have a tenor of 15 years. The interest rate was reported as 10%. The fixed interest rate term and working capital loans would be repaid out of two sources:

1. Tolls collected through the 30-year concession to operate the project;
2. A RM312 million contribution from UEM, representing its share of the cost of the project. The government had also given UEM permission to construct and develop a new town, about 10,000 hectares over 25 years in the vicinity of the Second Crossing including the construction of primary infrastructure. In acknowledgement that the Second Crossing and the expressways would enhance the value of the new town, UEM entered into a Cost Sharing

Agreement with LINK whereby UEM agreed to bear RM312 million of the construction cost.

Despite the prospective plan, the project was not running smoothly as planned since its opening. The bridge was grossly under-utilized and was having a traffic volume of only 4.2 million vehicles in 1998, which was less than the 11 million vehicles initially projected. This had forced the Malaysian government to pay RM20 million as compensation to LINK for the shortfall in guaranteed traffic volume and toll revenue. Motorists gave two reasons for avoiding the bridge – the tolls were simply too expensive, and it was too far away from the Johor Bahru (the nearest major city) shopping centers and container terminal (Fernandez, 1998). Under the developer's first proposal, the rates were RM8 for cars, RM21 for buses and vans, and RM53 for lorries, respectively. In March 1999, however, the Cabinet slashed the rates by half, fixing them at RM4.80 for cars, RM11.40 for vans and small lorries, RM25.50 for lorries, RM4.10 for taxis and RM6.20 for buses (Nambiar, 1999). Although the toll rates were slashed by almost half, the traffic volume did not increase much either. It was reported that the concessionaire only managed to collect RM85.1 million from 25.2 million vehicles using the new crossing since it began operations in March 1998 – about 33% less than their expectations (*New Straits Times*, 2001).

6.2 Conventional Financial Analysis and Cash Flow Models

In order to construct the cash flow model, the following key points are extracted from different sources of data, with logical assumptions made where the information is incomplete:

1. The total cost of the project is taken as RM1.4 billion, and its distribution during the three-year construction period is 35%, 35% and 30% respectively.
2. The debt: equity ratio is 70:30. The loan term is 15 years and the interest rate is 10%.

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3. The concession period is 30 years.
4. Operating and maintenance cost in 1998 made up 4% of the total cost and would escalate at 4% annually.
5. The corporate tax rate is 28%.
6. From the first year of operation (1998), traffic volume will grow by 18% annually up to 2007 and by half of the rate (9%) subsequently, until it reaches the full capacity.
7. Toll rates (both initial and reduced rates) as gathered from the news are summarized in Table 6.1. These rates would escalate with inflation, which is approximately 2%.

Vehicle Class	Initial (RM)	Reduced (RM)	Proportion (%)
Cars	8	4.80	20
Buses	21	6.20	20
Vans	21	11.40	25
Lorries	53	25.50	25
Taxis	8	4.10	10

Table 6.1: Toll Rates for Different Vehicle Classes

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	1995	1996	1997	1998	1999	...	2026	2027
Capacity (millions daily)				0.2	0.2	...	0.2	0.2
Traffic Volume (millions yearly)				11	13	...	73	73
Toll Rate (RM)				12	12	...	21	21
Gross Revenue (millions)				130	156	...	1504	1534
CAPEX (millions)	147	147	126			...		
Operation & Maintenance (millions)				56	58	...	168	175
EBIT (millions)	(147)	(147)	(126)	74	98	...	1336	1360
Debt Service Payment (millions)				129	129	...		
Taxes (millions)				0	0		374	381
Free Cash Flow to Equity (millions)	(147)	(147)	(126)	(55)	(31)		962	979

Figure 6.3: Sample Cash Flow Model for Scenario 2

A sample of the cash flow model is shown in Figure 6.3. These cash flows are evaluated from the project equity investors' point of view. The relevant discount rate would therefore be the required return-on-equity, R_e , which can be estimated using the Capital Asset Pricing Model:

$$R_e = R_f + \beta_e \times (R_m - R_f) \quad (6.1)$$

where R_f , the risk-free rate, is estimated as 8% from the interest rate of the 20-year Malaysian Government Security issued in 1998;

β_e , the equity beta, is estimated as 1.332 from the capital structure of the project (with Total Asset Value/Equity = $1/0.3 = 3.33$), and using an asset beta of 0.4 (following Wooldridge *et al.*'s (2002) recommendation);

R_m is the rate of return of the overall Malaysian stock market, taken as 15.03% using an estimation period from 1991 to 2000 (Shun, 2003).

Using the above values for Equation (6.1), the value of R_e can be calculated as 17.36%. This is used as the discount rate in the cash flow model.

A total of three different scenarios have been constructed in order to capture a fuller picture. Prior to construction, traffic volume was projected optimistically and the toll

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rate was high (referred as Scenario 1). However, the development was out of expectation – the traffic volume was low and the toll rates had to be lowered to attract more motorists (referred as Scenario 3). For analytical purposes, it is also of interest to construct a “mid-way” scenario, which has the original projected traffic volume but with the reduced toll rates. This is referred as Scenario 2. The results of financial analysis of these scenarios are summarized in Table 6.2, and the detailed cash flow models of these scenarios are compiled in Appendix II. The fact that Scenario 2 seems to yield the most reasonable results should not come as a surprise, since the finally reduced toll rates would more realistically generate the initial traffic volume projection. As such, the subsequent real option analysis will be based on the cash flow model of Scenario 2.

Scenario		NPV (RM: Million)	IRR (%)
1 (a)	Original projected traffic volume + Initial toll rates	1765.3	38.5
2 (b)	Original projected traffic volume + Reduced toll rates	326.6	22.1
3 (c)	Actual traffic volume + Reduced toll rates	– 449.6	11.0
Notes: (a) Refer to Appendix II – 01 (b) Refer to Appendix II – 02 (c) Refer to Appendix II – 03			

Table 6.2: NPV and IRR of the Project under Three Seperate Scenarios

6.3 Project Evaluation Using Real Option

6.3.1 Key Variables of Monte Carlo Simulation

The uncertainties in the project value are primarily affected by two factors: the initial traffic volume in 1998 (the first year of operation) and the growth rate of the traffic volume. The traffic volume variable in 1998 is assumed to follow a lognormal distribution since this variable can never go below zero. As in many other toll road projects, traffic volume generally increases in subsequent years. For simplicity, the initial annual growth rate is modeled by a normal distribution (which, following the earlier stated assumption, is reduced to half in 2008 and applied until traffic volume reaches the capacity of the bridge). The parameters chosen for these two distributions are compiled in Table 6.3. The original traffic projection ($\cong 11$ million) is taken as the mean value of the traffic volume variable. In practice, inputs from transportation modeling experts would be sought, and suitable modifications can even be made in the cash flow models. The basic procedure of option evaluation remains applicable, which demonstrates the strength of the methodology presented here. To make the case study more concrete, however, these parameters will be altered in the subsequent sensitivity analyses to examine their impact on the value of the options.

	Initial Traffic Volume (millions)	Initial Growth Rate (up to 2007)
Type of Distribution	Lognormal	Normal
Mean	10.95	18%
Standard Deviation	1.10	6%

Table 6.3: Probability Distribution of Variables

6.3.2 Valuation of Guarantee as a Put Option

The guarantee that the Malaysian government provided for the toll revenue is effectively a “put option” written to the sponsor of the project. Government guarantees are sometimes granted without much consideration of their real worth. In retrospect, it would be meaningful to assess the potential value of the guarantee granted in a project of such nature, which could be taken into consideration during the negotiation stage.

Effectively, the guarantee comes from the fact that if the toll revenue from actual traffic volume (CF_{ia}) in each year i reaches the level that has been projected (CF_{ip}) in the pro forma cash flow model (based on Scenario 2, as pointed out earlier), the government would not have to pay any subsidy. Otherwise, the government would have to make up for the shortfall in revenue, just like it actually did by paying the sponsor RM20 million in 1999. For the purpose of evaluating this form of guarantees, the government’s obligation to pay in each year (SF_i) would depend on the relative value between CF_{ia} and CF_{ip} , as shown in Figure 6.4. Therefore, the total subsidy (SD) that the government would provide over the entire concession period can be estimated by using the following equation:

$$SD = \sum_{i=4}^{33} \frac{SF_i}{(1 + R_f)^i} \quad (6.2)$$

Figure 6.4: Evaluation Model for Revenue Shortfall

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Due to the uncertainties in initial traffic volume and growth rate, the value of ***SD*** is not deterministic but instead follows a certain distribution. This distribution can be obtained by simulating cash flows based on the assumed distributions of the initial traffic volume and growth rate as specified earlier. During each trial, values of the initial traffic volume and growth rate are sampled and used to derive the gross revenue in each period. Since the cash flow model is constructed in a spreadsheet environment, the conditions set out in Figure 6.4 can be easily incorporated using logical functions in the relevant cells and hence the value of ***SF_i*** for each period can be derived accordingly. Finally, the cell that contains Equation (6.2) represents the forecast cell for the simulation.

Following the above procedure, the distribution of ***SD*** can be derived, which is shown in Figure 6.5. Table 6.4 also summarizes several key statistics of the forecast parameter. At this stage, the main issue is to decide which of the statistics would represent a fair value of the total subsidy. In view of the fact that the distribution is highly skewed, this researcher would not recommend the mean. Rather, the median represents a fair value, since there is an equal 50% chance that the total subsidy is overvalued (or undervalued). Obviously, the actual percentile adopted would depend on the negotiation and bargaining skills of the parties concerned (Razgaitis, 2003).

Finally, with a median value of RM54 million, it is noted that the value of the guarantee is quite significant (relative to the NPV of RM326.6 million in the base case of Scenario 2). This supports the argument that a proper evaluation of guarantees can be important.

Figure 6.5: Frequency Distribution Chart of Total Subsidy (*SD*)

Key Statistic	Value (Units Vary)
Trials	10,000
Mean (RM millions)	490.2
Median (RM millions)	54.0
Standard Deviation	752.8
Variance	566,672.0
Skewness	1.8
Kurtosis	5.6

Table 6.4: Simulation Results of Total Subsidy (*SD*)

6.3.3 Valuation of “Repayment” as a Call Option

In reality, it is hard to estimate the traffic volume. If it is lower than the initial projection, the government may subsidize the shortfall in revenue, as evaluated previously. Conversely, one could also argue that if the traffic volume somehow surpasses the initial projection by some pre-specified level, the government should rightfully demand a reduction in toll rates to benefit the users, increase taxes, or even directly participate in the upside of the project. All these represent a form of “repayment” from the concessionaire to the government. Alternatively, the notion of “repayment” can be viewed as a cap on the return of the project sponsor, so that acts of exploitation can be better controlled.

A procedure that is similar to the valuation of guarantees can be used to determine the appropriate conditions for repayment. Consider a scenario in which the government has determined that the internal rate-of-return (IRR) of the project investors should be capped at a level that is commensurate with an initial traffic growth rate of 20% (obviously, these thresholds of IRR and growth rate are subjected to negotiation between the government and the project sponsor). If the actual traffic volume in each year i (and the associated cash flow CF_{ia}) exceeds the projection based on the capped IRR that is commensurate with the traffic growth rate of 20% (which has a cash flow $CF_{i, 20\%}$), the government would then have the right to “call” for the excess cash flows, ECF_i (or “payment-in-kind”, such as a reduction in toll rates). This condition is depicted in Figure 6.6, and the total value of this repayment scheme, RP , can be estimated using Equation (6.3).

Figure 6.6: Evaluation Model for Excess Cash Flows in Repayment Scheme

$$RP = \sum_{i=4}^{33} \frac{ECF_i}{(1 + R_f)^i} \quad (6.3)$$

Again, by applying Monte Carlo simulation, a distribution of **RP** can be obtained. The corresponding key statistics of this forecast parameter is summarized in Table 6.5.

Key Statistic	Value (Units Vary)
Trials	10,000
Mean (RM millions)	123.45
Median (RM millions)	9.30
Standard Deviation	201.47
Variance	40,584.41
Skewness	1.73
Kurtosis	5.19

Table 6.5: Simulation Results of Repayment Scheme (*RP*)

6.3.4 Sensitivity Analysis of Option Values

In practice, it is always prudent to examine how sensitive the estimated option values are to the various input parameters. This is particularly important in a negotiation context. For example, if the government intends to match the value of guarantee that

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is granted with the value of repayment, the following issues deserve further investigations: (1) sensitivity of the estimated option values to the parameters of the distributions; (2) a suitable threshold that should be set in the referenced cash flow model that would trigger a repayment.

Table 6.6 and 6.7 show the results of sensitivity analyses of **SD** and **RP** subject to variations in the standard deviations of initial traffic volume and growth rate. From Table 6.6, it can be seen that the value of **SD** is more sensitive to the standard deviation of the initial traffic volume assumed. On the other hand, in Table 6.7, the value of **RP** seems to be more sensitive to the standard deviation of the growth rate. It should be noted that the standard deviations of these two variables determine the volatility of the project cash flows, which is a key determinant of the value of the two options evaluated. The findings essentially underline the differences in risks that confront the government and the project sponsor, since **RP** technically “belongs” to the former and **SD** to the latter.

		Standard Deviation of Growth Rate			
		3%	6%	9%	12%
Standard Deviation of Initial Traffic Volume	0.55	26.7	28.8	29.2	31.5
	1.10	46.6	54.0	60.8	66.5
	1.65	60.2	77.0	92.4	95.1
	2.20	85.6	104.8	121.1	123.1
	2.75	112.2	129.2	162.6	168.4
	3.30	140.1	169.3	180.1	191.8

Table 6.6: Sensitivity of Total Subsidy (in RM millions) to Standard Deviations of Initial Traffic Volume and Growth Rate

		Standard Deviation of Growth Rate			
		3%	6%	9%	12%
Standard Deviation of Initial Traffic Volume	0.55	1.95	4.39	6.01	7.19
	1.10	2.81	9.30	13.04	15.11
	1.65	2.60	11.93	18.88	20.66
	2.20	1.69	12.74	24.79	31.81
	2.75	0.24	13.94	24.87	33.25
	3.30	0.00	10.31	25.47	37.94

Table 6.7: Sensitivity of Repayment (in RM millions) to Standard Deviations of Initial Traffic Volume and Growth Rate

In Table 6.7, it is also interesting to note that the value of repayment does not always increase with the standard deviation of the initial traffic volume, particularly when the standard deviation of the growth rate is low. This seems counterintuitive to the known feature of a *financial* option, the value of which increases when volatility of the underlying asset increases. This peculiarity is due to the distribution chosen for the initial traffic volume (which is asymmetric) and the setting of the cash flow model (where factors such as traffic volume, growth rate, maximum capacity, and time value of money all interact in a complex manner). It emphasizes that financial and real options sometimes differ in their characteristics.

Table 6.8 compiles the different values of **RP** when the threshold of traffic growth rate varies (recall that this threshold, or cap, establishes the repayment condition). Obviously, at a higher threshold, the value of repayment would be lower, since there is a lower probability of the threshold being exceeded to trigger a repayment. Thus, if the government wants to match **RP** with the median value of total subsidy **SD** determined earlier (which is RM54 million), it would negotiate for a cap that is around 18% (which has a median of RM42.8 million).

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Threshold of Traffic Growth Rate, g	15%	16%	17%	18%	19%	20%	25%
Internal Rate of Return	19.9%	20.7%	21.4%	22.1%	22.8%	23.4%	25.9%
Value of Repayment (RM: millions)	481.6	312.8	137.8	42.8	18.2	9.3	0.8

Table 6.8: Sensitivity of Repayment to Threshold of Traffic Growth Rate

6.4 Flexibility in Design and Execution

Due to the project uncertainties and economic-based irreversibility, it would be wise to incorporate flexibility in the design and execution of infrastructure projects. Zhao and Tseng (2003), for example, state that although enhancing the foundation and columns of a structure represents additional upfront cost, it has a return in flexibility for future expansion. Similarly, in their “layering model”, Lessard and Miller (2000) suggest that creating options to allow for a greater range of responses in line with uncertain future outcomes is critical. They also comment that many successful projects are not selected *a priori*, but shaped and structured along the way – projects are shaped in episodes to gradually transform the initial hypothesis, make progress on critical issues, and solidify initial coalitions of players to achieve temporary and final commitment.

The need for flexibility in design and execution truly stands out in the case of the Second Crossing. As mentioned in the project background, the original projection of traffic volume was overly optimistic, and was further hit by the high initial toll rates. Moreover, based on the projection of traffic growth assumed, the volume would not reach capacity for a long period of time. This implies that the capacity that was put in place initially may simply be too large and hence the design is not optimum. The fact

that the cross-section of the bridge, which is made up of two precast concrete box girders (Figure 6.7), clearly shows that it should be possible to design and construct the bridge in two phases. There are at least two advantages associated with this strategy. First, completion and operation of the first phase allows information to be gathered on traffic demand, so that a proper judgment can be made on the timing and necessity to proceed with the second phase. Effectively, an “expansion option” is created. Second, the deferment of construction of the second phase allows for some savings in interest expenses, since less debt would be engaged upfront.

Figure 6.7: Cross Sectional View during the Bridge Construction

According to the cash flow model of Scenario 2, the traffic volume would reach capacity in 2012, or 15 years after commencement of operation. The fact that the traffic volume would not reach capacity for a long period of time implies that the initial capacity may be too large and the design is not optimum. Using the typical real option thinking of shaping a project and incorporating flexibility, two scenarios can be built up to create options for the project. First, the project could be completed in two stages. Given the current advancement in bridge engineering and construction technology, this should not be too difficult to achieve. Second, even if a single stage construction of the whole project is preferred (perhaps due to the reluctance to

re-mobilize equipment and manpower), the opening of some lanes of the bridge can be deferred so that some savings in the corresponding O&M expenses can be realized – at least until the opened lanes reached their capacity. These two scenarios of redesign will be examined in sequence.

6.4.1 Constructing the Bridge in Stages

Since the bridge has six lanes, it is sensible to propose that only four lanes are to be constructed at the 1st stage. The remaining two lanes will be built contingent upon the actual traffic volume. Effectively, the project is divided into two phases. Upon completion of Phase I (four lanes), construction of Phase II would represent an expansion option. At the same time, since the time of commencement of constructing Phase II can be flexibly determined, it represents a deferment option as well.

For simplicity sake, it is assumed that the scale of Phase I is proportionally 2/3 of the original project (based on 4 out of 6 lanes). The construction period of the four lanes would then be two years and operation would begin in 1997. Likewise, the capacity would be two-third of the total capacity, which is 48.67 million yearly. From the cash flow model of Phase I, the traffic volume would reach this level in 2006; thus construction of Phase II must be completed by the end of 2006 so that the expanded capacity can come on time. The construction period of Phase II is likewise taken as one year and the maturity of the expansion option is 11 years (from 1995 to 2006). Following the same principle, the construction cost, equity contribution and loan amount are divided proportionally.

With the traditional evaluation method, the net present value of Phase I, NPV_I (as of 1995), is determined as RM 590.90 million and the net present value of Phase II, NPV_{II} (as of 1995), is RM 69.13 million. Details of the cash flow models of Phase I and II for this scenario are given in Appendix II-06 and II-07. The present value of

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underlying asset of Phase II (i.e. net cash flows excluding CAPEX), S_{II} , is RM 143.78 million.

In the deferral/expansion option, the asset value is uncertain because of the uncertainty in (volatility of) traffic volume. The exercise price, K , which is the capital investment of Phase II in 2006, is:

$$K = 1/3 \times (30\% \times 1,400) \times (1+2\%)^{11} = \text{RM } 174.07 \text{ million}$$

Using Cox *et. al*'s (1979) approach, the up factor, u , and down factor, d , can be estimated based on the following:

$$u = e^{\sigma\sqrt{t}} = e^{0.1 \times \sqrt{1}} = 1.1052$$

$$d = e^{-\sigma\sqrt{t}} = e^{-0.1 \times \sqrt{1}} = 0.9048$$

The risk-neutral probabilities for the up and down movements are:

$$\Pi_u = \frac{e^{rf} - d}{u - d} = \frac{e^{0.08} - 0.9048}{1.1052 - 0.9048} = 0.8908$$

$$\Pi_d = \frac{-e^{rf} + u}{u - d} = \frac{-e^{0.08} + 1.1052}{1.1052 - 0.9048} = 0.1092$$

Then, an 11-step binomial model of asset value can be constructed:

Figure 6.8: Binomial Tree of Underlying Asset Value

The model of the value with option would be:

Figure 6.9: Binomial Tree of Project Value (Phase II) with Embedded Option

Using this model, the value of Phase II with embedded expansion option, V_{II} , is RM 71.64 million.

Looking at the entire picture, if the sponsor had chosen to incorporate flexibilities into the project by splitting it into two phases, much additional value would have been created. The additional value (with reference to the base case of Scenario 2) can be computed as:

$$NPV_I + V_{II} - NPV_{\text{base case}} = 590.90 + 71.64 - 326.60 = \text{RM } 335.94 \text{ million}$$

Excluding Phase I, NPV_{II} (which was earlier determined as RM 69.13 million) is almost the same as the value of Phase II with embedded expansion option (RM 71.64 million). Effectively, the option value is quite low ($71.64 - 69.13 = 2.51$). This is largely attributed to the fact that Phase II is “deep-in-the-money”.

Another interesting observation is that in this redesigned scenario, NPV_I itself (RM 590.90 million) is already greater than the NPV of the base case (RM 326.60 million). There are a couple of factors contributing to this: first, both of them have same

revenue from same traffic volume before 2006, but the redesigned Phase I has a lower CAPEX. Although the project as a whole in the base case has a larger traffic volume after 2006, the influence is small. Second, since less CAPEX is required in the redesigned Phase I, the sponsor would only need to borrow a portion of capital closer to 2006, which postpones the debt service. This reduces the PV of the debt burden and affects the NPV greatly.

