University of Alberta

Toward Innovative and Efficient Infrastructure Delivery

by

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Abstract

Mixed results have been experienced in international public-private partnerships (PPPs) in infrastructure development and there are worldwide controversy, criticism and conflicts over PPPs. A number of PPP projects have suffered disastrous consequences due to lack of knowledge and expertise in project financial evaluation, risk identification, assessment and allocation, and effective financial engineering techniques and efficient contracting methods to address incomplete information, asset specificity and opportunism. This causes significant political, social, and economic consequences to the public sector and economic losses to the private sector, with an overall impairment to the interests of the general public. This research has developed (1) an integrated general framework for the delivery of public infrastructure and services through PPPs; (2) an innovative financial evaluation methodology that reflects the characteristics of project finance, incorporates simulation and financial analysis techniques, and aims at a win-win solution for all parties involved; (3) a mathematical model to determine the appropriate length of the concession period that demarcates the rights and responsibilities between the public and private sectors in a project's life cycle; (4) a mathematical model that optimizes the concessionaire's capital structure when it is subject to various risks and financial viability requirements; and (5) a relational concession framework to build a cooperative/collaborative working environment to minimize opportunism and transaction costs. These research outputs make significant contributions to the knowledge body of public works and services provision, to overcoming various problems currently encountered, and to improving future practices in international PPPs toward innovative and efficient infrastructure and service delivery.

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CHAPTER 1: INTRODUCTION

PUBLIC INFRASTRUCTURE DELIVERY OPTIONS

A wide spectrum of options is available for the delivery of public infrastructure and services, ranging from direct provision by the government to outright privatization, with increasing responsibilities, risks, commitment, and rewards transferred from the government to the private sector (NCPPP 2002; 2003). For example, supply and service contracts usually have a short duration. In such contracts, the private contractor performs specified tasks (e.g., material/ equipment supplies, works construction and facilities maintenance) whereas it is not directly responsible for providing related services. In a lease-and-operate contract, the private contractor operates and maintains the facilities at its own risk against the payment of a lease fee. In a build-operate-transfer (BOT) project, the private contractor is also responsible for building and financing the project and it has to transfer project facilities in operational conditions and free of costs to the government at the end of the concession term. In divestiture, the ownership of existing assets and the responsibility for future expansion and upkeep are transferred to the private contractor, in addition to financing and carrying out the investments required to meet the obligations specified in the contract and/ or a general regulatory framework (Guislain and Kerf 1995).

PUBLIC-PRIVATE PARTNERSHIPS

PPPs as an Innovative Means for Infrastructure Development

There is a huge demand on public infrastructure and services worldwide, whereas the government budget of any country is always limited and it may be not desirable to increase taxes to generate the required money because of potential strong public opposition (even when budget deficits are on the rise) and the negative impacts of higher taxes on national and local economies. In addition, the public sector often lacks the technologies, skills and expertise required for efficient infrastructure development. Finally, civil servants often have less incentive to invest wisely than private project managers (World Bank and Inter-American Development Bank 1998). Facing these problems, governments worldwide are exploring innovative means for improved infrastructure development, and consequently different types of public-private partnerships (PPPs) have been practiced. The National Council for Public Private Partnerships (NCPPP) (2003) argues that there should be a broad acceptance of PPPs in meeting the needs of the public in the current climate of budget limitations at all government levels and that the course is inevitable that there will be more PPPs.

In the United States, the federal government calls for an increasing use of outsourcing to strengthen the quality and cost-efficiency of government services and to meet expanding public needs in tight budget times. Ultimately, 50 percent of "commercial activities" conducted by federal agencies are to be reviewed for possible outsourcing. Besides, the federal government is aggressively rating each public agency to assess its progress toward this goal (NCPPP 2003). In the United Kingdom, it is mandatory that all public capital projects should explore potential private finance options (Private Finance Panel 1995). In many developing countries such as China (Zhang and Kumaraswamy 2001), Egypt (Askar and Gab-Allah 2002), and Mexico (Vazquez and Allen 2004), build-operate-transfer (BOT) type infrastructure projects have been developed across a wide range of industrial sectors.

Definition of PPPs

PPPs are contractual relationships between the public and private sectors in public infrastructure development. The Canadian Council for Public Private Partnerships (http://www.pppcouncil.ca) defines PPP as "a cooperative venture between the public and private sectors, built on the expertise of each partner, that best meets clearly defined public needs through the appropriate allocation of resources, risks and rewards." PPPs can involve the design, construction, financing, operation and maintenance of public infrastructure and related facilities, or the provision of services.

No matter what the project scope is, the PPP is often "financially free standing", i.e., the project company is a distinct legal entity where project assets, project-related contracts, and project cashflows are segregated to a substantial degree from the sponsoring entities. Debt and equity used to finance the project are paid back from the cashflows generated by the project. Lenders have no recourse or only limited recourse to the general funds or assets of project sponsors (Finnerty 1996; Merna and Dubey 1998).

PPP Models

A spectrum of contractual models has been practiced worldwide with different degree of responsibilities and risks allocated to the private sector (Delmon 2000), including BBO (Buy-Build-Operate), BLT (Build-Lease-Transfer), BOO (Build-Own-Operate), BOOM (Build-Own-Operate-Maintain), BOOT (Build-Own-Operate-Transfer), BTO (Build-Transfer-Operate), DBFO (Design-Build-Finance-Operate), DBOM (Design-Build-Operate-Maintain), DOT (Develop-Operate-Transfer), LDO (Lease-Develop-Operate), MOT (Modernize-Operate-Transfer), ROO (Rehabilitate-Own-Operate), ROT (Rehabilitate-Operate-Transfer) and TOT (Transfer-Own-Transfer).

However, no matter which PPP model is used, the public sector is still responsible for regulatory control, determining the public services to be provided, relevant quality requirements and performance standards, monitoring the performance of the established PPPs, and taking corrective actions if the performance falls below expectation.

The BOT Concept

BOT is the underlying concept of the various PPP models. A BOT project can be described as a project based on a concession that is usually granted by a public client to a consortium of private sector participants, the concessionaire, who is required to "Build" the project with its own financial arrangements, "Operate" the project during the concession period to recover its investments and obtain a certain level of profits, and to "Transfer" the facilities of the project in an operational condition and usually at no cost to the client at the end of the concession period.

From its definition, it is seen that BOT generates a special purpose vehicle for project finance: the concessionaire is an independent legal entity created under the government-granted concession and registered according to relevant laws of the host country. Central to BOT are the complex contractual arrangements that are designed to fit within the overall legal framework of the host country: the concessionaire enters into contracts with a variety of project participants, for example, a construction contract between the concessionaire and the contractor. These contractual arrangements define each party's roles, liabilities, and apportionment of risks and rewards.

SIGNIFICANCE OF THE RESEARCH

Governments worldwide have shown increasing initiatives in PPPs in the delivery of public infrastructure and services. Since 1985, more than 1370 infrastructure projects with estimated capital costs of over $US575 billion have been developed or proposed to be developed with private finance in more than 100 countries (Ye and Tiong 2003) in both the developed world (NCPPP 2002) and the developing world (International Finance Corporation 1999). These projects are across a wide range of industries and sectors, including power, transportation, water supply/ disposal, telecommunications, oil/ gas, mining, schools, hospitals, and military facilities.

On the one hand, improved deliveries of many major public works and services that would not have been possible without private sector involvement have been widely reported. For example, it is reported that U. S. state and local governments have routinely experienced 10 – 40% cost savings and improvements in service quality and asset management through PPPs (NCPPP 2003). On the other hand, a number of PPP projects suffered disastrous consequences due to