In addition, there is a timing arrangement in the expansion option. As analyzed, the traffic volume of Phase I will reach its own capacity in 2006, which implies that it may be viable to finish the construction of Phase II at any time so long as it is before 2006. Thus, the government can take timely action to have Phase II built at a certain time before 2006 in order to ensure that sufficient traffic capacity is in place. In this way, the value of the project will be further enhanced due to the flexibility in timing to initiate the construction of Phase II.

6.4.2 Construct a Complete Bridge but Defer Opening of Certain

Lanes

In Section 6.4.1, it is assumed that the bridge is built in two stages. However, when the construction of Phase II is initiated, both equipment and manpower need to be mobilized again and thus will incur additional expenses. One alternative approach (at least in theory, although this is not often implemented) to execute the project is to build the entire bridge initially but only open certain number of lanes based on the initial traffic demand. Similar to the phasing strategy for construction, this idea also encompasses the spirit of real option by introducing flexibility in operation. To evaluate this scenario, it is again assumed that four lanes (Phase I) is opened first and the other two lanes (Phase II) would only be opened when Phase I reaches its capacity. In this case, the capital expenditure (CAPEX) on constructing the bridge in Phase I

will be equal to the total CAPEX of the project. What the sponsor incurs in Phase II is just the additional operating and maintenance (O&M) expenses for the lanes that are only opened in Phase II. To apply the real option theory, O&M expenses of Phase II is discounted back to the year in which Phase I reaches its capacity. The present value of the discounted O&M is the exercise price in evaluating this option.

Based on the same methodology as in Section 6.4.1, the net present value of Phase I, NPV_I (in 1995), is RM 239.24 million and that of Phase II, NPV_{II} (in 1995), is RM 106.65 million. The present value of underlying asset of Phase II (i.e. net cash flows excluding O&M), S_{II} , is RM 170.74 million. The value of Phase II with embedded expansion option is RM 108.98 million. The additional value introduced by this operating scenario (with reference to a base case of Scenario 2) can be computed as:

$$NPV_I + V_{II} - NPV_{\text{base case}} = 239.24 + 108.98 - 326.60 = \text{RM } 21.62 \text{ million.}$$

In this case, the additional value from operating flexibility (RM 21.6 million) is substantially lower than that of expansion option in Section 6.4.1 (RM 335.9 million). There are two possible explanations for this. First, once the bridge is built as a whole, the option would become “deep-in-the-money” and the extra value of deferring the opening of the lanes is really not that significant as compared to the value of expansion option (of dividing the construction into phases). Second, by constructing the bridge as a whole, larger capital has to be borrowed upfront and the present value of debt service payments would be higher as compared to the case of dividing the construction into stages.

6.4.3 Assessment of Four Possible Execution Strategies

In the evaluation process of both Section 6.4.1 and 6.4.2, a “4-plus-2” assumption is made, i.e., it is assumed that 4 lanes are constructed (or opened) in Phase I and the other 2 lanes are constructed (or opened) in Phase II. Obviously, the evaluation methodology is not limited by this assumption. It is equally reasonable to assume a “3-plus-3 scenario”, whereby 3 lanes will be constructed (or opened) in Phase I and the other three in Phase II. By making the necessary adjustments to the same procedure conducted in section 6.4.1 and 6.4.2, the revised values computed are summarized in Table 6.9 for all four possible execution strategies:

Alternative Project Execution Strategies		Provisions of Lanes in Each Phase	
		4-plus-2	3-plus-3
Divide Construction into 2 Stages	NPV (Phase I)	590.90 ⁽¹⁾	607.29 ⁽⁵⁾
	NPV (Phase II)	69.13 ⁽²⁾	126.67 ⁽⁶⁾
	Value of Phase II with Embedded Option	71.64	130.12
	Additional Value Introduced by this Execution Strategy (vis-a-vis the base case)	335.94	410.81
Construct the Whole Bridge but Open only Selected Number of Lanes	NPV (Phase I)	239.24 ⁽³⁾	133.84 ⁽⁷⁾
	NPV (Phase II)	106.65 ⁽⁴⁾	199.77 ⁽⁸⁾
	Value of Phase II with Embedded Option	108.98	203.01
	Additional Value Introduced by this Execution Strategy (vis-a-vis the base case)	21.62	10.25
(All figures in RM millions)			
Notes:			
(1) Refer to Appendix II – 06		(2) Refer to Appendix II – 07	
(3) Refer to Appendix II – 08		(4) Refer to Appendix II – 09	
(5) Refer to Appendix II – 10		(6) Refer to Appendix II – 11	
(7) Refer to Appendix II – 12		(8) Refer to Appendix II – 13	

Table 6.9: Evaluation of Four Possible Execution Strategies

Table 6.9 demonstrates that when the construction of the bridge is divided into two phases, the value derived from flexibility is greater than the strategy of opening only selected lanes. Once the bridge is built as a whole, the option value would be quite small despite savings of O&M expenses in Phase II. In Table 6.9, it is also interesting to note that whether a “4-plus-2” configuration is more optimal than a “3-plus-3” would depend on the type of execution strategy selected.

6.5 Summary

In all forms of public-private partnerships, project participants should take a holistic view of risk and value in the process of negotiation. Certain forms of governmental support, such as guarantees and subsidies, can be interpreted as options, since the obligations are triggered when some pre-specified conditions are met. The value of these options has to be properly accounted for, so as to strike a better balance between risk and benefit. The real option approach is a promising tool to value some of these options. Although there are many ways of modeling real options, the approach presented in this chapter makes use of Monte Carlo simulation of a cash flow model. In the case of the Malaysia-Singapore Second Crossing, it is demonstrated that the guarantee granted, which ultimately resulted in subsidy payments, could indeed be substantial. To match the value that has been conferred, a “repayment” scheme can be designed to place a cap on the private sector’s return. Together with scenario and sensitivity analyses, this case study relates these principles and tools to the context of negotiation.

Value can also be created by incorporating flexibility during different stages of a project life cycle. The value of flexibility is very significant indeed in the Second Crossing project due to the tremendous uncertainty in traffic forecast. In hindsight, the project could have been better structured by providing the eventual traffic capacity over two or more construction and operating phases. This strategy would allow more

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time for the uncertainties in traffic volume and growth trend to unravel. At the same time, additional interest savings would be realized, since less capital is required to be borrowed upfront when part of the bridge construction or operation is deferred.

CHAPTER 7

MAJOR CASE STUDY THREE: WASTEWATER TREATMENT PLANT IN SOUTHERN CHINA

The third case is studied in this chapter, which concerns a wastewater treatment plant located in one of the major cities in Southern China. Risks involved in the project are first analyzed based on the structure of the transaction, followed by the identification of real options in the project. Similar to the second case, Monte Carlo simulation is used to evaluate a guarantee on the lowest volume of treatment and a cap on the excess treatment volume. A discrete-time model using the binomial approach is also applied in the evaluation of an abandonment option. Based on the results derived, negotiation bands for the project value and water tariff are constructed. At the time of this writing, this project is still in the tender award stage and therefore the actual identities of the critical parties mentioned in the chapter are concealed. This, however, does not compromise the analyses conducted here in any way.

7.1 Background of the Project

Since the last decade, reform of state-owned enterprises has often been quoted as the main bottleneck of economic development in many provinces in China. One approach to solve this issue is to redesign the equity structure and shareholding system of state-owned enterprises. The purpose of this measure is to attract private investors to take part in the management and operation of state-owned enterprises. Through the new policy, it is hoped that government agencies could transfer some of the business risks to the private sector and enhance the operational efficiency of these enterprises.

In line with the above political and economic imperatives, in the current case of interest which takes place in one of the provincial cities in Southern China, an entity known as the City Development Group (CDG) is established as an agent of the City Government. A wastewater treatment plant, located in the north of the city, becomes a pilot case in the course of reform – CDG will transfer the operation of the wastewater treatment plant through a concession awarded to private bidders. Through this transaction, the City Government hopes to improve the operating efficiency of the plant with the advanced technology and management input given by the private sector. Also, it represents a pilot project to attract private investors to take part in the infrastructure development of the city.

The wastewater treatment system in this city is composed of the treatment plant itself and an extensive piping network connected to the plant. Construction of the wastewater treatment system was finished in July 2003. A total of RMB 1.03 billion has been invested in the whole project, out of which the wastewater treatment plant cost RMB 350 million. The plant has a capacity to treat 300,000 m³ per day during the dry season and 600,000 m³ per day during the rainy season. The entire system covers 38.54 square kilometers and serves 670,000 residents. The design of the plant makes use of advanced technology to treat wastewater in an effective and efficient manner.

7.2 Details of the Transaction

7.2.1 Structure of the Transaction

In this transaction, CDG plays the role as an agent to the City Government. The transaction is carried out as a Transfer-Operate-Transfer (TOT) scheme. The City Government authorizes CDG to transfer the right of operating the wastewater treatment plant to the successful bidder. At the end of the concession, the concessionaire is required to transfer the plant back to the City Government or CDG.

Together with the rights to operate the plant, the ownership of the assets is also transferred to the investors. As shown in Figure 7.1, both the rights of operation and ownership of assets are conferred to a Special Purpose Vehicle set up by the investors (hereafter referred as the “Concessionaire”). The Concessionaire would operate the plant and take on the risks of business and operation. Also, the Government has authorized the Public Utility Bureau to supervise and ensure the quality of effluent from the plant and report to CDG periodically. During the concession period, CDG has an obligation to pay for such wastewater treatment services, and the government will appropriate the funds for this fee payment from collected payments from the users and also other public budget sources.

Figure 7.1 indicates that the authorization of concession, the transfer of operation rights and management of the plant are the most important components in the transaction. The concessionaire is the entity that will take up the concession, earn the right of operating the plant and confront with risks throughout the concession period.

Figure 7.1: Structure of Transaction

(1) Authorization of Industry Management

7.2.2 Key Issues in the Agreement

7.2.2.1 Length of Concession Period

During the concession, the concessionaire holds the ownership of all assets and the corresponding auxiliary facilities of the plant, excluding the land. The concession period is an important factor to each party in estimating a fair transfer price. According to the guidelines issued in 2002 by the State Planning Committee, the Ministry of Construction, and the State Bureau of Environmental Protection on the industrialization of wastewater and solid waste treatment, the concession period of civil wastewater treatment project can go up to 30 years at most. In this transaction, with a large capital payment upfront and a relatively long payback period, and the concession period has been set at 25 years.

7.2.2.2 Treatment Volume and Tariff

In the project, the wastewater treatment volume is another important factor to consider, and it is also a key issue that both parties would negotiate upon. The treatment volume is affected by two factors: the scale of treatment and the sources of wastewater. The former factor is determined by the area that the system serves, the condition of the pipes and the system of discharge. Since the plant has already been constructed and operation has commenced, this factor is largely beyond the concessionaire's control, and the scale of wastewater treatment is largely fixed. On a related issue, construction of pipes serving the whole system was originally planned to be implemented in phases. The capacity of wastewater collection will increase gradually and reach the level reflected in the original design of the plant after a period of time.

The sources of wastewater are made up of residential wastewater and rain. In the analysis, the basic volume is derived based on the daily volume. Since the area that

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the plant serves is fixed, it is reasonable to conclude that the daily residential wastewater volume is certain. However, the volume of rain in different seasons would be quite different. Thus, the actual treatment volume will fluctuate during the dry and rainy seasons. As such, the yearly volume will have to be calculated based on the number of days and the corresponding volume in for both the dry and rainy seasons.

To alleviate the concern of a highly volatile cash flow profile of the concessionaire, CDG adopts a “Take-or-Pay” arrangement to guarantee the lowest wastewater volume (as illustrated in Figure 7.2). In this arrangement, if the actual volume is below the lowest guaranteed volume, the government would still make its payment based on the lowest guaranteed volume at a normal rate of pricing (i.e. tariff). If the actual volume is above the lowest volume guaranteed but below a certain cap, payment would be made based on the actual volume at the normal tariff. The cap is determined using past records of the average volume during the dry season (hereafter referred as the “capped normal” level). Last, if the actual volume surpasses this “capped normal” level, payment would be made in two parts using different tariffs: (i) normal tariff for the amount up to the “capped normal” level; and (ii) an adjusted tariff for the part that exceeds the “capped normal” level. This adjusted rate would be lower than the normal rate and has been set at RMB 0.22/m³.

Figure 7.2: Tariff and Pricing Arrangement

Table 7.1 gives the projection of the volume of wastewater treatment as specified in the tender document:

Year		1	2	3	4	5~25
Daily Volume (in 10,000 m ³)						
Projected Volume	Dry Season	15	19	22	25	30
	Rainy Season	26	33	38	46	60
Guaranteed Level		10	15	18	20	25
“Capped Normal” Level		15	19	22	25	30

Table 7.1: Projection of Volume of Wastewater

In general, a two-part tariff structure is adopted in many Build-Operate-Transfer (BOT) water supply projects (Jamieson and Wilson, 1997; Harris and Bourdeaux, 2001). The two-part tariff arrangement usually comprises a capacity charge and a

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variable cost charge, with the variable cost charge aiming to compensate the project promoter for its variable operating and maintenance costs. In this current project, the normal tariff rate is determined by taking consideration of the rates in other cities, the basic operating costs, plus a certain rate of return. The adjusted tariff rate is then designed to make up for the additional variable costs. Thus, in some ways, the rationale behind the two-part pricing of this project deviates slightly from the usual two-part tariff adopted in BOT water supply projects.

7.2.2.3 Tariff Adjustment

During the concession, the cost of treatment may fluctuate due to costs of labor, power, chemical and other sources. To protect the interest of the concessionaire, tariffs should be adjusted according to the actual cost of treatment. In this transaction, the agreement states that tariff can be adjusted biyearly through negotiation.

7.2.2.4 Reinvestment in Equipment Renewal and Replacement

Since the concession period is 25 years and the life span of most equipment would not last for such a long period, it is necessary to incur reinvestments to renew the equipment at certain intervals during the concession.

Generally, the cost of reinvestment may be borne either by the asset owner or by the concessionaire. The actual choice of arrangement would have some impact on the initial transfer price and the final salvage value of the project. In this project, the concessionaire is asked to be responsible for reinvestment and the government would not pay for any salvage value at the end of the concession.

7.2.3 Two Scenarios of Bidding

In this transaction, it is necessary to consider two bidding scenarios and the bidders are supposed to propose their values for two different variables. One is the normal rate of tariff for treating wastewater, which will be paid by CDG to the concessionaire throughout the concession period (recall that the adjusted rate of tariff is not a variable since it has been set at RMB 0.22/m³). In this first scenario, the transfer price has been fixed at RMB 350 million. In the second scenario, the normal tariff is fixed at RMB 1.00/m³ and the initial transfer price becomes the variable, the amount of which will be paid by the concessionaire to CDG at the consummation of the deal. Obviously, during the financial evaluation process, the first variable is related to the second given a predetermined rate of return for the investors. Based on this principle, the government (and the private investor) could effectively set one of the two variables and work out a range for the other variable which it would negotiate with the investors.

7.3 Risk Factors faced by the Concessionaire

7.3.1 Default of Payment by Government

According to the agreement, payment will be made to the concessionaire by the government through CDG. The rate, however, would be different from that collected directly from the end users by the government. As a result, the concessionaire may face the risk of default of payment when the government experiences a severe budget deficit, perhaps due to a significant number of non-collectibles or bad debts.

7.3.2 Volume of Wastewater

As mentioned previously, the volume of wastewater represents an important factor of consideration to the concessionaire in the project. This variable would have an impact on the tariff and the initial transfer price. However, it is hard to estimate the actual realized volume since part of it is subjected to weather condition, which cannot be predicted accurately. In the transaction, this risk is alleviated by having the lowest guaranteed volume under the “take-or-pay” arrangement.

7.3.3 Changes in Operating Costs

Throughout the concession period, the operating cost of wastewater treatment is subjected to increase in the costs of labor, electricity, chemical substances and other factors. According to the contractual agreement, tariff will be adjusted biyearly through negotiation, which may help to alleviate the risk of excessive inflation of the operating costs. Although one may reasonably assume that the negotiated tariff would make up for any changes in operating costs, there is no basis to predict that the outcome will be fair to both parties in the first place (hence, this factor is ignored in the subsequent real option analysis).

7.3.4 Reinvestments

At different stages of the concession period, it would be necessary for the concessionaire to make reinvestments in order to renew or replace equipment so that operation is continued at the optimum level of efficiency and the specified quality of effluent can be maintained. These costs (and the risks associated with the quantum) are assumed by the concessionaire. Furthermore, the concessionaire will not obtain any salvage value for the renewed equipment at the end of the concession according

to the contractual terms.

7.3.5 Force Majeure

Throughout the concession period, incidents which are beyond the control of both the concessionaire and the government may happen. According to the agreement, such incidents may be classified as force majeure events, which include war, earthquake, cyclone, strike, and terrorism. These incidents would inevitably result in losses if the plant operation is interrupted. As stated in the agreement, losses due to force majeure events may be considered only if the concessionaire reports these losses to CDG within ten days after the incidents. This tight timeline imposes some uncertainty and pressure to the concessionaire to provide a good estimate of the losses that it suffers.

7.4. Real Options Identified in the Project

7.4.1 Guarantee on Treatment Volume Provided by the Government

As mentioned earlier, CDG adopts a “Take-or-Pay” arrangement to guarantee the lowest wastewater volume. When the actual volume is below the lowest volume guaranteed, the government will still make payment for the lowest guaranteed volume at the normal tariff. This arrangement offers the concessionaire the right to claim a normal payment even though a low volume (below the guaranteed level) has actually been realized. Essentially, the volume uncertainty is captured in the form of a put option – without the payoff from this option (i.e. guarantee) to make up for the shortfall, the concessionaire will only be compensated for the actual volume. The payoff from the option is illustrated in Figure 7.3; this put option has enhanced the value of the project from the concessionaire’s standpoint.

Figure 7.3: Modeling the Guarantee as a Put Option

7.4.2 Cap on the Tariff — Call Option given to the Government

In the tariff design, the agreement states that if the actual volume surpasses the “capped normal” level, the payment will be made in two parts: normal rate for the part that is below the “capped normal” level; and an adjusted rate for the part that exceeds the “capped normal” level. It is understood that the adjusted rate is lower than the normal rate. Effectively, this arrangement lowers the price of the paranormal volume once the threshold is exceeded. By limiting the price of the paranormal volume, the government will avoid over paying the concessionaire even when the total volume has exceeded the normal expectation by a large margin. This essentially represents a form of a binary/digital call option owned by the government — it has the right to “call” for a reduction in rates once the volume exceeds the threshold. This is conceptually shown in Figure 7.4.

Figure 7.4: Modeling of the Tariff Cap as a Binary Call Option

7.4.3 Abandonment Option

According to the agreement, the existing equipment should be replaced in the 13th year. In this case, the concessionaire could phase the project into two stages: a 13-year operation followed by a subsequent 12-year operation. In the 13th year, the concessionaire could decide whether to make reinvestments in the project based on the operation in the previous years and the economic projection for the next 12 years. If the assessment is positive, the concessionaire will continue operation by incurring the cost of reinvestments. The concessionaire can, at least in theory, refuse to invest in equipment replacement, rescind the contract and abandon the project. Although unlikely to be exercised, this phasing strategy offers the concessionaire an option in the form of abandonment (i.e. a put option).

7.5. Evaluation of the Transaction

7.5.1 Modeling of the Cash flows

In order to evaluate the transaction, it is necessary to build up a pro forma cash flow model for the project. In this case, the free cash flows to total asset (FCF in short) are estimated for each year based on the following assumptions:

1. The long-term interest rate in China is 5.76% and the loan term is 10 years.
2. As mentioned in Section 7.3.3, re-negotiation of tariffs due to changes in operating costs is not considered in this evaluation, since it is almost impossible to predict such outcomes.
3. It is assumed that there are 325 days in dry season and 40 days rainy season respectively in a year.
4. The revenue of the project will be calculated simply as:
$$\text{Total revenue} = \text{Actual volume} \times \text{Tariff}$$
5. The adjusted tariff (above the “capped normal” level) is set at RMB 0.22 per m³.
6. According to China’s tax regulation, the tax rates for income and city development and maintenance are 5% and 11% respectively. The corporate tax rate is 33%.

A sample of the cash flow model is given in Table 7.2. The cash flows are evaluated on the basis of total free cash flows available to both equity and debt holders (i.e. free cash flows to total asset).

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Year	1	2	...	13	...	25
Revenue	59.15	74.95	...	121.50	...	121.50
Depreciation (1)	14	14	...	14	...	14
Depreciation (2)			...	10.24	...	
Salvage Value			...	6.15	...	
Recycle of Working Capital			...		...	3.50
Total Cash Inflow	59.15	74.95	...	127.65	...	125.00
CAPEX	350.00		...	123.00	...	
Working Capital	3.50		...		...	
Fixed Cost	27.99	31.02	...	39.37	...	39.37
Variable Cost	0.03	0.03	...	0.06	...	0.06
Interest	14.31	12.90	...	5.16	...	0.20
Tax on Revenue & City Maintenance	3.28	4.16	...	6.74	...	6.74
Corporate Tax	0.00	4.23	...	15.15	...	20.17
Total Cash Outflow	384.80	39.45	...	184.33	...	66.34
FCF	(325.65)	35.50	...	(56.68)	...	58.66
Notes: 1. All Figures shown are in RMB: million 2. Depreciation (1) is for original equipment Depreciation (2) is for renewed equipment						

Table 7.2: Cash Flow Model

7.5.2 Evaluation of the Range of IRR and Tariff using NPV Method

As pointed out in Section 7.2.3, there are two possible bidding scenarios: the first is to determine the transfer price with a given level of normal tariff (referred as Scenario 1); the second is to determine the level of normal tariff with a given amount of transfer price (Scenario 2). The two scenarios can be established using a common cash flow model, which is shown in Appendix III – 01. Based on this cash flow model, the two scenarios are analyzed using the NPV method:

$$NPV = \sum_{i=1}^n \frac{FCF_i}{(1 + IRR)^i} - I_0 \quad (7.1)$$

In Equation (7.1), FCF_i is the free cash flows to total asset for each year, IRR denotes the internal rate of return (or the discount rate) for the period, I_0 denotes the initial

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transfer price. In this project, the interest rate of the loan is 5.76%. When the transfer price is set to be equal to the original cost of development (which is RM 350 million – see Section 7.1), the IRR is 14.18%. Since the government and the concessionaire would separately evaluate this transaction using different rates of return, the relevant range of IRR will be between 5.76% and 14.18%.

For Scenario 1, the normal tariff has been specified in the tender document as RMB 1.00 per m³ and the bidder is supposed to propose a transfer price. The transfer price at different internal rates of return can be solved by setting NPV = 0 in Equation (7.1) using the trial-and-error method. The results are summarized as follows:

IRR (%)	5.76	6.00	7.00	8.00	9.00	10.00
Transfer price (RMB: million)	738.55	719.00	645.63	583.10	530.25	484.35
IRR (%)	11.00	12.00	13.00	14.00	14.18	
Transfer price (RMB: million)	444.66	410.36	380.50	354.35	350.00	

Table 7.3: Transfer Prices at different IRRs

In Scenario 2, the transfer price is fixed at RMB 350 million, which is the original development cost without considering the cost of the land. Following the same procedure and using the same cash flow model, the tariff levels for different internal rates of return can be derived as follows:

IRR (%)	5.76	6.00	7.00	8.00	9.00	10.00
Tariff (RMB/m ³)	0.688	0.696	0.730	0.765	0.800	0.837
IRR (%)	11.00	12.00	13.00	14.00	14.18	
Tariff (RMB/m ³)	0.875	0.914	0.953	0.993	1.000	

Table 7.4: Tariff Levels for different IRRs

7.5.3 Evaluation of Options Identified

7.5.3.1 Key Variables of Real Options

The main uncertainty in the project arises from the volume of wastewater treatment. The amount of rainfall in each year will have a large impact on the volume. Annual rainfall data from 1994 to 2002 (shown in Table 7.5) can be assumed to follow a lognormal distribution.

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002
Rainfall (mm)	715.7	772.8	1058.6	853.7	1186.5	1016.8	1080.7	870	922.2

Table 7.5: Rainfall Data from 1994 to 2002

The volatility of rainfall is computed as follows:

Since the rainfall data is summarized in an annual basis, we define:

$N+1$: Number of observations

S_i : rainfall in every year

τ : Length of time interval in years

and let

$$u_i = \ln\left(\frac{S_i}{S_{i-1}}\right)$$

An estimate, s , of the standard deviation of u_i is then

$$s = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (u_i - \bar{u})^2}$$

where $\bar{u}$ is the mean of u_i .

The volatility per annum is given by

$$\sigma = \frac{s}{\sqrt{\tau}}$$

The volatility has been estimated as 21.70%, which is used as a proxy for the volatility of free cash flow.

In subsequent analysis, the interest rate of 10-year Chinese Government Security issued in 2005 is adopted as the free risk rate: $R_f = 4.44\%$.

7.5.3.2 Option Value

Using the above parameters, the value of options (guarantee, cap and abandonment) will be studied.

1. Guarantee

The guarantee the government has written on the lowest volume is a form of put option to the investor. In reality, the volume is uncertain due to the fluctuation of rainfall in each year and it can sometimes be lower than the guaranteed level. Conceptually, the total revenue can be illustrated in Equation (7.2):

$$R = \begin{cases} V \times T, & \text{if } V > V_g \\ V_g \times T, & \text{if } V < V_g \end{cases} \quad (7.2)$$

In Equation (7.2), V is the actual volume, V_g is the guaranteed volume, T denotes the normal tariff level, and R is the total revenue.

The value of guarantee comes from the fact that if, in a specific year, cash flow from the actual volume (CF_{ia}) — derived from $R = V \times T$, is lower than what has been guaranteed (CF_{ig}) — derived from $R = V_g \times T$, the government is essentially making up for the shortfall in cash flow. Then, the shortfall that the government would make up in each year (S_i) would depend on the relative value between CF_{ia} and CF_{ig} , as shown in Figure 7.5. Therefore, the value of guarantee over the entire period (G) can be estimated by using Equation (7.3).

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Figure 7.5: Model of Guarantee Option

$$G = \sum_{i=1}^{25} \frac{S_i}{(1 + R_f)^i} \quad (7.3)$$

In the analysis, the volume of wastewater during the dry season is assumed to follow a lognormal distribution (note that in this case it is not necessary to introduce a distribution for the volume during the rainy season since this is always higher than that of a dry season). Using Monte Carlo simulation, the value of guarantee (G) can be evaluated by incorporating logical functions in relevant cells in the spreadsheet (see Appendix III – 02). Table 7.6 and Table 7.7 compile the values of guarantee for different transfer prices and tariff rates.

IRR (%)	5.76	6.00	7.00	8.00	9.00	10.00
Transfer price (RMB: million)	738.55	719.00	645.63	583.10	530.25	484.35
Guarantee (RMB: million)	3.10	2.96	3.29	2.95	2.80	2.43
IRR (%)	11.00	12.00	13.00	14.00	14.18	
Transfer price (RMB: million)	444.66	410.36	380.50	354.35	350.00	
Guarantee (RMB: million)	2.38	2.26	2.41	2.37	2.55	

Table 7.6: Value of Guarantee at different Transfer Prices

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IRR (%)	5.76	6.00	7.00	8.00	9.00	10.00
Tariff (RMB/m ³)	0.688	0.696	0.730	0.765	0.800	0.837
Guarantee (RMB: million)	2.15	2.23	2.34	2.28	2.18	2.12
IRR (%)	11.00	12.00	13.00	14.00	14.18	
Tariff (RMB/m ³)	0.875	0.914	0.953	0.993	1.000	
Guarantee (RMB: million)	2.25	2.24	2.34	1.82	2.55	

Table 7.7: Value of Guarantee at different Tariff Rates

From the results in Table 7.6 and 7.7, the value of guarantee seems to be very low and would appear to be insignificant to the option owner (i.e. the concessionaire). Table 7.8 and 7.9 show the sensitivity analyses of the value of guarantee subjected to variations in the range of $\pm$ (10%-30%) of the guaranteed volume. The results indicate that when the level of guaranteed volume is lowered by 10 percent or more, the value of guarantee becomes zero. This finding is intuitive indeed, since when the guaranteed level is lowered by a significant amount, the put option granted would become increasingly worthless (or, in the parlance of financial options, the put option has become “out-of-the-money”). On the other hand, the value of guarantee increases significantly when the level of guaranteed volume is raised. Furthermore, such increase is not linear. This implies that in the case of negotiation, the government should be cautious in adjusting its guaranteed volume upwards by an appreciable amount.

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Value of Guarantee (RMB: million)		Variation of Guaranteed Volume						
		-30%	-20%	-10%	0%	+10%	+20%	+30%
IRR (%)	Transfer Price (RMB: million)							
5.76	738.55	0.00	0.00	0.00	3.10	13.03	34.02	89.44
6.0	719.00	0.00	0.00	0.00	2.96	13.34	36.58	108.21
7.0	645.63	0.00	0.00	0.00	3.29	12.13	34.91	87.33
8.0	583.10	0.00	0.00	0.00	2.95	12.82	29.77	93.40
9.0	530.25	0.00	0.00	0.00	2.80	11.42	28.84	82.06
10.0	484.35	0.00	0.00	0.00	2.43	10.52	33.36	89.38
11.0	444.66	0.00	0.00	0.00	2.38	10.27	33.28	99.46
12.0	410.36	0.00	0.00	0.00	2.26	9.85	24.03	87.21
13.0	380.50	0.00	0.00	0.00	2.41	9.75	29.94	93.65
14.0	354.35	0.00	0.00	0.00	2.37	9.66	28.79	88.34
14.18	350.00	0.00	0.00	0.00	2.55	10.01	29.76	76.69

Table 7.8: Sensitivity of Value of Guarantee to the Guaranteed Volume
at different Transfer Prices

Value of Guarantee (RMB: million)		Variation of Guaranteed Volume						
		-30%	-20%	-10%	0%	+10%	+20%	+30%
IRR (%)	Tariff (RMB/m ³)							
5.76	0.688	0.00	0.00	0.00	2.15	8.62	22.44	60.21
6.0	0.696	0.00	0.00	0.00	2.23	8.84	21.44	68.72
7.0	0.730	0.00	0.00	0.00	2.34	9.17	25.12	77.07
8.0	0.765	0.00	0.00	0.00	2.28	9.31	28.08	66.18
9.0	0.800	0.00	0.00	0.00	2.18	8.94	21.73	73.37
10.0	0.837	0.00	0.00	0.00	2.12	8.95	25.73	80.94
11.0	0.875	0.00	0.00	0.00	2.25	9.16	27.34	78.08
12.0	0.914	0.00	0.00	0.00	2.24	9.06	24.83	79.92
13.0	0.953	0.00	0.00	0.00	2.34	8.32	30.71	88.81
14.0	0.993	0.00	0.00	0.00	1.82	9.79	25.26	96.25
14.18	1.000	0.00	0.00	0.00	2.55	9.79	32.03	90.01

Table 7.9: Sensitivity of Value of Guarantee to the Guaranteed Volume
at different Tariff Rates

2. Cap

According to the agreement, in the case that the actual volume surpasses the “capped normal” level, the government’s payment will not be made based on the normal rate of tariff. Instead, the excess will be paid at a rate which is lower than that of the normal tariff. The revenue of the concessionaire is basically represented by Equation (7.4) depending on the level of actual volume:

$$R = \begin{cases} V \times T, & \text{if } V < V_c \\ V \times T + (V - V_c) \times T_a, & \text{if } V > V_c \end{cases} \quad (7.4)$$

In Equation (7.4), V is the actual volume, V_c is the volume at the “capped normal” level, T denotes the normal tariff, T_a is the adjusted tariff (set at RMB 0.22 per m^3), and R is the total revenue.

Suppose there is no cap in the contractual arrangement. The cash flows made to the concessionaire (denoted as CF_{ia}) will then be based on the entire volume multiplied by the normal tariff – it does not matter whether V is greater or less than V_c , since V_c does not exist when there is no cap. In reality, however, there is a cap in the contractual arrangement, and the cash flow to the concessionaire (denoted as CF_{ic}) is in fact made up of the two parts in Equation (7.4). The value of the cap is derived from the fact that when V exceeds V_c , CF_{ia} would be higher than CF_{ic} (since the adjusted tariff for volume in excess of the cap is lower than the normal tariff) but the government is only obliged to pay for the lower CF_{ic} . This is conceptually shown in Figure 7.6. Therefore, the value of the cap over entire period (C) can be estimated by Equation (7.5).

Figure 7.6: Model of the Cap

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$$C = \sum_{i=1}^{25} \frac{C_i}{(1 + R_f)^i} \quad (7.5)$$

Conceptually, the value of the cap (C) can be evaluated in the same way as what have been done for the value of the guarantee by using Monte Carlo simulation (for details of the cash flow model, see Appendix III – 03). The only difference in this case is that the lognormal distribution is now applied to the volume of treatment during the rainy season (rather than the dry season), since the cap is only applicable to volume at the high end (rather than the low end). Table 7.10 and Table 7.11 present the value of the cap at different transfer prices and tariff levels.

IRR (%)	5.76	6.00	7.00	8.00	9.00	10.00
Transfer Price (RMB: million)	738.55	719.00	645.63	583.10	530.25	484.35
Value of Cap (RMB: million)	77.80	77.18	77.48	76.24	76.69	75.39
IRR (%)	11.00	12.00	13.00	14.00	14.18	
Transfer Price (RMB: million)	444.66	410.36	380.50	354.35	350.00	
Value of Cap (RMB: million)	74.65	75.16	75.58	75.30	75.38	

Table 7.10: Value of Cap at different Transfer Prices

IRR (%)	5.76	6.00	7.00	8.00	9.00	10.00
Tariff (RMB/m ³)	0.688	0.696	0.730	0.765	0.800	0.837
Value of Cap (RMB: million)	46.40	47.40	50.71	53.39	57.07	59.66
IRR (%)	11.00	12.00	13.00	14.00	14.18	
Tariff (RMB/m ³)	0.875	0.914	0.953	0.993	1.000	
Value of Cap (RMB: million)	63.05	67.33	70.78	73.47	75.38	

Table 7.11: Value of Cap at different Tariff Rates

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Table 7.10 and 7.11 shows that the value of the cap is quite large – in some cases it even constitutes more than 20% of the initial transfer price. Compared to the value of guarantee, the value of the cap is far more significant and comparatively the option owned by the government (the cap) seems to be much more valuable than the option owned by the concessionaire (the guarantee). Table 7.12 and 7.13 illustrate the sensitivity analyses for the value of the cap subjected to variations in the “capped normal” level in the range of $\pm$ (10%-30%). Note that unlike the case for guarantee, the value of cap decreases when the “capped normal” level increases. This is expected since in this case the cap is a call option rather than a put option. When the “capped normal” level increases, the call option will become increasingly “out-of-the-money”. Compared with the case of guarantee, it is noticed that the decrease in value of the cap behaves in a more regular manner (i.e. more linear) with the percentage increase in the “capped normal” level.

Value of Cap (RMB: million)		“Capped Normal” Level						
		-30%	-20%	-10%	0%	+10%	+20%	+30%
IRR (%)	Transfer Price (RMB: million)							
5.76	738.55	106.74	94.87	86.69	77.80	68.93	60.32	55.00
6.0	719.00	102.06	96.52	86.86	77.18	69.28	61.12	69.18
7.0	645.63	102.93	94.35	86.91	77.48	69.03	58.95	54.58
8.0	583.10	102.52	93.76	84.78	76.24	67.47	57.66	54.31
9.0	530.25	104.24	91.94	84.37	76.69	68.53	61.65	52.71
10.0	484.35	100.42	90.91	82.34	75.39	67.45	59.93	51.33
11.0	444.66	98.94	90.38	85.18	74.65	67.92	57.98	51.55
12.0	410.36	99.30	92.34	83.83	75.16	66.66	56.81	50.35
13.0	380.50	101.45	90.02	84.62	75.58	67.13	57.59	52.77
14.0	354.35	99.01	91.79	82.67	75.30	67.40	57.15	51.29
14.18	350.00	101.00	92.57	83.64	75.38	64.54	59.38	49.95

Table 7.12: Sensitivity of Value of Cap to the “Capped Normal” Level
at different Transfer Prices

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Value of Cap (RMB: million)		“Capped Normal” Level						
		-30%	-20%	-10%	0%	+10%	20%	+30%
IRR (%)	Tariff (RMB/m ³)							
5.76	0.688	62.07	56.44	52.21	46.40	41.22	36.87	28.76
6.0	0.696	63.80	58.40	51.69	47.40	41.96	36.58	30.33
7.0	0.730	65.78	61.63	57.17	50.71	43.80	42.01	32.38
8.0	0.765	70.97	66.39	58.38	53.39	44.53	41.26	36.78
9.0	0.800	75.52	69.40	64.95	57.07	48.89	46.04	41.05
10.0	0.837	79.96	73.83	68.16	59.66	51.39	47.03	37.85
11.0	0.875	84.60	77.94	70.50	63.05	51.99	50.18	42.30
12.0	0.914	87.52	79.40	77.09	67.33	55.05	52.37	44.56
13.0	0.953	94.59	85.29	76.43	70.78	57.28	54.14	51.04
14.0	0.993	99.47	91.02	83.06	73.47	62.12	58.15	51.23
14.18	1.000	101.00	93.82	84.85	75.38	66.57	59.55	48.60

Table 7.13: Sensitivity of Value of Cap to the “Capped Normal” Level at different Tariff Rates

3. Abandonment

As mentioned previously, since the equipment must be renewed in the 13th year, the concession can be divided into two phases: a 12-year operation followed by a second 13-year operation. From the basic cash flow model, asset values of the two separate phases can be computed quite conveniently. As a matter of fact, the value of the 12-year operating phase is almost certain to have a negative value, since this operating period is too short to allow for a full payback of the initial investment incurred. Thus, if the value of the subsequent 13-year operation with reinvestment is also negative when the project is evaluated at the end of year 12, the project should be abandoned. This option avoids a greater loss from the viewpoint of the investor.

The abandonment option is evaluated by using a binomial tree model and assuming a risk-neutral world as subsequently shown in Figure 7.7 and Figure 7.8. Since the

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initial investment incurred in Year 1 is much larger than the amount of reinvestment in Year 13, the exercise price in this case cannot be simply taken as the amount of reinvestment in Year 13. Rather, the decision of whether to reinvest (in order to continue with the operation) would be based on the asset value of both phases less all the investments made. If the asset value of both phases are larger than all the investments made (i.e., the project will generate a positive return), it will make sense to continue with operation in Year 13. Otherwise, the project should be abandoned.

To evaluate the abandonment option, the underlying asset value is the sum of both phases ($S = S_I + S_{II}$); the exercise price would be the sum of both investments in the first and the second phase, $K = [e^{r_f \times 12} \times \text{CAPEX}(I)] + \text{CAPEX}(II)$. The up- and down- factors (u and d) and the associated risk-neutral probabilities (Π_u & Π_d) can be computed as follows:

$$u = e^{\sigma\sqrt{t}} = e^{0.2170 \times \sqrt{1}} = 1.2423$$

$$d = e^{-\sigma\sqrt{t}} = e^{-0.2170 \times \sqrt{1}} = 0.8049$$

$$\Pi_u = \frac{e^{r_f} - d}{u - d} = \frac{e^{0.0444} - 0.8049}{1.2423 - 0.8049} = 0.5498$$

$$\Pi_d = \frac{-e^{r_f} + u}{u - d} = \frac{-e^{0.0444} + 1.2423}{1.2423 - 0.8049} = 0.4502$$

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Figure 7.7: Binomial Tree of Asset Value

The model for the value of the project embedded with abandonment option would be:

Figure 7.8: Binomial Tree of Project Value with Option

The value of abandonment option is simply the difference between the value V in Figure 7.8 and the basic net present value of the project without option. However, throughout the evaluation for this project, the discount rate is set to be equal to the

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respective IRR for each scenario; therefore the basic NPV is technically equal to 0. In short, the value of the abandonment option in this case would be simply equal to the value V in Figure 7.8:

$$V_{\text{opt}} = V - \text{NPV} = V - 0 = V \text{ (in Figure 7.8)}$$

Table 7.14 and 7.15 present the different option values of abandonment for each bidding condition. It can be concluded that the value of abandonment for both bidding scenarios are large compared with the investments made in the project, which suggests that it is important to re-evaluate the economic feasibility of the project as it proceeds along various phases.

IRR (%)	5.76	6.00	7.00	8.00	9.00	10.00
Investment (RMB: million)	738.55	719.00	645.63	583.10	530.25	484.35
Abandonment Option (RMB: million)	231.46	224.74	199.40	177.68	159.18	143.06
IRR (%)	11.00	12.00	13.00	14.00	14.18	
Investment (RMB: million)	444.66	410.36	380.50	354.35	350.00	
Abandonment Option (RMB: million)	129.05	116.88	106.25	96.91	95.35	

Table 7.14: Value of Abandonment Option at different Transfer Prices

IRR (%)	5.76	6.00	7.00	8.00	9.00	10.00
Tariff (RMB/m ³)	0.688	0.696	0.730	0.765	0.800	0.837
Abandonment (RMB: million)	117.75	116.74	112.83	109.41	106.44	103.74
IRR (%)	11.00	12.00	13.00	14.00	14.18	
Tariff (RMB/m ³)	0.875	0.914	0.953	0.993	1.000	
Abandonment (RMB: million)	101.36	99.22	97.33	95.63	95.35	

Table 7.15: Value of Abandonment Option at different Tariff Rates

7.6 Negotiation Band

Since there are two possible bidding scenarios, both parties, CDG and the concessionaire, could reach an agreement on the transfer price or the tariff level. With the results of the option analysis, the values of guarantee and cap could in principle be taken into consideration by both parties during the course of negotiation. Since the value of the project is different to both parties after considering the values of these options, a negotiation range exists between the two parties.

The guarantee provided by the government adds value to the concessionaire's position. In Scenario 1, the maximum transfer price (with a fixed normal tariff evaluated at different values of IRR), which the concessionaire is willing to pay, should then increase by the value of guarantee: $[I_0 + \text{Guarantee Value}]$. On the other hand, the cap structure brings savings to CDG when the treatment volume exceeds the "capped normal" level. In this way, CDG should be willing to accept a lower transfer price, which is $[I_0 - \text{Cap Value}]$. The inclusion of these two options with the initial transfer price is summarized in Table 7.16. Graphically, the shaded area between the two lines in Figure 7.9 thus represents a "negotiation band" that marks the range that is acceptable to both parties in order to arrive at a mutually agreed value for the transfer price. In addition, from the previous sensitivity analyses, both the levels set for the minimum guaranteed volume and the capped normal volume have great impact on the value of the guarantee and the cap. Both parties should also negotiate on these two levels that essentially represent the "exercise volume" for the two options.

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IRR (%)	5.76	6.00	7.00	8.00	9.00	10.00
Transfer Price, I_0 (million)	738.55	719.00	645.63	583.10	530.25	484.35
$I_0 + G$	741.65	721.96	648.92	586.05	533.05	486.78
$I_0 - C$	660.75	641.82	568.15	506.86	453.56	408.96
IRR (%)	11.00	12.00	13.00	14.00	14.18	
Transfer Price, I_0 (million)	444.66	410.36	380.50	354.35	350.00	
$I_0 + G$	447.04	412.62	382.91	356.72	352.55	
$I_0 - C$	370.01	335.2	304.92	279.05	274.62	

Table 7.16: Range of Feasible Transfer Prices with the Inclusion of Guarantee and Cap

Figure 7.9: Negotiation Band of Initial Transfer Price (with a fixed normal tariff)

In Scenario 2, various tariff rates are determined for different internal rates of return with a fixed transfer price I_0 of RMB 350 million. At each tariff level T , the guarantee option would add value G to the concessionaire, and the effective transfer price that the concessionaire is actually paying is $[I_0 - G]$. To compensate for the value of guarantee that has been given away, CDG may negotiate for a lower normal tariff level T_g . In other words, the difference in net present values based on T and T_g should be equal to the value of the guarantee in order to strike an equitable balance. T_g can be solved using Equation (7.6), which is a modified form of Equation (7.1), by setting

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NPV = 0 in the equation (and using the “Goal Seek” function for the respective IRR values).

$$NPV = \sum_{i=1}^n \frac{FCF_i}{(1 + IRR)^i} - (I_0 - G) \quad (7.6)$$

In Equation (7.6), I_0 is the fixed transfer price of RMB 350 million, G is the guarantee value, and FCF_i is a function of tariff, T_g . The lower tariff levels have been computed and summarized as follows:

IRR (%)	5.76	6.00	7.00	8.00	9.00	10.00
Original Tariff, T (RMB/m ³)	0.688	0.696	0.730	0.765	0.800	0.837
Modified Tariff, T _g	0.686	0.694	0.727	0.762	0.798	0.835
IRR (%)	11.00	12.00	13.00	14.00	14.18	
Original Tariff, T (RMB/m ³)	0.875	0.914	0.953	0.993	1.000	
Modified Tariff, T _g	0.872	0.911	0.950	0.990	0.996	

Table 7.17 Modified Tariff to Compensate for the Guarantee

On the other hand, the cap would reduce the project value to the concessionaire and the concessionaire is paying for an effective transfer price of $[I_0 + C]$. To compensate for this higher effective transfer price, the concessionaire would ask for a higher normal tariff to make up for the value given away by the cap. Similar to the case above, the modified tariff, T_c , can be solved through Equation (7.7):

$$NPV = \sum_{i=1}^n \frac{FCF_i}{(1 + IRR)^i} - (I_0 + C) \quad (7.7)$$

A similar procedure is followed and the higher tariff levels have been determined and summarized in Table 7.18:

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IRR (%)	5.76	6.00	7.00	8.00	9.00	10.00
Original Tariff, T (RMB/m ³)	0.688	0.696	0.730	0.765	0.800	0.837
Modified Tariff, T _c	0.725	0.735	0.776	0.818	0.864	0.910
IRR (%)	11.00	12.00	13.00	14.00	14.18	
Original Tariff, T (RMB/m ³)	0.875	0.914	0.953	0.993	1.000	
Modified Tariff, T _c	0.958	1.010	1.062	1.114	1.126	

Table 7.18 Modified Tariff to Compensate for the Cap

Combining the results of Table 7.17 and Table 7.18, Figure 7.10 can be constructed. The two lines represent the lower tariff, T_g, and the higher tariff, T_c respectively. The shaded area between the two lines would represent the negotiation band that provides the range for a mutually acceptable tariff rate.

Figure 7.10: Negotiation Band of Normal Tariff Rate (with a fixed transfer price)

7.7 Risk Comparison between the Two Bidding Scenarios

Evidently, in each of the two bidding scenarios, the transfer price is related to the tariff level. In fact, when all the real options are not considered, there is actually no

difference between the two scenarios, since each of them is evaluated using the same required rate of return!

However, according to the evaluation results of NPV analysis (Section 7.5.2), Scenario 1 (with fixed tariffs) generally produces a higher transfer price for the range of IRR considered (see Table 7.3: All values are > RMB 350 million). Following the line of thought of real option, this is undesirable – once the concessionaire has invested in the project based on Scenario 1, it would have already incurred a higher sunk cost as the transfer price in the project cannot be recovered. In addition, the asset value may be affected by other uncertainties during the operation stage. For instance, Scenario 1 has a fixed tariff that is higher than that in Scenario 2 (see Table 7.4: All tariff levels are less than the rate of RMB 1.00/m³ of Scenario 1). A higher tariff level would imply a higher level of obligation on the part of the government, which may turn out to be a fiscal burden to the government. This then creates a higher probability that the government would default on its payment or otherwise call for re-negotiation utilizing its strong political clout. In short, considering all these factors, Scenario 1 is deemed to impose a higher risk to the concessionaire.

7.8 Summary

During the course of economic development in China, there is a need to perform capital restructuring of state-owned enterprises, especially in the public service infrastructure domain. This measure has been suggested as an effective way to propel the economy. There are many ways that private investors can cooperate with the government. Successful cooperation then requires a fair negotiation among the parties involved.

This chapter analyzes the risks and options embedded in a wastewater treatment plant project transacted on a TOT basis. To attract private sector's interest, the government

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has introduced some favorable policies into the deal, such as a guarantee on the lowest treatment volume (which translates into a guaranteed lowest revenue) of the project to the concessionaire. At the same time, the government has set a “capped normal” level on the volume, above which a discounted rate of tariff is applied. This effectively places a cap on the level of return of the concessionaire, which represents a call option given to the government (since the government could “call” for the discount when volume exceeds the threshold).

In the analysis of this case, application of Monte Carlo simulation in conjunction with a basic cash flow model again proves to be straightforward and useful to evaluate the two options: the guarantee and the cap. An abandonment option is also created on the basis of the reinvestment structure and is evaluated with the typical binomial tree model of real option theory. With the results of the evaluation, negotiation bands for the initial transfer price and the normal tariff level are constructed, which represent a feasible range for the parameters. This would help to facilitate a fair negotiation exercise between the two parties.

CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS

The last chapter first summarizes the common types of options identified in the short cases and the three major case studies. Based on the literature review and results of case analyses, a holistic risk management framework that incorporates the real option concept is induced. Issues on real option modeling are discussed next, focusing in particular practical implementation that suits the context of construction and infrastructure projects. A negotiation setting between parties involved in a project is also developed. Finally, the chapter closes with some recommendations for further research.

8.1 Common Types of Options in PPP/PFI Projects

Since 1970s, privatization has been recognized as an approach to solve the difficulty of funding large scale public projects, which have and would continue to play an important role in the development of economy around the world. PPP/PFI is one of the most popular procurement methods adopted. With this procurement method, government will not provide funding (except indirect guarantees and support) for public works. Instead, through the PPP/PFI scheme, government has become one of the major participants involved in infrastructure systems along with the private sector.

Since PPP/PFI projects are highly risky, it is important to manage the risks involved. The existing risk management strategies are based on the evaluation of traditional discount cash flow methods (DCF), which ignore managerial flexibilities in the management process. This research has investigated the application of real option in PPP/PFI projects through short and three major case studies. The case analyses in this research indicate that some option strategies can be designed to manage risks in a project in a proactive approach. As a result, options are embedded or can be created in the project. In the literature review, Section 2.3.4 described some options that are commonly found in other industries. Some of these options are also similarly found in large infrastructure projects studied in this research. These are summarized here:

Call options: Generally, large scale infrastructure projects can be split into two or more phases. This has been found in the case of the Dabhol Power Plant project and should have been introduced into the case of the Malaysia-Singapore Second Crossing as discussed in Chapter 6, whereby execution of the latter phase would be contingent on the success of the former.

Put options: During the execution of a project, in a downside scenario, the manager may own a put option of reducing the capacity of a project, or shutdown/sell the assets

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to avoid great losses. Alternatively, the government might provide guarantees against downside risks, which is indeed a form of put option. These scenarios have been reflected in all the three major case studies.

Switching options: During the development of a project, there are bound to be factors that will vary and affect the value of a project. For example, the cost of raw materials of a plant would fluctuate. The strategy is to design an operation that can take alternative kinds of input resources, as exemplified by the Dabhol Power Plant case: naphtha was chosen as the alternative fuel to gas. Another example is found in the case of Rocksavage Power Plant. These kinds of strategies create switching options for the project.

Timing option: Generally, to avoid downside risks, investors might want to wait and develop a project later, or even give up the investment. This was illustrated as an abandonment option in the case of Indiantown Cogeneration project.

Compound options: In some projects, two or more options can exist concurrently and mutually influence the chances of being exercised. The compound option refers to a combination of two or more type of options. For example, a project split into multiple phases would imply a “sequential call option” such as the combination of expansion option and switching option in Dabhol Power Plant. The interactions among various types of options impose greater complexity in evaluation as the total value is usually not a simple sum of the parts.

Learning option: Some projects are pilot projects that are developed without much precedence or enough experience in terms of policy and technology. Under this scenario, the pilot projects are adopted simply as a learning ground or part of a larger strategic plan to pursue future goals. For example, in its entirety, a pilot project in a politically unstable or less developed country is a learning option for a corporation to explore future business opportunities in the country. The Dabhol Power Plant project

essentially provided a learning option to Enron for its future ventures in India. Section 4.3.5 has also described a new design and construction approach for multiple plants by staggering the execution timing, thereby creating a learning option.

8.2 An Integrated Real Options-Risk Management Framework

8.2.1 Toward a New Risk Management Process

Risks exist throughout all stages of a privately financed infrastructure project. A successful privately financed infrastructure project largely depends on the ability to manage risks that exist in all stages by the parties involved in the project. Standard risk management processes follows three typical steps: risks identification, risks measurement, and risk mitigation. Generally, the methods of risk mitigation include avoidance, reduction, shifting or transfer, and retention. Although these four strategies could help manage uncertainty and can effectively reduce the negative effects of uncertainty, they presume certain degree of losses (e.g., see Mak and Picken, 2000).

As a matter of fact, the conventional approaches limit managers' ability to recognize and exploit opportunities to increase project value. The analysis of the short cases and three major cases provided different strategies under related risks. These strategies helped the managers to increase the value of their projects. Therefore, it is necessary to develop a risk management framework which considers the flexibility of management.

Figure 8.1: A New Risk Management Process in Infrastructure Project

Figure 8.1 shows a new risk management process which incorporate the real option theory. The process includes risk identification and subsequent design of risk mitigation strategies. As analyzed previously, since real option is a better method to evaluate a project than NPV and it can enhance the value of a project, the process will adopt this as the first approach to manage risks. In this process, parties who are willing to assume total or partial risks will take an option approach to shape and manage the risks. However, this option approach could only shape and mitigate certain risks; there are other residual risks that cannot be managed well by this way. On the other hand, it will be helpful to realize the complementary nature of other conventional risk mitigation strategies in view of these residual risks that cannot be handled by the real option approach. As shown in the figure, these residual risks

would filter through the option strategies. Together with those risks that are not assumed by the sponsor in the first place, all these will be managed by traditional risk mitigation strategies: avoidance, reduction and transfer. Combining the two types of risk management thinking (real option and conventional), the new process should lead to a more proactive approach in totality.

In Figure 8.1, risk identification forms the first step in this new risk management process. In this framework, the risks are indeed classified in a new form according to the nature of options. This will be described next in Section 8.2.2.

8.2.2 Risk Classification in a PPP/PFI Project

In Figure 8.1, a logical starting point of risk management is the identification of potential risks before taking measures to mitigate the effects of these risks. Risks associated with privately financed projects can be identified by investigating risk events that appear throughout different stages of project development or by investigating the sources of these risks. This leads to various approaches of risk identification. The most common approach is the checklist approach. Chapter 2 has reviewed risk classification schemes that were developed by Li et al. (2005) and Wang and Tiong (2000). In Chapter 4, Table 4.1, 4.2, 4.3 and 4.4, this researcher has also developed his own checklists based on the general and specific risk categorization approach. Therefore, armed with all these reviews and findings, a holistic approach is adopted in this section to classify risks together with the stages that these options can be found in a project life cycle.

According to real option theory, there are five main parameters in an option model, among which the nature of timing or maturity of option is an important parameter to determine. In a financial option model, maturity is a parameter which is fixed by contract; but in a real option model, it is under the control of the option owner — the

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owner will take action according to his ongoing exposure to risks that changes along the way as the project proceeds. As a matter of fact, risks in a project will vary according to their nature and stages within which they are embedded. For instance, the completion risk of construction will occur in the construction stage. This timing characteristic matches the timing nature of real option. Therefore, it is natural to classify risks according to various stages of the project life cycle.

According to the key functions of a project, its life cycle can be generally divided into three stages: initial stage, execution stage and the stage of facility in service. In the initial stage, the search of opportunities, feasibility studies, and planning and design of a project are conducted. These three functions play an exploratory role and also form and shape the scope of project. The study of risks at this stage also lays a solid foundation for a project. During the execution stage, key functions mainly focus on the construction and installation of the facility. This process is so complex that many risks and uncertainties are involved. Moreover, it is time critical; therefore capital expenditures and construction costs are big ticket items in this stage. The stage of facility in service includes: operation and maintenance of the project and subsequent project upgrading. In a PPP/PFI project, this stage is a key process from which revenue and returns are recouped. The risks vary broadly in this stage (e.g. including market, currency exchange, inflation etc.) and the financial condition of the project is highly subjected to successful management of these risks.

Table 8.1 presents a checklist constructed by the author for some of the major risks that can be found in different stages of the project life cycle. Table 8.2 matches relevant risks and options with the profile of these various stages of the project life cycle.

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Stages	Risks/Uncertainties	General risk (G) or Specific risk (S)
Initial	• Delay in project approval and permits	G
	• Design deficiency	G
	• Availability of Finance	G
	• Increase in financing cost	G
	• No experience of PPP/PFI projects	G
	• Public opposition to project	G
Execution	• Land acquisition and compensation	G
	• Geotechnical condition	G
	• Construction cost overrun	G
	• Construction time delay	G
	• Quality of construction	G
	• Variation in scope	G
	• Default by concession company, contractor, or government	G
	• Environmental damage	G
	• Restriction on import equipment/materials	S
	• Force majeure	G
Facility in Service	• Demand risk	S
	• Fluctuation of supply	S
	• Government restriction on profit and tariff	G
	• Operation cost overrun	S
	• Inflation	G
	• Foreign currency exchange rate	G
	• Changes in law	G
	• Payment failure by government	G
	• Termination by government	G
	• Government's adverse action or inaction	G
	• Labor risk	S
	• Technology risk	S
	• Condition of facility	S
	• Force majeure	G

Table 8.1: Checklist of Risks in different Stages of Project Life Cycle

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Stages of Project Life Cycle			
	Initial	Execution	Facility In Service
Key functions	<ul style="list-style-type: none"> • Search of opportunities • Feasibility studies • Planning and design 	<ul style="list-style-type: none"> • Construction of facility • Installation of services 	<ul style="list-style-type: none"> • Operation • Maintenance • Upgrading
Nature of each stage	<ul style="list-style-type: none"> • Exploratory • Shaping 	<ul style="list-style-type: none"> • Time-critical • Expediting 	<ul style="list-style-type: none"> • “Moment of truth” • Adapting to reality
Level of commitment / investment / sunk cost	Low – especially when planning incurs relatively lower cost compared to other stages	High – capital expenditures and construction costs are big ticket items	Varies – costs are tied to future expansion plan, switching costs, deterioration rate etc.
Degree of freedom to incorporate options / flexibility	High	Moderate	Low
Most relevant types of options	<div> <div>Operating</div> <ul style="list-style-type: none"> • Deferment • Abandonment </div>	<ul style="list-style-type: none"> • Abandonment 	<ul style="list-style-type: none"> • Expansion / Contraction • Switching • Abandonment
	<div> <div>Non-operating</div> <ul style="list-style-type: none"> • Learning </div>	<ul style="list-style-type: none"> • Learning 	<ul style="list-style-type: none"> • Restructuring • Learning
Value of options	<p>Highest</p> <ul style="list-style-type: none"> • Uncertainty and turbulence elevate the value of flexibility • Time-to-maturity of option is still distant 	<p>Lowest</p> <ul style="list-style-type: none"> • Many uncertainties have unraveled • More constraints have taken root with facilities in place 	

Table 8.2: Matching Profile of Options to Stages of Project Life Cycle

8.3 Option Modeling

As analyzed in the literature review and case studies, there are many ways to model and evaluate real options. By broadly categorizing models into continuous-time and discrete-time, Garvin and Cheah (2004) commented on the merits and challenges of applying each of them to the context of infrastructure projects. Borison (2003) also categorized the different real option approaches based on their assumptions made and the mechanics involved.

In continuous-time modeling of options, the usual way is to assume a given stochastic process for the underlying asset value, and then derive and solve an appropriate partial differential equation (PDE). This modeling framework also requires specifications of the necessary boundary conditions and constraints. When a project has more complex feature, the modeling modifications required can lead to highly complicated PDEs, or it may even be difficult to determine PDEs that can represent the underlying stochastic processes. Even after constructing a PDE, problem remains with solving the PDE to derive numerical solutions for the parameter of interest. When closed form solutions are available, the resulting PDEs may be solved directly. However, more often than not in PPP/PFI projects, analytical solutions do not exist and numerical approximation techniques are required. In fact, the binomial model can be thought of as one of the numerical approximation techniques in the limit.

A prominent example of continuous-time models is the Black-Scholes equation. Modifications of the basic form of the Black-Scholes equation have also been developed. For many opportunities with non-standard features, the Black-Scholes equation or its modified forms are usually too restrictive to represent the features of a project (Kemna, 1993; Sachdeva and Vandenberg, 1993, Teisberg, 1995).

In this research, discrete-time models are adopted in the analyses of options identified

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in the major cases. Generally, a project is analyzed using spreadsheets constructed for cash flow models. The data contained cannot be captured completely by a single PDE in continuous-time modeling. By using a discrete-time model such as the binomial tree, options in the major cases are evaluated. These include the expansion option, abandonment option, timing (extension) option and switching option in the Dabhol Power Plant project and the expansion option in the Malaysia-Singapore Second Crossing case. As the results demonstrate, given reasonable and appropriate assumptions, discrete-time models can evaluate these options sufficiently. In fact, these lattice models are more intuitive than continuous-time models and they require less mathematical background and skills to develop and implement – an attribute that is more appealing to construction professionals and analysts who might not be familiar with option pricing concepts.

However, one of the limitations of using a binomial tree model is that since it is a discrete-time model, the number of nodes can grow exponentially to improve accuracy and convergence of value as the number of time steps increases.

Monte Carlo simulation is another approach that has been used in this research to evaluate options. Binomial tree model requires definite parameters of the option. However, some parameters of options cannot be determined in a straightforward manner. The exercise conditions of the guarantee options in the last two major case studies illustrate this. In the Malaysia-Singapore Second Crossing, the guarantee option written by the government might be exercised in any years provided there is a shortfall of traffic volume. In other words, the maturity periods of the guarantee options are not fixed and it would be difficult to use a binomial tree model to evaluate these multiple options. On the other hand, these multiple exercise conditions can be built into the spreadsheet model together with the factors of uncertainties with their specific distributions. The value of the option can then be generated by simulating numerous values for the risk factors. This approach was proven to be adequate in the analysis of the Malaysia-Singapore Second Crossing case and the Wastewater

Treatment Plant project. In addition, Monte Carlo simulation can be used when two or more risk factors influence the value of an option – what needs to be done is just to define their correlations.

Finally, sensitivity analysis, though simple and common, remains an important tool in augmenting real option analysis. In the evaluation of options, the variables determined are important and critical to the resulting value of the options. For instance, sensitivity analyses of the initial traffic volume and growth rate in the Malaysia-Singapore Second Crossing case, and the guaranteed volume and “capped normal level” in the Wastewater Treatment Plant project, confirm that variations of these factors have great influence on the results of options. Sensitivity analysis assist all parties involved in getting a feel of the feasible range of values and thereby making a better judgment.

8.4 Real Option and Negotiation

In the context of a PPP/PFI project, the implication of valuation on negotiation can be illustrated using a general case in Figure 8.2. The figure summarizes hypothetical positions of a service provider and a government agency that is going to enter into an off-take contract. The overall contractual package may include arrangements such as a guaranteed minimum return, a right of access to build plants in an adjacent state, and others. The tariff level, subject to negotiation, would translate into a certain level of benefits to both parties (e.g. commercial profits to the producer; social benefits to the local community). Note that the positive and negative slopes of the lines are consistent with the positions of the producer and the government respectively. Given the initial scenario (bold lines), there would be no feasible negotiating range, as the government would not accept a tariff level higher than y , while the producer is unwilling to construct and run the plant if the tariff level is lower than z . If the value of concessions and guarantees in the support package are properly accounted for, the producer, having priced in such additional value, may be willing to accept a lower

tariff level at x (dashed line). For the producer, the vertical distance between the dashed and the bold line effectively represents the benefits of having such concessions and guarantees. This in turn creates a feasible negotiating range of $(y - x)$ and a win-win situation – since both parties would enjoy positive benefits. The project would have avoided cancellation simply due to a negotiation breakdown when individual parties focus solely on risks and not properly factoring the value of the support package into consideration. Obviously, on the flipped side of the argument, a party that is granting too many concessions should be alert to exploitation, since its true position really reflects a lower level of return when the value of the concessions granted are taken into account.

Figure 8.2: Impact of Priced Options on Negotiation

In a negotiation setting, the determination of factors such as x and y is important since it will influence the feasible bargaining range. Generally, to optimize the benefit or the ability to make money of a large scale infrastructure project, the private sector will ask for support from government in some forms such as guarantee on the level of IRR of the project. For instance, in Dabhol Power Plant, the government provided a guarantee that the project would generate an IRR of equity of 16%; in Malaysia-Singapore Second Crossing, the government granted a guarantee on the

projected revenue in each year, which ultimately worked back to a certain IRR.

It is also interesting to note and conclude that with a predetermined value of IRR, the concessionaire would normally negotiate only on one variable, such as the tariff rate for power (as in the Dabhol case) or the toll rates for traffic. However, in the Wastewater Treatment Plant project, the government effectively introduced a different tender setting, in which the concessionaire can bid either on the initial transfer price of the plant or the tariff for the normal volume of treated water. When there are two tender parameters, the value of IRR can essentially take up a wider range, as can be seen in the analysis throughout the third major case study. Thus, both parties, the government and concessionaire, could estimate the transfer price and tariff for a series of IRR under the uncertainty factor, the volume of treatment. As shown in Figure 7.9 and 7.10, this tender setting would create a range of IRR that broadens the negotiation context for the parties involved, and there is more room for making the deal economically feasible to both parties.

Finally, even when two bidding scenarios have the same IRR or NPV under the conventional DCF analysis, the “riskiness” of two scenarios may not be similar in the eyes of real option. In the Wastewater Treatment Plant project, there are two bidding scenarios designed in the document. As commented in Section 7.7, given the same IRR, Scenario 1 has a higher initial transfer price and higher normal tariff while Scenario 2 has a lower initial transfer price and lower normal tariff (Table 8.3). From the real option standpoint, the concessionaire actually owns the right to abandon the project in the form of an American option when the plant is in operation. Comparing the two scenarios, the concessionaire would be less likely to abandon the project in Scenario 1 since the normal tariff is higher (it should be realized that the normal tariff is related to the asset value of the plant. A higher asset value will drive the abandonment option “out-of-the-money”). As a result, the government would likely to prefer an outcome of Scenario 1. Furthermore, it can collect a higher initial transfer price in Scenario 1.

Bidding Scenario (from Section 7.7)	Initial Transfer Price (Concessionaire to Government)	Normal Tariff (Government to Concessionaire)
1	High	High
2	Low	Low

Table 8.3: Comparison of Initial Transfer Price and Normal Tariff for both Scenarios

8.5 Recommendations for Future Research

Obviously, this research represents only an incremental step towards closing the gap of applying real option between the architecture, engineering and construction-infrastructure sector and other industries. Inevitably, there are limitations to this research and the author prompts further investigations into the following areas:

- Since this research adopts the case study approach, naturally it is limited by the number of cases available to fortify the findings gathered. The study of real option in the context of construction and infrastructure systems is still in its infancy. Due to the characteristics of cases, this research only analyzes the risks that have been identified by the author in those cases. More case studies should be built up in order to identify: (1) preferred methods to model other different types of options; (2) design and confirm execution strategies that have higher chances of being applied successfully in line with the real option thinking.
- On the technical side, the interaction between multiple sequential and concurrent options remains mathematically challenging. In the major case studies, each of the options identified is evaluated separately. In reality, the options may interact with each other. For instance, the exercise of one option may be contingent upon the status of another option, which together influences the final value. This serves as another possible direction for future research.

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- In real option model, the volatility parameter is one of the most important parameters. In evaluation of infrastructure projects, it is notoriously difficult to estimate, and this depends on the type of projects. For power projects, proxies may be available from traded prices of fuel sources and electricity; for toll roads and water or wastewater projects, it is harder to find proxies from the market since volume and charges of traffic/water/wastewater are influenced by many factors. For all pragmatic purposes, some assumptions are inevitable, but realistic assumptions only come about when more future studies of these types of projects are conducted.
- In a way, the analysis in Section 7.6 would suggest that option evaluation is meaningful to the design of negotiation setting only when the options are quantifiable in the first place. Yet, as suggested by Table 5.1 in the Dabhol Power Plant case, there are other options (e.g. learning option, growth option) that are hardly quantifiable unless supplemented with plenty of loose assumptions (which in turn renders such quantification valueless). Although these “hard-to-quantify” options are less useful in the context of negotiation, they are significant in the context of strategic planning. The study of interactions among corporate strategy, project management and real option will be a bright area for future research.

Author's Publication

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APPENDIX I

Appendix I-01 — Appendix I-12:

Cash Flows and Quantitative Models related to Major Case Study I:

Dabhol Power Plant in India

Appendix I - 01: Breakdown of Project Power Cost to MSED (Phase I: cents/KwH)

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Fixed O&M	0.56	0.58	0.61	0.63	0.66	0.68	0.71	0.74	0.77	0.80	0.83	0.86	0.90	0.93	0.97	1.01	1.05	1.09	1.13	1.18
Debt Service	0.37	0.38	0.40	0.42	0.43	0.45	0.47	0.49	0.51	0.53	0.55	0.57	0.59	0.62	0.64	0.67	0.69	0.72	0.75	0.78
Capital Recovery Charge	2.55	2.65	2.76	2.87	2.98	3.10	3.23	3.36	3.49	3.63	3.77	3.93	4.08	4.25	4.42	4.59	4.78	4.97	5.17	5.37
Total Capacity payment	3.48	3.62	3.76	3.91	4.07	4.23	4.40	4.58	4.76	4.95	5.15	5.36	5.57	5.79	6.03	6.27	6.52	6.78	7.05	7.33
Variable O&M Fee	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Fuel Management Fee	0.10	0.10	0.11	0.11	0.12	0.12	0.13	0.13	0.14	0.14	0.15	0.15	0.16	0.17	0.17	0.18	0.19	0.19	0.20	0.21
Gas Price	3.45	3.57	3.70	3.83	3.96	4.10	4.24	4.39	4.54	4.70	4.87	5.04	5.21	5.40	5.58	5.78	5.98	6.19	6.41	6.63
Total Energy Payment	3.57	3.70	3.83	3.96	4.10	4.24	4.39	4.55	4.71	4.87	5.04	5.22	5.41	5.60	5.79	6.00	6.21	6.43	6.65	6.89
Total Tariff Payment	7.05	7.31	7.59	7.87	8.17	8.48	8.80	9.13	9.47	9.83	10.20	10.58	10.98	11.39	11.82	12.26	12.72	13.20	13.70	14.22

APPENDIX I

Appendix I - 02: Debt Service (Phase I) (US\$: Million)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Us Ex-Im Bank (298)			298.00	272.58	245.03	215.16	182.78	147.69	109.64	68.40	23.70	0.00			
Annual Payment				50.45	50.45	50.45	50.45	50.45	50.45	50.45	50.45	23.70			
Interest				25.03	22.90	20.58	18.07	15.35	12.41	9.21	5.75	1.00			
Principle				25.42	27.55	29.87	32.38	35.10	38.04	41.24	44.70	22.71			
OPIC (100)			100.00	95.32	90.17	84.51	78.28	71.43	63.89	55.60	46.48	36.45	25.41	13.27	0.00
Annual Payment				14.68	14.68	14.68	14.68	14.68	14.68	14.68	14.68	14.68	14.68	14.68	13.27
Interest				10.00	9.53	9.02	8.45	7.83	7.14	6.39	5.56	4.65	3.64	2.54	1.33
Principle				4.68	5.15	5.66	6.23	6.85	7.54	8.29	9.12	10.03	11.04	12.14	11.95
BOA and ABNAMRO Bank(150)			150.00	136.10	120.67	103.54	84.53	63.43	40.01	14.01	0.00				
Annual Payment				30.40	30.40	30.40	30.40	30.40	30.40	30.40	14.01				
Interest				16.50	14.97	13.27	11.39	9.30	6.98	4.40	0.77				
Principle				13.90	15.43	17.13	19.01	21.10	23.42	26.00	13.24				
Sydication of Indian Bank led by IDBI (95)			95.00	90.42	85.03	78.70	71.26	62.52	52.25	40.18	26.01	9.35	0.00		
Annual Payment				21.21	21.21	21.21	21.21	21.21	21.21	21.21	21.21	21.21	9.35		
Interest				16.63	15.82	14.88	13.77	12.47	10.94	9.14	7.03	4.55	0.82		
Principle				4.59	5.39	6.33	7.44	8.74	10.27	12.07	14.18	16.66	8.53		
Total Debt Service				116.74	116.74	116.74	116.74	116.74	116.74	116.74	100.35	59.59	24.03	14.68	13.27

Appendix I- 03: Free Cash Flows to Equity (FCFE) before Negotiation (Phase I) (US\$: Million)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Gross Revenue	0.00	0.00	0.00	407.48	422.84	438.77	455.31	472.48	490.29	508.78	527.97	547.88
Cost	0.00	0.00	0.00	210.04	217.39	225.00	232.88	241.03	249.47	258.20	267.23	276.59
Depreciation	0.00	0.00	0.00	23.05	23.05	23.05	23.05	23.05	23.05	23.05	23.05	23.05
Operation Expenses	0.00	0.00	0.00	35.31	36.72	38.19	39.72	41.31	42.96	44.68	46.47	48.33
EBIT	0.00	0.00	0.00	139.08	145.67	152.53	159.66	167.09	174.81	182.85	191.22	199.92
Tax	0.00	0.00	0.00									
Capital Expenditure	83.70	111.60	83.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Debt Service	0.00	0.00	0.00	116.74	116.74	116.74	116.74	116.74	116.74	116.74	100.35	59.59
Salvage Value												
FCFE	(83.70)	(111.60)	(83.70)	45.39	51.98	58.84	65.97	73.40	81.12	89.16	113.91	163.38
NPV = 174.91 S₁₉₉₃ = 416.70 K₁₉₉₃ = 241.75												

Appendix I-03: Free Cash Flows to Equity (FCFE) before Negotiation (Phase I) (US\$: Million) (Cont.,)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Gross Revenue	568.56	590.01	612.28	635.39	659.37	684.27	710.11	736.93	764.77	793.67	823.66
Cost	286.27	296.29	306.66	317.39	328.50	340.00	351.90	364.21	376.96	390.15	403.81
Depreciation	23.05	23.05	23.05	23.05	23.05	23.05	23.05	23.05	23.05	23.05	23.05
Operation Expenses	50.26	52.27	54.36	56.53	58.80	61.15	63.59	66.14	68.78	71.53	74.40
EBIT	208.98	218.40	228.21	238.41	249.03	260.08	271.57	283.53	295.98	308.93	322.40
Tax		100.47	104.98	109.67	114.55	119.64	124.92	130.43	136.15	142.11	148.31
Capital Expenditure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Debt Service	24.03	14.68	13.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Salvage Value											461.00
FCFE	208.00	126.31	133.01	151.79	157.53	163.49	169.70	176.16	182.88	189.87	658.15

Appendix I - 04: Breakdown of Project Power Cost to MSEB (Phase II: cents/KwH)

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Fixed O&M	0.55	0.57	0.59	0.62	0.64	0.67	0.70	0.72	0.75	0.78	0.81	0.85	0.88	0.92	0.95	0.99	1.03	1.07	1.11	1.16
Debt Service	0.41	0.43	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.61	0.63	0.66	0.68	0.71	0.74	0.77	0.80	0.83	0.86
Capital Recovery Charge	2.79	2.90	3.02	3.14	3.26	3.39	3.53	3.67	3.82	3.97	4.13	4.30	4.47	4.65	4.83	5.02	5.23	5.43	5.65	5.88
Total Capacity payment	3.75	3.90	4.06	4.22	4.39	4.56	4.74	4.93	5.13	5.34	5.55	5.77	6.00	6.24	6.49	6.75	7.02	7.30	7.60	7.90
Variable O&M Fee	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.09	0.09	0.09	0.10	0.10	0.11
Fuel Management Fee	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08
Distillate Price	2.83	2.93	3.03	3.14	3.25	3.36	3.48	3.60	3.73	3.86	3.99	4.13	4.28	4.43	4.58	4.74	4.91	5.08	5.26	5.44
Total Energy Payment	2.92	3.02	3.13	3.24	3.35	3.47	3.59	3.72	3.85	3.99	4.13	4.27	4.42	4.58	4.74	4.90	5.08	5.25	5.44	5.63
Total Tariff Payment	6.67	6.92	7.18	7.46	7.74	8.03	8.34	8.65	8.98	9.32	9.68	10.04	10.42	10.82	11.23	11.66	12.10	12.56	13.04	13.53

Appendix I - 05: Debt Service (Phase II) (US\$: Million)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Jan. and Bel. Ex-Im Bank (654)			654	598.23	537.77	472.23	401.19	324.18	240.70	150.21	52.11	0.00			
Annual Payment				110.71	110.71	110.71	110.71	110.71	110.71	110.71	110.71	52.11			
Interest				54.94	50.25	45.17	39.67	33.70	27.23	20.22	12.62	2.19			
Principle				55.77	60.46	65.54	71.04	77.01	83.48	90.49	98.09	49.92			
OPIC (220)			220	209.71	198.40	185.95	172.25	157.19	140.62	122.40	102.35	80.29	56.04	29.35	0.00
Annual Payment				32.29	32.29	32.29	32.29	32.29	32.29	32.29	32.29	32.29	32.29	32.29	29.35
Interest				22.00	20.97	19.84	18.59	17.23	15.72	14.06	12.24	10.23	8.03	5.60	2.94
Principle				10.29	11.32	12.45	13.69	15.06	16.57	18.23	20.05	22.05	24.26	26.68	26.42
BOA and ABNAMRO Bank(330)			330	299.43	265.49	227.83	186.01	139.60	88.09	30.91	0.00				
Annual Payment				66.87	66.87	66.87	66.87	66.87	66.87	66.87	30.91				
Interest				36.30	32.94	29.20	25.06	20.46	15.36	9.69	1.70				
Principle				30.57	33.93	37.67	41.81	46.41	51.52	57.18	29.21				
Syndication of Indian Bank led by IDBI (210)			210	199.87	187.97	173.98	157.54	138.23	115.54	88.88	57.55	20.74	0.00		
Annual Payment				46.88	46.88	46.88	46.88	46.88	46.88	46.88	46.88	46.88	20.74		
Interest				36.75	34.98	32.89	30.45	27.57	24.19	20.22	15.55	10.07	1.82		
Principle				10.13	11.90	13.99	16.43	19.31	22.69	26.66	31.33	36.81	18.93		
Total Debt Service				256.75	256.75	256.75	256.75	256.75	256.75	256.75	220.78	131.28	53.03	32.29	29.35

Appendix I - 06: Free Cash Flows to Equity (FCFE) before Negotiation (Phase II) (US\$: Million)

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Gross Revenue	0.00	0.00	0.00	787.79	817.72	848.80	881.07	914.57	949.35	985.45	1022.94
Cost	0.00	0.00	0.00	349.55	361.78	374.45	387.55	401.12	415.16	429.69	444.73
Depreciation	0.00	0.00	0.00	46.65	46.65	46.65	46.65	46.65	46.65	46.65	46.65
Operation Expenses	0.00	0.00	0.00	74.11	77.07	80.16	83.36	86.70	90.17	93.77	97.52
EBIT	0.00	0.00	0.00	317.48	332.21	347.55	363.51	380.11	397.38	415.35	434.04
Tax	0.00	0.00	0.00								
Capital Expenditure	135.60	180.80	135.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Debt Service	0.00	0.00	0.00	256.75	256.75	256.75	256.75	256.75	256.75	256.75	220.78
Salvage Value											
FCFE	(135.60)	(180.80)	(135.60)	107.37	122.11	137.45	153.40	170.00	187.28	205.24	259.91
NPV ₁₉₉₃ = 353.87 NPV ₁₉₉₆ = 555.07											
S ₁₉₉₃ = 603.55											
K ₁₉₉₃ = 249.69											

Appendix I - 06: Free Cash Flows to Equity (FCFE) before Negotiation (Phase II) (US\$: Million) (Cont.,)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gross Revenue	1061.85	1102.26	1144.20	1187.75	1232.97	1279.91	1328.65	1379.24	1431.78	1486.32	1542.95	1601.75
Cost	460.29	476.40	493.08	510.33	528.19	546.68	565.82	585.62	606.12	627.33	649.29	672.01
Depreciation	46.65	46.65	46.65	46.65	46.65	46.65	46.65	46.65	46.65	46.65	46.65	46.65
Operation Expenses	101.42	105.48	109.70	114.09	118.65	123.40	128.33	133.47	138.81	144.36	150.13	156.14
EBIT	453.49	473.73	494.78	516.68	539.47	563.18	587.85	613.51	640.21	667.99	696.88	726.95
Tax			227.60	237.67	248.16	259.06	270.41	282.21	294.50	307.27	320.57	334.40
Capital Expenditure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Debt Service	131.28	53.03	32.29	29.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Salvage Value												933.00
FCFE	368.86	467.34	281.54	296.31	337.96	350.77	364.09	377.94	392.36	407.36	422.97	1372.20

Appendix I - 07: Breakdown of Project Power Cost to MSEB (Phase I: cents/KwH)

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Fixed O&M	0.47	0.49	0.51	0.53	0.55	0.57	0.59	0.62	0.64	0.67	0.70	0.72	0.75	0.78	0.81	0.85	0.88	0.92	0.95	0.99
Debt Service	0.32	0.33	0.35	0.36	0.37	0.39	0.40	0.42	0.44	0.46	0.47	0.49	0.51	0.53	0.55	0.58	0.60	0.62	0.65	0.67
Capital Recovery Charge	2.18	2.27	2.36	2.45	2.55	2.65	2.76	2.87	2.98	3.10	3.23	3.36	3.49	3.63	3.78	3.93	4.08	4.25	4.42	4.59
Total Capacity payment	2.97	3.09	3.21	3.34	3.47	3.61	3.76	3.91	4.06	4.23	4.40	4.57	4.76	4.95	5.14	5.35	5.56	5.79	6.02	6.26
Variable O&M Fee	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Fuel Management Fee	0.10	0.10	0.11	0.11	0.12	0.12	0.13	0.13	0.14	0.14	0.15	0.15	0.16	0.17	0.17	0.18	0.19	0.19	0.20	0.21
Distillate Price	2.94	3.04	3.15	3.26	3.37	3.49	3.61	3.74	3.87	4.01	4.15	4.29	4.44	4.60	4.76	4.93	5.10	5.28	5.46	5.65
Total Energy Payment	3.06	3.17	3.28	3.39	3.51	3.64	3.77	3.90	4.04	4.18	4.32	4.48	4.63	4.80	4.97	5.14	5.32	5.51	5.70	5.90
Total Tariff Payment	6.03	6.26	6.49	6.74	6.99	7.25	7.52	7.81	8.10	8.40	8.72	9.05	9.39	9.74	10.11	10.49	10.89	11.30	11.72	12.16

APPENDIX I

Appendix I - 08: Debt Service (Phase I) (US\$: Million)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Us Ex-Im Bank (298)			298	272.58	245.03	215.16	182.78	147.69	109.64	68.40	23.70	0.00			
Annual Payment				50.45	50.45	50.45	50.45	50.45	50.45	50.45	50.45	23.70			
Interest				25.03	22.90	20.58	18.07	15.35	12.41	9.21	5.75	1.00			
Principle				25.42	27.55	29.87	32.38	35.10	38.04	41.24	44.70	22.71			
OPIC (100)			100	95.32	90.17	84.51	78.28	71.43	63.89	55.60	46.48	36.45	25.41	13.27	0.00
Annual Payment				14.68	14.68	14.68	14.68	14.68	14.68	14.68	14.68	14.68	14.68	14.68	13.27
Interest				10.00	9.53	9.02	8.45	7.83	7.14	6.39	5.56	4.65	3.64	2.54	1.33
Principle				4.68	5.15	5.66	6.23	6.85	7.54	8.29	9.12	10.03	11.04	12.14	11.95
BOA and ABNAMRO Bank(150)			150	136.10	120.67	103.54	84.53	63.43	40.01	14.01	0.00				
Annual Payment				30.40	30.40	30.40	30.40	30.40	30.40	30.40	14.01				
Interest				16.50	14.97	13.27	11.39	9.30	6.98	4.40	0.77				
Principle				13.90	15.43	17.13	19.01	21.10	23.42	26.00	13.24				
Sydication of Indian Bank led by IDBI (95)			95	90.42	85.03	78.70	71.26	62.52	52.25	40.18	26.01	9.35	0.00		
Annual Payment				21.21	21.21	21.21	21.21	21.21	21.21	21.21	21.21	21.21	9.35		
Interest				16.63	15.82	14.88	13.77	12.47	10.94	9.14	7.03	4.55	0.82		
Principle				4.59	5.39	6.33	7.44	8.74	10.27	12.07	14.18	16.66	8.53		
Total Debt Service				116.74	116.74	116.74	116.74	116.74	116.74	116.74	100.35	59.59	24.03	14.68	13.27

Appendix I - 09: Free Cash Flows to Equity (FCFE) after Negotiation (Phase I) (US\$: Million)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Gross Revenue	0.00	0.00	0.00	371.05	385.04	399.55	414.61	430.25	446.47	463.31	480.79	498.93
Cost	0.00	0.00	0.00	190.58	197.25	204.16	211.30	218.70	226.35	234.27	242.47	250.96
Depreciation	0.00	0.00	0.00	23.05	23.05	23.05	23.05	23.05	23.05	23.05	23.05	23.05
Operation Expenses	0.00	0.00	0.00	31.76	33.03	34.36	35.73	37.16	38.65	40.19	41.80	43.47
EBIT	0.00	0.00	0.00	125.66	131.70	137.99	144.53	151.34	158.43	165.80	173.47	181.45
Tax	0.00	0.00	0.00									
Capital Expenditure	83.70	111.60	83.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Debt Service	0.00	0.00	0.00	116.74	116.74	116.74	116.74	116.74	116.74	116.74	100.35	59.59
Salvage Value												
FCFE	(83.70)	(111.60)	(83.70)	31.97	38.01	44.30	50.84	57.65	64.74	72.11	96.17	144.91
NPV = 110.31 S ₁₉₉₃ = 352.06 K ₁₉₉₃ = 241.75												

Appendix I - 09: Free Cash Flows to Equity (FCFE) after Negotiation (Phase I) (US\$: Million) (Cont.,)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Gross Revenue	517.76	537.30	557.58	578.64	600.49	623.16	646.70	671.13	696.49	722.81	750.13
Cost	259.74	268.84	278.24	287.98	298.06	308.49	319.29	330.47	342.03	354.01	366.40
Depreciation	23.05	23.05	23.05	23.05	23.05	23.05	23.05	23.05	23.05	23.05	23.05
Operation Expenses	45.21	47.02	48.90	50.85	52.89	55.00	57.20	59.49	61.87	64.35	66.92
EBIT	189.76	198.40	207.39	216.75	226.48	236.61	247.16	258.12	269.54	281.41	293.77
Tax		91.26	95.40	99.70	104.18	108.84	113.69	118.74	123.99	129.45	135.13
Capital Expenditure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Debt Service	24.03	14.68	13.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Salvage Value											461.00
FCFE	188.78	115.51	121.77	140.09	145.35	150.82	156.51	162.44	168.60	175.01	642.68

Appendix I - 10: Breakdown of Project Power Cost to MSEB (Phase II: cents/KwH)

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Fixed O&M	0.42	0.44	0.45	0.47	0.49	0.51	0.53	0.55	0.57	0.60	0.62	0.65	0.67	0.70	0.73	0.76	0.79	0.82	0.85	0.88
Debt Service	0.31	0.32	0.34	0.35	0.36	0.38	0.39	0.41	0.42	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.60	0.63	0.65
Capital Recovery Charge	2.11	2.19	2.28	2.37	2.47	2.57	2.67	2.78	2.89	3.00	3.12	3.25	3.38	3.51	3.65	3.80	3.95	4.11	4.27	4.45
Total Capacity payment	2.84	2.95	3.07	3.19	3.32	3.46	3.59	3.74	3.89	4.04	4.20	4.37	4.55	4.73	4.92	5.11	5.32	5.53	5.75	5.98
Variable O&M Fee	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.09	0.09	0.09	0.10	0.10	0.11
Fuel Management Fee	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08
Distillate Price	2.15	2.23	2.30	2.38	2.47	2.55	2.64	2.74	2.83	2.93	3.03	3.14	3.25	3.36	3.48	3.60	3.73	3.86	3.99	4.13
Total Energy Payment	2.24	2.32	2.40	2.48	2.57	2.66	2.76	2.85	2.95	3.06	3.17	3.28	3.39	3.51	3.64	3.76	3.90	4.03	4.18	4.32
Total Tariff Payment	5.08	5.27	5.47	5.68	5.89	6.12	6.35	6.59	6.84	7.10	7.37	7.65	7.94	8.24	8.55	8.88	9.22	9.57	9.93	10.31

Appendix I - 11: Debt Service (Phase II) (US\$: Million)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Jan. and Bel. Ex-Im Bank (654)			654	598.23	537.77	472.23	401.19	324.18	240.70	150.21	52.11	0.00			
Annual Payment				110.71	110.71	110.71	110.71	110.71	110.71	110.71	110.71	52.11			
Interest				54.94	50.25	45.17	39.67	33.70	27.23	20.22	12.62	2.19			
Principle				55.77	60.46	65.54	71.04	77.01	83.48	90.49	98.09	49.92			
OPIC (220)			220	209.71	198.40	185.95	172.25	157.19	140.62	122.40	102.35	80.29	56.04	29.35	0.00
Annual Payment				32.29	32.29	32.29	32.29	32.29	32.29	32.29	32.29	32.29	32.29	32.29	29.35
Interest				22.00	20.97	19.84	18.59	17.23	15.72	14.06	12.24	10.23	8.03	5.60	2.94
Principle				10.29	11.32	12.45	13.69	15.06	16.57	18.23	20.05	22.05	24.26	26.68	26.42
BOA and ABNAMRO Bank(330)			330	299.43	265.49	227.83	186.01	139.60	88.09	30.91	0.00				
Annual Payment				66.87	66.87	66.87	66.87	66.87	66.87	66.87	30.91				
Interest				36.30	32.94	29.20	25.06	20.46	15.36	9.69	1.70				
Principle				30.57	33.93	37.67	41.81	46.41	51.52	57.18	29.21				
Sydication of Indian Bank led by IDBI (210)			210	199.87	187.97	173.98	157.54	138.23	115.54	88.88	57.55	20.74	0.00		
Annual Payment				46.88	46.88	46.88	46.88	46.88	46.88	46.88	46.88	46.88	20.74		
Interest				36.75	34.98	32.89	30.45	27.57	24.19	20.22	15.55	10.07	1.82		
Principle				10.13	11.90	13.99	16.43	19.31	22.69	26.66	31.33	36.81	18.93		
Total Debt Service				256.75	256.75	256.75	256.75	256.75	256.75	256.75	220.78	131.28	53.03	32.29	29.35

Appendix I - 12: Free Cash Flows to Equity (FCFE) after Negotiation (Phase II) (US\$: Million)

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Gross Revenue	0.00	0.00	0.00	614.26	637.60	661.84	687.00	713.13	740.25	768.40	797.64	827.98
Cost	0.00	0.00	0.00	271.96	281.48	291.33	301.53	312.08	323.01	334.31	346.01	358.12
Depreciation	0.00	0.00	0.00	46.65	46.65	46.65	46.65	46.65	46.65	46.65	46.65	46.65
Operation Expenses	0.00	0.00	0.00	59.45	61.83	64.30	66.88	69.55	72.33	75.23	78.24	81.36
EBIT	0.00	0.00	0.00	236.19	247.64	259.55	271.95	284.84	298.26	312.22	326.74	341.85
Tax	0.00	0.00	0.00									
Capital Expenditure	135.60	180.80	135.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Debt Service	0.00	0.00	0.00	256.75	256.75	256.75	256.75	256.75	256.75	256.75	220.78	131.28
Salvage Value												
FCFE	(135.60)	(180.80)	(135.60)	26.09	37.54	49.45	61.85	74.74	88.16	102.11	152.60	257.21
$\begin{aligned} NPV_{1993} &= 103.74 & NPV_{1996} &= 164.31 \\ S_{1993} &= 354.43 \\ K_{1993} &= 249.68 \end{aligned}$												

Appendix I - 12: Free Cash Flows to Equity (FCFE) after Negotiation (Phase II) (US\$: Million) (Cont.,)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gross Revenue	859.49	892.20	926.17	961.42	998.03	1036.04	1075.50	1116.47	1159.01	1203.17	1249.02
Cost	370.66	383.63	397.06	410.95	425.34	440.22	455.63	471.58	488.09	505.17	522.85
Depreciation	46.65	46.65	46.65	46.65	46.65	46.65	46.65	46.65	46.65	46.65	46.65
Operation Expenses	84.62	88.00	91.52	95.19	98.99	102.95	107.07	111.35	115.81	120.44	125.26
EBIT	357.56	373.92	390.93	408.63	427.05	446.21	466.15	486.89	508.46	530.91	554.27
Tax		172.00	179.83	187.97	196.44	205.26	214.43	223.97	233.89	244.22	254.96
Capital Expenditure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Debt Service	53.03	32.29	29.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Salvage Value											933.00
FCFE	351.18	216.28	228.40	267.31	277.26	287.60	298.37	309.57	321.22	333.34	1278.95

APPENDIX II

Appendix II-01 — Appendix II-13:

Cash Flows and Quantitative Models related to Major Case Study II:

Malaysia-Singapore Second Crossing

APPENDIX II

Appendix II - 01 : Cash Flow Model for Scenario 1

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Capacity (million daily)				0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Yearly Traffic Growth Rate					18%	18%	18%	18%	18%	18%	18%	18%	18%	9%	9%	9%	9%
Traffic Volume(million yearly)				10.95	12.92	15.25	17.99	21.23	25.05	29.56	34.88	41.16	48.57	52.94	57.70	62.90	68.56
Toll Rate (RM)				25.10	25.60	26.11	26.64	27.17	27.71	28.27	28.83	29.41	30.00	30.60	31.21	31.83	32.47
Gross Revenue (million)				274.85	330.80	398.16	479.22	576.79	694.22	835.57	1005.69	1210.45	1456.89	1619.77	1800.86	2002.20	2226.05
CAPEX (million)	147.00	147.00	126.00														
Operating & Maintenance (million)				56.00	58.24	60.57	62.99	65.51	68.13	70.86	73.69	76.64	79.71	82.89	86.21	89.66	93.24
EBIT (million)	(147.00)	(147.00)	(126.00)	218.85	272.56	337.59	416.23	511.28	626.09	764.71	932.00	1133.81	1377.19	1536.88	1714.65	1912.54	2132.80
Debt Service (million)				128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84
EBT (million)	(147.00)	(147.00)	(126.00)	90.00	143.72	208.74	287.38	382.43	497.25	635.86	803.15	1004.96	1248.34	1408.03	1585.81	1783.70	2003.96
TAX (million)				25.20	40.24	58.45	80.47	107.08	139.23	178.04	224.88	281.39	349.54	394.25	444.03	499.44	561.11
FCFE (million)	(147.00)	(147.00)	(126.00)	64.80	103.48	150.29	206.92	275.35	358.02	457.82	578.27	723.57	898.81	1013.79	1141.78	1284.26	1442.85
NPV = 1765.34 million																	
IRR = 38.53%																	

APPENDIX II

Appendix II - 01 : Cash Flow Model for Scenario 1 (Cont.,)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Capacity (million daily)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Yearly Traffic Growth Rate	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%
Traffic Volume(million yearly)	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00
Toll Rate (RM)	33.12	33.78	34.46	35.15	35.85	36.57	37.30	38.04	38.80	39.58	40.37	41.18	42.00	42.84	43.70	44.57
Gross Revenue (million)	2417.68	2466.03	2515.36	2565.66	2616.98	2669.32	2722.70	2777.16	2832.70	2889.35	2947.14	3006.08	3066.20	3127.53	3190.08	3253.88
CAPEX (million)																
Operating & Maintenance (million)	96.97	100.85	104.89	109.08	113.45	117.98	122.70	127.61	132.72	138.02	143.55	149.29	155.26	161.47	167.93	174.64
EBIT (million)	2320.71	2365.18	2410.47	2456.58	2503.53	2551.33	2600.00	2649.54	2699.98	2751.33	2803.59	2856.80	2910.95	2966.06	3022.15	3079.24
Debt Service (million)	128.84															
EBT (million)	2191.86	2365.18	2410.47	2456.58	2503.53	2551.33	2600.00	2649.54	2699.98	2751.33	2803.59	2856.80	2910.95	2966.06	3022.15	3079.24
TAX (million)	613.72	662.25	674.93	687.84	700.99	714.37	728.00	741.87	756.00	770.37	785.01	799.90	815.06	830.50	846.20	862.19
FCFE (million)	1578.14	1702.93	1735.54	1768.74	1802.54	1836.96	1872.00	1907.67	1943.99	1980.96	2018.59	2056.89	2095.88	2135.56	2175.95	2217.05

APPENDIX II

Appendix II - 02 : Cash Flow Model for Scenario 2

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Capacity (million daily)				0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Yearly Traffic Growth Rate					18%	18%	18%	18%	18%	18%	18%	18%	18%	9%	9%	9%	9%
Traffic Volume(million yearly)				10.95	12.92	15.25	17.99	21.23	25.05	29.56	34.88	41.16	48.57	52.94	57.70	62.90	68.56
Toll Rate (RM)				11.84	12.07	12.31	12.56	12.81	13.07	13.33	13.59	13.87	14.14	14.43	14.72	15.01	15.31
Gross Revenue (million)				129.59	155.98	187.74	225.96	271.96	327.34	393.98	474.20	570.74	686.95	763.75	849.13	944.07	1049.61
CAPEX (million)	147.00	147.00	126.00														
Operating & Maintenance (million)				56.00	58.24	60.57	62.99	65.51	68.13	70.86	73.69	76.64	79.71	82.89	86.21	89.66	93.24
EBIT (million)	(147.00)	(147.00)	(126.00)	73.59	97.74	127.17	162.97	206.45	259.20	323.12	400.50	494.10	607.24	680.85	762.92	854.41	956.37
Debt Service (million)				128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84
EBT (million)	(147.00)	(147.00)	(126.00)	(55.25)	(31.11)	(1.68)	34.12	77.61	130.36	194.28	271.66	365.26	478.40	552.01	634.08	725.56	827.52
TAX (million)				0.00	0.00	0.00	9.55	21.73	36.50	54.40	76.06	102.27	133.95	154.56	177.54	203.16	231.71
FCFE (million)	(147.00)	(147.00)	(126.00)	(55.25)	(31.11)	(1.68)	24.57	55.88	93.86	139.88	195.59	262.99	344.44	397.45	456.54	522.41	595.92
NPV = 326.6 million IRR = 22.10%																	

APPENDIX II

Appendix II - 02 : Cash Flow Model for Scenario 2 (Cont.,)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Capacity (million daily)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Yearly Traffic Growth Rate	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%
Traffic Volume(million yearly)	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00
Toll Rate (RM)	15.62	15.93	16.25	16.57	16.90	17.24	17.59	17.94	18.30	18.66	19.04	19.42	19.80	20.20	20.61	21.02
Gross Revenue (million)	1139.97	1162.77	1186.03	1209.75	1233.94	1258.62	1283.79	1309.47	1335.66	1362.37	1389.62	1417.41	1445.76	1474.67	1504.17	1534.25
CAPEX (million)																
Operating & Maintenance (million)	96.97	100.85	104.89	109.08	113.45	117.98	122.70	127.61	132.72	138.02	143.55	149.29	155.26	161.47	167.93	174.64
EBIT (million)	1043.00	1061.92	1081.14	1100.66	1120.49	1140.64	1161.09	1181.86	1202.94	1224.35	1246.07	1268.12	1290.50	1313.20	1336.24	1359.61
Debt Service (million)	128.84															
EBT (million)	914.15	1061.92	1081.14	1100.66	1120.49	1140.64	1161.09	1181.86	1202.94	1224.35	1246.07	1268.12	1290.50	1313.20	1336.24	1359.61
TAX (million)	255.96	297.34	302.72	308.19	313.74	319.38	325.10	330.92	336.82	342.82	348.90	355.07	361.34	367.70	374.15	380.69
FCFE (million)	658.19	764.58	778.42	792.48	806.76	821.26	835.98	850.94	866.12	881.53	897.17	913.05	929.16	945.51	962.09	978.92

APPENDIX II

Appendix II - 03 : Cash Flow Model for Scenario 3

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Capacity (million daily)				0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Yearly Traffic Growth Rate					18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	9%	9%	9%
Traffic Volume (million yearly)				4.17	4.92	5.81	6.85	8.08	9.54	11.26	13.28	15.67	18.50	20.16	21.97	23.95	26.11
Toll Rate (RM)				11.84	12.07	12.31	12.56	12.81	13.07	13.33	13.59	13.87	14.14	14.43	14.72	15.01	15.31
Gross Revenue (million)				49.35	59.40	71.49	86.05	103.57	124.66	150.04	180.58	217.35	261.60	290.85	323.37	359.52	399.72
CAPEX (million)	147.00	147.00	126.00														
Operating & Maintenance (million)				56.00	58.24	60.57	62.99	65.51	68.13	70.86	73.69	76.64	79.71	82.89	86.21	89.66	93.24
EBIT (million)	(147.00)	(147.00)	(126.00)	(6.65)	1.16	10.92	23.06	38.06	56.52	79.18	106.89	140.71	181.90	207.96	237.16	269.86	306.47
Debt Service(million)				128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84
EBT (million)	(147.00)	(147.00)	(126.00)	(135.49)	(127.68)	(117.92)	(105.79)	(90.79)	(72.32)	(49.67)	(21.95)	11.87	53.05	79.11	108.31	141.02	177.63
TAX (million)				0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.32	14.86	22.15	30.33	39.49	49.74
FCFE (million)	(147.00)	(147.00)	(126.00)	(135.49)	(127.68)	(117.92)	(105.79)	(90.79)	(72.32)	(49.67)	(21.95)	8.54	38.20	56.96	77.99	101.53	127.89
NPV = (449.60) million																	
IRR = 11.00%																	

APPENDIX II

Appendix II - 03 : Cash Flow Model for Scenario 3 (Cont.,)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Capacity (million daily)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Yearly Traffic Growth Rate	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%
Traffic Volume (million yearly)	28.46	31.02	33.81	36.85	40.17	43.79	47.73	52.02	56.70	61.81	67.37	73.00	73.00	73.00	73.00	73.00
Toll Rate (RM)	15.62	15.93	16.25	16.57	16.90	17.24	17.59	17.94	18.30	18.66	19.04	19.42	19.80	20.20	20.61	21.02
Gross Revenue (million)	444.40	494.09	549.33	610.74	679.02	754.94	839.34	933.18	1037.51	1153.50	1282.46	1417.41	1445.76	1474.67	1504.17	1534.25
CAPEX (million)																
Operating & Maintenance (million)	96.97	100.85	104.89	109.08	113.45	117.98	122.70	127.61	132.72	138.02	143.55	149.29	155.26	161.47	167.93	174.64
EBIT (million)	347.43	393.23	444.44	501.66	565.58	636.95	716.64	805.57	904.79	1015.48	1138.92	1268.12	1290.50	1313.20	1336.24	1359.61
Debt Service(million)	128.84															
EBT (million)	218.59	393.23	444.44	501.66	565.58	636.95	716.64	805.57	904.79	1015.48	1138.92	1268.12	1290.50	1313.20	1336.24	1359.61
TAX (million)	61.20	110.11	124.44	140.46	158.36	178.35	200.66	225.56	253.34	284.33	318.90	355.07	361.34	367.70	374.15	380.69
FCFE (million)	157.38	283.13	320.00	361.19	407.22	458.61	515.98	580.01	651.45	731.14	820.02	913.05	929.16	945.51	962.09	978.92

Appendix II - 04: Cash Flow Model for the Evaluation of Guarantee

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Capacity (million daily)	Cells with assumed distributions given in Table 6.3			0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Yearly Traffic Growth Rate					18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	9%	9%	9%
Traffic Volume(million yearly)				10.95	12.92	15.25	17.99	21.23	25.05	29.56	34.88	41.16	48.57	52.94	57.70	62.90	68.56
Toll Rate (RM)				11.84	12.07	12.31	12.56	12.81	13.07	13.33	13.59	13.87	14.14	14.43	14.72	15.01	15.31
Gross Revenue (million)				129.59	155.98	187.74	225.96	271.96	327.34	393.98	474.20	570.74	686.95	763.75	849.13	944.07	1049.61
CAPEX (million)	147.00	147.00	126.00														
Operating & Maintenance (million)				56.00	58.24	60.57	62.99	65.51	68.13	70.86	73.69	76.64	79.71	82.89	86.21	89.66	93.24
EBIT (million)	(147.00)	(147.00)	(126.00)	73.59	97.74	127.17	162.97	206.45	259.20	323.12	400.50	494.10	607.24	680.85	762.92	854.41	956.37
Debt Service (million)				128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84
EBT (million)	(147.00)	(147.00)	(126.00)	(55.25)	(31.11)	(1.68)	34.12	77.61	130.36	194.28	271.66	365.26	478.40	552.01	634.08	725.56	827.52
TAX (million)				0.00	0.00	0.00	9.55	21.73	36.50	54.40	76.06	102.27	133.95	154.56	177.54	203.16	231.71
FCFE (million) - Simulated	(147.00)	(147.00)	(126.00)	(55.25)	(31.11)	(1.68)	24.57	55.88	93.86	139.88	195.59	262.99	344.44	397.45	456.54	522.41	595.82
Guaranteed FCFE with Scenario 2 as base case (million)	(147.00)	(147.00)	(126.00)	(55.25)	(31.11)	(1.68)	24.57	55.88	93.86	139.88	195.59	262.99	344.44	397.45	456.54	522.41	595.82
Government's obligation to pay,SFi (million) - Simulated	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subsidy that government would provide, $SD = \sum_{i=4}^{33} \frac{SF_i}{(1+R_f)^i}$ (Equation 6.2)																	

Appendix II - 04: Cash Flow Model for the Evaluation of Guarantee (Cont.,)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Capacity (million daily)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Yearly Traffic Growth Rate	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%
Traffic Volume(million yearly)	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00
Toll Rate (RM)	15.62	15.93	16.25	16.57	16.90	17.24	17.59	17.94	18.30	18.66	19.04	19.42	19.80	20.20	20.61	21.02
Gross Revenue (million)	1139.97	1162.77	1186.03	1209.75	1233.94	1258.62	1283.79	1309.47	1335.66	1362.37	1389.62	1417.41	1445.76	1474.67	1504.17	1534.25
CAPEX (million)																
Operating & Maintenance (million)	96.97	100.85	104.89	109.08	113.45	117.98	122.70	127.61	132.72	138.02	143.55	149.29	155.26	161.47	167.93	174.64
EBIT (million)	1043.00	1061.92	1081.14	1100.66	1120.49	1140.64	1161.09	1181.86	1202.94	1224.35	1246.07	1268.12	1290.50	1313.20	1336.24	1359.61
Debt Service (million)	128.84															
EBT (million)	914.15	1061.92	1081.14	1100.66	1120.49	1140.64	1161.09	1181.86	1202.94	1224.35	1246.07	1268.12	1290.50	1313.20	1336.24	1359.61
TAX (million)	255.96	297.34	302.72	308.19	313.74	319.38	325.10	330.92	336.82	342.82	348.90	355.07	361.34	367.70	374.15	380.69
FCFE (million) - Simulated	658.19	764.58	778.42	792.48	806.76	821.26	835.98	850.94	866.12	881.53	897.17	913.05	929.16	945.51	962.09	978.92
Guaranteed FCFE with Scenario 2 as base case (million)	658.19	764.58	778.42	792.48	806.76	821.26	835.98	850.94	866.12	881.53	897.17	913.05	929.16	945.51	962.09	978.92
Government's obligation to pay,SFi (million) - Simulated	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix II - 05 : Cash Flow Model for the Evaluation of Repayment

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Capacity (million daily)		Cells with assumed distributions given in Table 6.3		0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Yearly Traffic Growth Rate				18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	9%	9%	9%
Traffic Volume(million yearly)				10.95	12.92	15.25	17.99	21.23	25.05	29.56	34.88	41.16	48.57	52.94	57.70	62.90	68.56
Toll Rate (RM)				11.84	12.07	12.31	12.56	12.81	13.07	13.33	13.59	13.87	14.14	14.43	14.72	15.01	15.31
Gross Revenue (million)				129.59	155.98	187.74	225.96	271.96	327.34	393.98	474.20	570.74	686.95	763.75	849.13	944.07	1049.61
CAPEX (million)	147.00	147.00	126.00														
Operating & Maintenance (million)				56.00	58.24	60.57	62.99	65.51	68.13	70.86	73.69	76.64	79.71	82.89	86.21	89.66	93.24
EBIT (million)	(147.00)	(147.00)	(126.00)	73.59	97.74	127.17	162.97	206.45	259.20	323.12	400.50	494.10	607.24	680.85	762.92	854.41	956.37
Debt Service (million)				128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84
EBT (million)	(147.00)	(147.00)	(126.00)	(55.25)	(31.11)	(1.68)	34.12	77.61	130.36	194.28	271.66	365.26	478.40	552.01	634.08	725.56	827.52
TAX (million)				0.00	0.00	0.00	9.55	21.73	36.50	54.40	76.06	102.27	133.95	154.56	177.54	203.16	231.71
FCFE (million) - Simulated	(147.00)	(147.00)	(126.00)	(55.25)	(21.85)	15.30	55.27	106.64	172.56	257.06	365.25	503.67	593.25	605.82	618.60	631.59	644.78
FCFE (million) -Projected (based on traffic growth g=20%)	(147.00)	(147.00)	(126.00)	(12.05)	15.04	43.85	78.80	121.15	172.42	234.44	309.40	399.96	509.31	580.74	618.60	631.59	644.78
Excess Cash Flow, ECFi (million) - Simulated	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Repayment that government would obtain, $RP = \sum_{i=4}^{33} \frac{ECF_i}{(1 + R_f)^i}$ (Equation 6.3)

Appendix II - 05 : Cash Flow Model for the Evaluation of Repayment (Cont.,)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Capacity (million daily)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Yearly Traffic Growth Rate	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%
Traffic Volume(million yearly)	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00
Toll Rate (RM)	15.62	15.93	16.25	16.57	16.90	17.24	17.59	17.94	18.30	18.66	19.04	19.42	19.80	20.20	20.61	21.02
Gross Revenue (million)	1139.97	1162.77	1186.03	1209.75	1233.94	1258.62	1283.79	1309.47	1335.66	1362.37	1389.62	1417.41	1445.76	1474.67	1504.17	1534.25
CAPEX (million)																
Operating & Maintenance (million)	96.97	100.85	104.89	109.08	113.45	117.98	122.70	127.61	132.72	138.02	143.55	149.29	155.26	161.47	167.93	174.64
EBIT (million)	1043.00	1061.92	1081.14	1100.66	1120.49	1140.64	1161.09	1181.86	1202.94	1224.35	1246.07	1268.12	1290.50	1313.20	1336.24	1359.61
Debt Service (million)	128.84															
EBT (million)	914.15	1061.92	1081.14	1100.66	1120.49	1140.64	1161.09	1181.86	1202.94	1224.35	1246.07	1268.12	1290.50	1313.20	1336.24	1359.61
TAX (million)	255.96	297.34	302.72	308.19	313.74	319.38	325.10	330.92	336.82	342.82	348.90	355.07	361.34	367.70	374.15	380.69
FCFE (million) - Simulated	658.19	764.58	778.42	792.48	806.76	821.26	835.98	850.94	866.12	881.53	897.17	913.05	929.16	945.51	962.09	978.92
FCFE (million) - Projected (based on traffic growth g=20%)	658.19	764.58	778.42	792.48	806.76	821.26	835.98	850.94	866.12	881.53	897.17	913.05	929.16	945.51	962.09	978.92
Excess Cash Flow, ECFi (million) - Simulated	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX II

Appendix II - 06 : Cash Flow Model for the Scenario of Construction in Two Stages: 4+2 Lanes (Phase I)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Capacity (million daily)			0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Yearly Traffic Growth Rate				18%	18%	18%	18%	18%	18%	18%	18%	18%	9%	9%	9%	9%	9%
Traffic Volume (million yearly)			10.95	12.92	15.25	17.99	21.23	25.05	29.56	34.88	41.16	48.57	48.67	48.67	48.67	48.67	48.67
Toll Rate (RM)			11.84	12.07	12.31	12.56	12.81	13.07	13.33	13.59	13.87	14.14	14.43	14.72	15.01	15.31	15.62
Gross Revenue (million)			129.59	155.98	187.74	225.96	271.96	327.34	393.98	474.20	570.74	686.95	702.10	716.15	730.47	745.08	759.98
CAPEX (million)	168.00	112.00															
Operating & Maintenance (million)			37.33	38.83	40.38	41.99	43.67	45.42	47.24	49.13	51.09	53.14	55.26	56.37	57.50	58.64	59.82
EBIT (million)	(168.00)	(112.00)	92.26	117.15	147.36	183.96	228.29	281.91	346.74	425.07	519.65	633.81	646.84	659.78	672.97	686.43	700.16
Debt Service (million)			85.90	85.90	85.90	85.90	85.90	85.90	85.90	85.90	85.90	85.90	85.90	85.90	85.90	85.90	85.90
EBT (million)	(168.00)	(112.00)	6.36	31.26	61.46	98.07	142.39	196.02	260.85	339.17	433.75	547.91	560.95	573.88	587.08	600.54	614.27
TAX (million)			1.78	8.75	17.21	27.46	39.87	54.88	73.04	94.97	121.45	153.42	157.06	160.69	164.38	168.15	171.99
FCFE (million)	(168.00)	(112.00)	4.58	22.50	44.25	70.61	102.52	141.13	187.81	244.20	312.30	394.50	403.88	413.20	422.70	432.39	442.27
NPV = 590.9 million																	

APPENDIX II

Appendix II - 06 : Cash Flow Model for the Scenario of Construction in Two Stages: 4+2 Lanes (Phase I) (Cont.,)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Capacity (million daily)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Yearly Traffic Growth Rate	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%
Traffic Volume (million yearly)	48.67	48.67	48.67	48.67	48.67	48.67	48.67	48.67	48.67	48.67	48.67	48.67	48.67	48.67	48.67	48.67
Toll Rate (RM)	15.93	16.25	16.57	16.90	17.24	17.59	17.94	18.30	18.66	19.04	19.42	19.80	20.20	20.61	21.02	21.44
Gross Revenue (million)	775.18	790.68	806.50	822.63	839.08	855.86	872.98	890.44	908.25	926.41	944.94	963.84	983.12	1002.78	1022.83	1043.29
CAPEX (million)																
Operating & Maintenance (million)	61.01	62.23	63.48	64.75	66.04	67.36	68.71	70.09	71.49	72.92	74.38	75.86	77.38	78.93	80.51	82.12
EBIT (million)	714.17	728.45	743.02	757.88	773.04	788.50	804.27	820.35	836.76	853.49	870.56	887.98	905.73	923.85	942.33	961.17
Debt Service (million)																
EBT (million)	714.17	728.45	743.02	757.88	773.04	788.50	804.27	820.35	836.76	853.49	870.56	887.98	905.73	923.85	942.33	961.17
TAX (million)	199.97	203.97	208.05	212.21	216.45	220.78	225.19	229.70	234.29	238.98	243.76	248.63	253.61	258.68	263.85	269.13
FCFE (million)	514.20	524.48	534.97	545.67	556.59	567.72	579.07	590.65	602.47	614.52	626.81	639.34	652.13	665.17	678.47	692.04

Appendix II - 07 : Cash Flow Model for the Scenario of Construction in Two Stages: 4+2 Lanes (Phase II)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Traffic Volume(million yearly)		4.27	9.04	14.23	19.89	24.33	24.33	24.33	24.33	24.33	24.33	24.33	24.33	24.33	24.33	24.33	24.33	24.33	24.33	24.33	24.33	24.33
Toll Rate (RM)		14.43	14.72	15.01	15.31	15.62	15.93	16.25	16.58	16.91	17.25	17.59	17.94	18.30	18.67	19.04	19.42	19.81	20.21	20.61	21.02	21.44
Gross Revenue (million)	0.00	61.65	133.02	213.64	304.60	380.07	387.68	395.43	403.34	411.40	419.63	428.03	436.59	445.32	454.22	463.31	472.57	482.03	491.67	501.50	511.53	521.76
CAPEX(million)	174.07																					
Operating & Maintenance (million)	0.00	23.67	24.62	25.61	26.63	27.70	28.80	29.95	31.15	32.40	33.70	35.04	36.44	37.90	39.42	41.00	42.64	44.34	46.11	47.96	49.88	51.87
EBIT (million)	(174.07)	37.98	108.39	188.04	277.97	352.38	358.87	365.47	372.18	379.01	385.94	392.98	400.14	407.42	414.81	422.31	429.94	437.69	445.55	453.54	461.65	469.89
Debt service (million)		53.40	53.40	53.40	53.40	53.40	53.40	53.40	53.40	53.40	53.40	53.40	53.40	53.40	53.40	53.40						
EBT (million)	(174.07)	(15.42)	54.99	134.64	224.57	298.98	305.47	312.07	318.78	325.60	332.54	339.58	346.74	354.01	361.40	368.91	429.94	437.69	445.55	453.54	461.65	469.89
TAX (million)	0.00	0.00	15.40	37.70	62.88	83.71	85.53	87.38	89.26	91.17	93.11	95.08	97.09	99.12	101.19	103.30	120.38	122.55	124.75	126.99	129.26	131.57
FCFE (million)	(174.07)	(15.42)	39.60	96.94	161.69	215.26	219.94	224.69	229.52	234.44	239.43	244.50	249.65	254.89	260.21	265.62	309.56	315.13	320.80	326.55	332.39	338.32
NPV = 69.13 million																						

APPENDIX II

Appendix II - 08 : Cash Flow Model for the Scenario of Opening 4 Lanes followed by 2 (Phase I)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Capacity (million daily)				0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Yearly Traffic Growth Rate					18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	9%	9%	9%
Traffic Volume(million yearly)				10.95	12.92	15.25	17.99	21.23	25.05	29.56	34.88	41.16	48.57	48.67	48.67	48.67	48.67
Toll Rate (RM)				11.84	12.07	12.31	12.56	12.81	13.07	13.33	13.59	13.87	14.14	14.43	14.72	15.01	15.31
Gross Revenue (million)				129.59	155.98	187.74	225.96	271.96	327.34	393.98	474.20	570.74	686.95	702.10	716.15	730.47	745.08
CAPEX (million)	147.00	147.00	126.00														
Operating & Maintenance (million)				37.33	38.83	40.38	41.99	43.67	45.42	47.24	49.13	51.09	53.14	54.20	55.28	56.39	57.52
EBIT (million)	(147.00)	(147.00)	(126.00)	92.26	117.15	147.36	183.96	228.29	281.91	346.74	425.07	519.65	633.81	647.90	660.86	674.08	687.56
Debt Service (million)				128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84
EBT (million)	(147.00)	(147.00)	(126.00)	(36.58)	(11.69)	18.51	55.12	99.44	153.07	217.90	296.22	390.80	504.96	519.06	532.02	545.24	558.72
TAX (million)				0.00	0.00	5.18	15.43	27.84	42.86	61.01	82.94	109.43	141.39	145.34	148.97	152.67	156.44
FCFE (million)	(147.00)	(147.00)	(126.00)	(36.58)	(11.69)	13.33	39.69	71.60	110.21	156.89	213.28	281.38	363.57	373.72	383.05	392.57	402.28
NPV = 239.24 million																	

APPENDIX II

Appendix II - 08 : Cash Flow Model for the Scenario of Opening 4 Lanes followed by 2 (Phase I) (Cont.,)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Capacity (million daily)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Yearly Traffic Growth Rate	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%
Traffic Volume(million yearly)	48.67	48.67	48.67	48.67	48.67	48.67	48.67	48.67	48.67	48.67	48.67	48.67	48.67	48.67	48.67	48.67
Toll Rate (RM)	15.62	15.93	16.25	16.57	16.90	17.24	17.59	17.94	18.30	18.66	19.04	19.42	19.80	20.20	20.61	21.02
Gross Revenue (million)	759.98	775.18	790.68	806.50	822.63	839.08	855.86	872.98	890.44	908.25	926.41	944.94	963.84	983.12	1002.78	1022.83
CAPEX (million)																
Operating & Maintenance (million)	58.67	59.84	61.04	62.26	63.50	64.77	66.07	67.39	68.74	70.11	71.52	72.95	74.40	75.89	77.41	78.96
EBIT (million)	701.31	715.34	729.65	744.24	759.12	774.31	789.79	805.59	821.70	838.13	854.90	871.99	889.43	907.22	925.37	943.87
Debt Service (million)	128.84															
EBT (million)	572.47	715.34	729.65	744.24	759.12	774.31	789.79	805.59	821.70	838.13	854.90	871.99	889.43	907.22	925.37	943.87
TAX (million)	160.29	200.29	204.30	208.39	212.55	216.81	221.14	225.56	230.08	234.68	239.37	244.16	249.04	254.02	259.10	264.28
FCFE (million)	412.18	515.04	525.34	535.85	546.57	557.50	568.65	580.02	591.62	603.46	615.53	627.84	640.39	653.20	666.26	679.59

Appendix II - 09 : Cash Flow Model for the Scenario of Opening 4 Lanes followed by 2 (Phase II)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Traffic Volume(million yearly)		4.27	9.04	14.23	19.89	24.33	24.33	24.33	24.33	24.33	24.33	24.33	24.33	24.33	24.33	24.33	24.33	24.33	24.33	24.33	24.33
Toll Rate (RM)		14.72	15.01	15.31	15.62	15.93	16.25	16.58	16.91	17.25	17.59	17.94	18.30	18.67	19.04	19.42	19.81	20.21	20.61	21.02	21.44
Gross Revenue (million)		62.89	135.69	217.94	310.72	387.71	395.47	403.38	411.44	419.67	428.07	436.63	445.36	454.27	463.35	472.62	482.07	491.71	501.55	511.58	521.81
CAPEX(million)																					
Operating & Maintenance (million)	161.40																				
EBIT (million)	(161.40)	62.89	135.69	217.94	310.72	387.71	395.47	403.38	411.44	419.67	428.07	436.63	445.36	454.27	463.35	472.62	482.07	491.71	501.55	511.58	521.81
Debt service (million)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
EBT (million)	(161.40)	62.89	135.69	217.94	310.72	387.71	395.47	403.38	411.44	419.67	428.07	436.63	445.36	454.27	463.35	472.62	482.07	491.71	501.55	511.58	521.81
TAX (million)	0.00	17.61	37.99	61.02	87.00	108.56	110.73	112.95	115.20	117.51	119.86	122.26	124.70	127.19	129.74	132.33	134.98	137.68	140.43	143.24	146.11
FCFE (million)	(161.40)	45.28	97.70	156.91	223.72	279.15	284.74	290.43	296.24	302.16	308.21	314.37	320.66	327.07	333.61	340.29	347.09	354.03	361.11	368.34	375.70
NPV = 106.65 million																					

Appendix II - 10 : Cash Flow Model for the Scenario of Construction in Two Stages: 3+3 Lanes (Phase I)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Capacity (million daily)			0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Yearly Traffic Growth Rate				18%	18%	18%	18%	18%	18%	18%	18%	18%	9%	9%	9%	9%	9%
Traffic Volume(million yearly)			10.95	12.92	15.25	17.99	21.23	25.05	29.56	34.88	36.50	36.50	36.50	36.50	36.50	36.50	36.50
Toll Rate (RM)			11.84	12.07	12.31	12.56	12.81	13.07	13.33	13.59	13.87	14.14	14.43	14.72	15.01	15.31	15.62
Gross Revenue (million)			129.59	155.98	187.74	225.96	271.96	327.34	393.98	474.20	506.13	516.25	526.58	537.11	547.85	558.81	569.99
CAPEX (million)	105.00	105.00															
Operating & Maintenance (million)			28.00	29.12	30.28	31.50	32.76	34.07	35.43	36.85	38.32	39.09	39.87	40.67	41.48	42.31	43.15
EBIT (million)	(105.00)	(105.00)	101.59	126.86	157.45	194.46	239.21	293.27	358.55	437.35	467.81	477.17	486.71	496.44	506.37	516.50	526.83
Debt Service (million)			64.42	64.42	64.42	64.42	64.42	64.42	64.42	64.42	64.42	64.42	64.42	64.42	64.42	64.42	64.42
EBT (million)	(105.00)	(105.00)	37.17	62.44	93.03	130.04	174.79	228.85	294.13	372.93	403.39	412.74	422.29	432.02	441.95	452.08	462.41
TAX (million)			10.41	17.48	26.05	36.41	48.94	64.08	82.36	104.42	112.95	115.57	118.24	120.97	123.75	126.58	129.47
FCFE (million)	(105.00)	(105.00)	26.76	44.95	66.98	93.63	125.85	164.77	211.77	268.51	290.44	297.18	304.05	311.06	318.20	325.50	332.93
NPV = 607.29 million																	

APPENDIX II

Appendix II - 10 : Cash Flow Model for the Scenario of Construction in Two Stages: 3+3 Lanes (Phase I) (Cont.,)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Capacity (million daily)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	1.20
Yearly Traffic Growth Rate	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%
Traffic Volume(million yearly)	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50
Toll Rate (RM)	15.93	16.25	16.57	16.90	17.24	17.59	17.94	18.30	18.66	19.04	19.42	19.80	20.20	20.61	21.02	21.44
Gross Revenue (million)	581.38	593.01	604.87	616.97	629.31	641.90	654.73	667.83	681.19	694.81	708.70	722.88	737.34	752.08	767.12	782.47
CAPEX (million)																
Operating & Maintenance (million)	44.02	44.90	45.80	46.71	47.65	48.60	49.57	50.56	51.57	52.61	53.66	54.73	55.82	56.94	58.08	59.24
EBIT (million)	537.37	548.11	559.08	570.26	581.66	593.30	605.16	617.27	629.61	642.20	655.05	668.15	681.51	695.14	709.04	723.23
Debt Service (million)																
EBT (million)	537.37	548.11	559.08	570.26	581.66	593.30	605.16	617.27	629.61	642.20	655.05	668.15	681.51	695.14	709.04	723.23
TAX (million)	150.46	153.47	156.54	159.67	162.87	166.12	169.45	172.83	176.29	179.82	183.41	187.08	190.82	194.64	198.53	202.50
FCFE (million)	386.90	394.64	402.54	410.59	418.80	427.17	435.72	444.43	453.32	462.39	471.63	481.07	490.69	500.50	510.51	520.72

Appendix II - 11 : Cash Flow Model for the Scenario of Construction in Two Stages: 3+3 Lanes (Phase II)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Traffic Volume(million yearly)		4.66	12.07	16.44	21.20	26.40	32.06	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50
Toll Rate (RM)		13.87	14.15	14.43	14.72	15.01	15.31	15.62	15.93	16.25	16.58	16.91	17.25	17.59	17.94	18.30	18.67	19.04	19.42	19.81	20.21	20.61	21.02	21.44
Gross Revenue (million)		64.63	170.73	237.23	312.10	396.31	490.92	570.13	581.53	593.16	605.02	617.12	629.46	642.05	654.89	667.99	681.35	694.98	708.88	723.06	737.52	752.27	767.31	782.66
CAPEX(million)	250.97																							
Operating & Maintenance (million)		32.81	34.12	35.48	36.90	38.38	39.91	41.51	43.17	44.90	46.69	48.56	50.50	52.52	54.63	56.81	59.08	61.45	63.90	66.46	69.12	71.88	74.76	77.75
EBIT (million)	(250.97)	31.82	136.62	201.74	275.20	357.93	451.01	528.61	538.36	548.26	558.33	568.56	578.96	589.53	600.27	611.18	622.27	633.53	644.98	656.60	668.40	680.39	692.56	704.91
Debt service (million)		76.99	76.99	76.99	76.99	76.99	76.99	76.99	76.99	76.99	76.99	76.99	76.99	76.99	76.99	76.99								
EBT (million)	(250.97)	(45.17)	59.62	124.75	198.21	280.94	374.02	451.62	461.37	471.27	481.34	491.57	501.97	512.54	523.28	534.19	544.98	555.77	566.60	577.40	588.29	599.21	610.16	621.13
TAX (million)	0.00	0.00	16.69	34.93	55.50	78.66	104.73	126.45	129.18	131.96	134.77	137.64	140.55	143.51	146.52	149.57	152.64	155.71	158.78	161.85	164.92	168.00	171.08	174.16
FCFE (million)	(250.97)	(45.17)	42.93	89.82	142.71	202.28	269.29	325.17	332.18	339.31	346.56	353.93	361.42	369.03	376.76	384.62	392.54	400.45	408.37	416.29	424.21	432.13	440.05	447.97
NPV = 126.67 million																								

Appendix II - 12 : Cash Flow Model for the Scenario of Opening 3 Lanes followed by 3 (Phase I)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Capacity (million daily)				0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Yearly Traffic Growth Rate					18%	18%	18%	18%	18%	18%	18%	18%	18%	9%	9%	9%	9%
Traffic Volume(million yearly)				10.95	12.92	15.25	17.99	21.23	25.05	29.56	34.88	36.50	36.50	36.50	36.50	36.50	36.50
Toll Rate (RM)				11.84	12.07	12.31	12.56	12.81	13.07	13.33	13.59	13.87	14.14	14.43	14.72	15.01	15.31
Gross Revenue (million)				129.59	155.98	187.74	225.96	271.96	327.34	393.98	474.20	506.13	516.25	526.58	537.11	547.85	558.81
CAPEX (million)	147.00	147.00	126.00														
Operating & Maintenance (million)				28.00	29.12	30.28	31.50	32.76	34.07	35.43	36.85	38.32	39.85	41.45	43.10	44.83	46.62
EBIT (million)	(147.00)	(147.00)	(126.00)	101.59	126.86	157.45	194.46	239.21	293.27	358.55	437.35	467.81	476.40	485.13	494.01	503.02	512.19
Debt Service (million)				128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84	128.84
EBT (million)	(147.00)	(147.00)	(126.00)	(27.25)	(1.99)	28.61	65.62	110.36	164.43	229.71	308.51	338.97	347.56	356.29	365.16	374.18	383.34
TAX (million)				0.00	0.00	8.01	18.37	30.90	46.04	64.32	86.38	94.91	97.32	99.76	102.24	104.77	107.34
FCFE (million)	(147.00)	(147.00)	(126.00)	(27.25)	(1.99)	20.60	47.25	79.46	118.39	165.39	222.12	244.06	250.24	256.53	262.92	269.41	276.01
NPV = 133.84 million																	

APPENDIX II

Appendix II - 12 : Cash Flow Model for the Scenario of Opening 3 Lanes followed by 3 (Phase I) (Cont.,)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Capacity (million daily)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Yearly Traffic Growth Rate	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%
Traffic Volume(million yearly)	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50
Toll Rate (RM)	15.62	15.93	16.25	16.57	16.90	17.24	17.59	17.94	18.30	18.66	19.04	19.42	19.80	20.20	20.61	21.02
Gross Revenue (million)	569.99	581.38	593.01	604.87	616.97	629.31	641.90	654.73	667.83	681.19	694.81	708.70	722.88	737.34	752.08	767.12
CAPEX (million)																
Operating & Maintenance (million)	48.49	50.43	52.44	54.54	56.72	58.99	61.35	63.81	66.36	69.01	71.77	74.64	77.63	80.73	83.96	87.32
EBIT (million)	521.50	530.96	540.57	550.33	560.25	570.32	580.54	590.93	601.47	612.17	623.04	634.06	645.25	656.60	668.12	679.80
Debt Service (million)	128.84															
EBT (million)	392.65	530.96	540.57	550.33	560.25	570.32	580.54	590.93	601.47	612.17	623.04	634.06	645.25	656.60	668.12	679.80
TAX (million)	109.94	148.67	151.36	154.09	156.87	159.69	162.55	165.46	168.41	171.41	174.45	177.54	180.67	183.85	187.07	190.34
FCFE (million)	282.71	382.29	389.21	396.24	403.38	410.63	417.99	425.47	433.06	440.76	448.59	456.52	464.58	472.75	481.05	489.46

Appendix II - 13 : Cash Flow Model for the Scenario of Opening 3 Lanes followed by 3 (Phase II)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Traffic Volume(million yearly)		4.66	12.07	16.44	21.20	26.40	32.06	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50
Toll Rate (RM)		13.87	14.15	14.43	14.72	15.01	15.31	15.62	15.93	16.25	16.58	16.91	17.25	17.59	17.94	18.30	18.67	19.04	19.42	19.81	20.21	20.61	21.02
Gross Revenue (million)		64.63	170.73	237.23	312.10	396.31	490.92	570.13	581.53	593.16	605.02	617.12	629.46	642.05	654.89	667.99	681.35	694.98	708.88	723.06	737.52	752.27	767.31
CAPEX(million)																							
Operating & Maintenance (million)	228.36																						
EBIT (million)	(228.36)	64.63	170.73	237.23	312.10	396.31	490.92	570.13	581.53	593.16	605.02	617.12	629.46	642.05	654.89	667.99	681.35	694.98	708.88	723.06	737.52	752.27	767.31
Debt service (million)			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
EBT (million)	(228.36)	64.63	170.73	237.23	312.10	396.31	490.92	570.13	581.53	593.16	605.02	617.12	629.46	642.05	654.89	667.99	681.35	694.98	708.88	723.06	737.52	752.27	767.31
TAX (million)	0.00	18.10	47.81	66.42	87.39	110.97	137.46	159.64	162.83	166.08	169.41	172.79	176.25	179.78	183.37	187.04	190.78	194.59	198.49	202.46	206.51	210.64	214.85
FCFE (million)	(228.36)	46.53	122.93	170.80	224.71	285.34	353.46	410.49	418.70	427.07	435.62	444.33	453.21	462.28	471.52	480.95	490.57	500.39	510.39	520.60	531.01	541.63	552.47
NPV = 199.77 million																							

APPENDIX III

Appendix III-01 — Appendix III-03:

Cash Flows and Quantitative Models related to Major Case Study III:

Wastewater Treatment Plant in Southern China

APPENDIX III

Appendix III - 01 :Profoma Cash Flow Model for Scenario 1 and 2 (All Figures in RMB million)

	1	2	3	4	5	6	7	8	9	10	11	12	13
Projected Volume of Treatment (Dry Season)	15	19	22	25	30	30	30	30	30	30	30	30	30
Projected Volume of Treatment (Rainy Season)	26	33	38	46	60	60	60	60	60	60	60	60	60
Days of Dry Season	325	325	325	325	325	325	325	325	325	325	325	325	325
Days of Rainy Season	40	40	40	40	40	40	40	40	40	40	40	40	40
Actual Volume of Treatment (Dry Season)	15	19	22	25	30	30	30	30	30	30	30	30	30
Actual Volume of Treatment (Rainy Season)	26	33	38	46	60	60	60	60	60	60	60	60	60
Normal Tariff	1	1	1	1	1	1	1	1	1	1	1	1	1
Actual Volume of Treatment	59.15	74.95	86.7	99.65	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5
Revenue	59.15	74.95	86.7	99.65	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5
Depreciation (1)	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Depreciation (2)													10.24
Salvage Value													6.15
Recycle of Working Capital													
Cash Inflow	59.15	74.95	86.7	99.65	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	127.65
CAPEX	350.00												123.00
Working Capital	3.50												
Fixed Cost	27.99	31.02	33.30	35.58	39.37	39.37	39.37	39.37	39.37	39.37	39.37	39.37	39.37
Variable Cost	0.03	0.03	0.04	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Interest	14.31	12.90	11.49	10.08	8.67	7.26	5.85	4.44	3.02	1.61	0.20	0.20	5.16
Tax on Revenue & City Maintenance	3.28	4.16	4.81	5.53	6.74	6.74	6.74	6.74	6.74	6.74	6.74	6.74	6.74
Corporate Tax	0.00	4.23	7.61	11.36	17.38	17.84	18.31	18.77	19.24	19.71	20.17	20.17	15.15
Cash Outflow	384.80	39.45	45.76	52.51	63.55	64.01	64.48	64.95	65.41	65.88	66.34	66.34	184.33
FCF	(325.65)	35.50	40.94	47.14	57.95	57.49	57.02	56.55	56.09	55.62	55.16	55.16	(56.68)
Scenario 1: Fix normal tariff at RMB 1.00 per m3 and transfer price (CAPEX) can be obtained by setting NPV=0 for different IRRs													
Scenario 2: Fix transfer price (CAPEX) at RMB 350 million and normal tariff can be obtained by setting NPV=0 for different IRRs													

Appendix III - 01 :Profoma Cash Flow Model for Scenario 1 and 2 (All Figures in RMB million) (Cont.,)

	14	15	16	17	18	19	20	21	22	23	24	25
Projected Volume of Treatment (Dry Season)	10,000 m ³ /day	30	30	30	30	30	30	30	30	30	30	30
Projected Volume of Treatment (Rainy Season)	10,000 m ³ /day	60	60	60	60	60	60	60	60	60	60	60
Days of Dry Season	day	325	325	325	325	325	325	325	325	325	325	325
Days of Rainy Season	day	40	40	40	40	40	40	40	40	40	40	40
Actual Volume of Treatment (Dry Season)	10,000 m ³ /day	30	30	30	30	30	30	30	30	30	30	30
Actual Volume of Treatment (Rainy Season)	10,000 m ³ /day	60	60	60	60	60	60	60	60	60	60	60
Normal Tariff	RMB/m ³	1	1	1	1	1	1	1	1	1	1	1
Actual Volume of Treatment	1,000,000 m ³ /year	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5
Revenue		121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5
Depreciation (1)		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Depreciation (2)		10.24	10.245	10.245	10.245	10.245	10.245	10.245	10.245	10.245	10.245	
Salvage Value												
Recycle of Working Capital												3.50
Cash Inflow		121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	125
CAPEX												
Working Capital												
Fixed Cost		39.37	39.37	39.37	39.37	39.37	39.37	39.37	39.37	39.37	39.37	39.37
Variable Cost		0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Interest		4.17	3.18	2.19	1.19	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Tax on Revenue & City Maintenance		6.74	6.74	6.74	6.74	6.74	6.74	6.74	6.74	6.74	6.74	6.74
Corporate Tax		15.48	15.81	16.14	16.46	16.79	16.79	16.79	16.79	16.79	16.79	20.17
Cash Outflow		61.65	61.98	62.31	62.64	62.96	62.96	62.96	62.96	62.96	62.96	66.34
FCF		59.85	59.52	59.19	58.86	58.54	58.54	58.54	58.54	58.54	58.54	58.66

Appendix III - 02: Profoma Cash Flow Model for Guarantee (All Figures in RMB million)

	1	2	3	4	5	6	7	8	9	10	11	12	13
Guaranteed Volume of Treatment	10,000 m ³ /day	10	15	19	22	25	25	25	25	25	25	25	25
Projected Volume of Treatment (Dry Season)	10,000 m ³ /day	15	19	22	25	30	30	30	30	30	30	30	30
Projected Volume of Treatment (Rainy Season)	10,000 m ³ /day	26	33	38	46	60	60	60	60	60	60	60	60
Days of Dry Season	day	325	325	325	325	325	325	325	325	325	325	325	325
Days of Rainy Season	day	40	40	40	40	40	40	40	40	40	40	40	40
Actual Volume for Treatment (Dry Season)	10,000 m ³ /day	15	19	22	25	30	30	30	30	30	30	30	30
Actual Volume for Treatment (Rainy Season)	10,000 m ³ /day	26	33	38	46	60	60	60	60	60	60	60	60
Normal Tariff	RMB/m ³	1	1	1	1	1	1	1	1	1	1	1	1
Actual Volume of Treatment	1000,000 m ³ /year	59.15	74.95	86.7	99.65	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5
Revenue		59.15	74.95	86.7	99.65	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5
Depreciation (1)		14	14	14	14	14	14	14	14	14	14	14	14
Depreciation (2)													10.24
Salvage Value													6.15
Recycle of Working Capital													
Cash Inflow		59.15	74.95	86.7	99.65	121.5	121.5	121.5	121.5	121.5	121.5	121.5	127.65
CAPEX	350												123
Working Capital	3.5												
Fixed Cost	27.99	31.02	33.30	35.58	39.37	39.37	39.37	39.37	39.37	39.37	39.37	39.37	39.37
Variable Cost	0.03	0.03	0.04	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Interest	14.31	12.90	11.49	10.08	8.67	7.26	5.85	4.44	3.02	1.61	0.20	0.20	5.16
Tax on Revenue & City Maintenance	3.28	4.16	4.81	5.53	6.74	6.74	6.74	6.74	6.74	6.74	6.74	6.74	6.74
Corporate Tax	0.00	4.23	7.61	11.36	17.38	17.84	18.31	18.77	19.24	19.71	20.17	20.17	15.15
Cash Outflow	384.80	39.45	45.76	52.51	63.55	64.01	64.48	64.95	65.41	65.88	66.34	66.34	184.33
CFia - Simulated	(325.65)	35.50	40.94	47.14	57.95	57.49	57.02	56.55	56.09	55.62	55.16	55.16	-56.68
Guaranteed Cash Flow, CFig	(341.00)	27.27	34.77	36.86	47.67	47.20	46.74	46.27	45.81	45.34	44.87	44.87	-66.96
Government's obligation to pay, Si - Simulated	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$\text{Value of Guarantee, } G = \sum_{t=1}^{25} \frac{S_t}{(1 + R_f)^t} \quad (\text{Equation 7.3})$$

APPENDIX III

Appendix III - 02: Profoma Cash Flow Model for Guarantee (All Figures in RMB million) (Cont.,)

	14	15	16	17	18	19	20	21	22	23	24	25
Guaranteed Volume of Treatment	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day
Projected Volume of Treatment (Dry Season)	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day
Projected Volume of Treatment (Rainy Season)	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day
Days of Dry Season	325	325	325	325	325	325	325	325	325	325	325	325
Days of Rainy Season	40	40	40	40	40	40	40	40	40	40	40	40
Actual Volume for Treatment (Dry Season)	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day
Actual Volume for Treatment (Rainy Season)	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day
Normal Tariff	1	1	1	1	1	1	1	1	1	1	1	1
Actual Volume of Treatment	1000,000 m ³ /year	1000,000 m ³ /year	1000,000 m ³ /year	1000,000 m ³ /year	1000,000 m ³ /year	1000,000 m ³ /year	1000,000 m ³ /year	1000,000 m ³ /year	1000,000 m ³ /year	1000,000 m ³ /year	1000,000 m ³ /year	1000,000 m ³ /year
Revenue	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5
Depreciation (1)	14	14	14	14	14	14	14	14	14	14	14	14
Depreciation (2)	10.24	10.24	10.24	10.24	10.24	10.24	10.24	10.24	10.24	10.24	10.24	10.24
Salvage Value												
Recycle of Working Capital												
Cash Inflow	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5
CAPEX												
Working Capital												
Fixed Cost	39.37	39.37	39.37	39.37	39.37	39.37	39.37	39.37	39.37	39.37	39.37	39.37
Variable Cost	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Interest	4.17	3.18	2.19	1.19	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Tax on Revenue & City Maintenance	6.74	6.74	6.74	6.74	6.74	6.74	6.74	6.74	6.74	6.74	6.74	6.74
Corporate Tax	15.48	15.81	16.14	16.46	16.79	16.79	16.79	16.79	16.79	16.79	16.79	16.79
Cash Outflow	61.65	61.98	62.31	62.64	62.96	62.96	62.96	62.96	62.96	62.96	62.96	62.96
CFia - Simulated	59.85	59.52	59.19	58.86	58.54	58.54	58.54	58.54	58.54	58.54	58.54	58.54
Guaranteed Cash Flow, CFig	49.56	49.24	48.91	48.58	48.25	48.25	48.25	48.25	48.25	48.25	48.25	48.25
Governemnt's obligation to pay, Si - Simulated	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix III - 03 : Profoma Cash Flow Model for "Cap" (All Figures in RMB million)

	1	2	3	4	5	6	7	8	9	10	11	12	13
Volume of the "Capped Normal" Level	15	19	22	25	30	30	30	30	30	30	30	30	30
Projected Volume of Treatment (Dry Season)	15	19	22	25	30	30	30	30	30	30	30	30	30
Projected Volume of Treatment (Rainy Season)	26	33	38	46	60	60	60	60	60	60	60	60	60
Days of Dry Season	325	325	325	325	325	325	325	325	325	325	325	325	325
Days of Rainy Season	40	40	40	40	40	40	40	40	40	40	40	40	40
Actual Volume of Treatment (Dry Season)	15	19	22	25	30	30	30	30	30	30	30	30	30
Actual Volume of Treatment (Rainy Season)	15	19	22	25	30	30	30	30	30	30	30	30	30
Over part of Volume (Rainy Season)	11	14	16	21	30	30	30	30	30	30	30	30	30
Normal Tariff	1	1	1	1	1	1	1	1	1	1	1	1	1
Adjusted Pricing	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Actual Volume of Treatment	59.15	74.95	86.7	99.65	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5
Revenue	55.72	70.58	81.71	93.10	112.14	112.14	112.14	112.14	112.14	112.14	112.14	112.14	112.14
Depreciation (1)	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Depreciation (2)													10.24
Salvage Value													6.15
Recycle of Working Capital													
Cash Inflow	55.72	70.58	81.71	93.10	112.14	112.14	112.14	112.14	112.14	112.14	112.14	112.14	118.29
CAPEX	350.00												123.00
Working Capital	3.50												
Fixed Cost	27.99	31.02	33.30	35.58	39.37	39.37	39.37	39.37	39.37	39.37	39.37	39.37	39.37
Variable Cost	0.03	0.03	0.04	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Interest	14.31	12.90	11.49	10.08	8.67	7.26	5.85	4.44	3.02	1.61	0.20	0.20	5.16
Tax on Revenue & City Maintenance	3.09	3.92	4.53	5.17	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22
Corporate Tax	0.00	2.87	6.05	9.32	14.46	14.93	15.39	15.86	16.32	16.79	17.25	17.25	12.24
Cash Outflow	384.61	37.85	43.93	50.11	60.11	60.58	61.04	61.51	61.97	62.44	62.91	62.91	180.89
Cash Flow with Adjusted Tariff, CFia - Simulated	(328.89)	32.73	37.78	42.99	52.03	51.56	51.10	50.63	50.17	49.70	49.23	49.23	(62.60)
Cash Flow with Normal Tariff, CFic - Simulated	(325.65)	35.50	40.94	47.14	57.95	57.49	57.02	56.55	56.09	55.62	55.16	55.16	(56.68)
Value of Government Benefits from the Cap, Ci - Simulated	3.24	2.76	3.16	4.15	5.92	5.92	5.92	5.92	5.92	5.92	5.92	5.92	5.92

$$\text{Value of the "Cap", } C = \sum_{t=1}^{25} \frac{C_t}{(1 + R_f)^t} \quad (\text{Equation 7.5})$$

Appendix III - 03 : Profoma Cash Flow Model for "Cap" (All Figures in RMB million) (Cont.,)

	14	15	16	17	18	19	20	21	22	23	24	25
Volume of the "Capped" Level	30	30	30	30	30	30	30	30	30	30	30	30
Projected Volume of Treatment (Dry Season)	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day	10,000 m ³ /day
Projected Volume of Treatment (Rainy Season)	60	60	60	60	60	60	60	60	60	60	60	60
Days of Dry Season	325	325	325	325	325	325	325	325	325	325	325	325
Days of Rainy Season	40	40	40	40	40	40	40	40	40	40	40	40
Actual Volume of Treatment (Dry Season)	30	30	30	30	30	30	30	30	30	30	30	30
Actual Volume of Treatment (Rainy Season)	30	30	30	30	30	30	30	30	30	30	30	30
Over part of Volume (Rainy Season)	30	30	30	30	30	30	30	30	30	30	30	30
Normal Tariff	1	1	1	1	1	1	1	1	1	1	1	1
Adjusted Pricing	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Actual Volume of Treatment	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5	121.5
Revenue	112.14	112.14	112.14	112.14	112.14	112.14	112.14	112.14	112.14	112.14	112.14	112.14
Depreciation (1)	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Depreciation (2)	10.24	10.24	10.24	10.24	10.24	10.24	10.24	10.24	10.24	10.24	10.24	10.24
Salvage Value												
Recycle of Working Capital												
Cash Inflow	112.14	112.14	112.14	112.14	112.14	112.14	112.14	112.14	112.14	112.14	112.14	112.14
CAPEX												3.50
Working Capital												
Fixed Cost	39.37	39.37	39.37	39.37	39.37	39.37	39.37	39.37	39.37	39.37	39.37	39.37
Variable Cost	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Interest	4.17	3.18	2.19	1.19	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Tax on Revenue & City Maintenance	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22
Corporate Tax	12.56	12.89	13.22	13.55	13.87	13.87	13.87	13.87	13.87	13.87	13.87	13.87
Cash Outflow	58.22	58.54	58.87	59.20	59.53	59.53	59.53	59.53	59.53	59.53	59.53	62.91
Cash Flow with Adjusted Tariff, CFia - Simulated	53.92	53.60	53.27	52.94	52.61	52.61	52.61	52.61	52.61	52.61	52.61	52.73
Cash Flow with Normal Tariff, CFic - Simulated	59.85	59.52	59.19	58.86	58.54	58.54	58.54	58.54	58.54	58.54	58.54	58.66
Value of Government Benefits from the Cap, Ci - Simulated	5.92	5.92	5.92	5.92	5.92	5.92	5.92	5.92	5.92	5.92	5.92	5.92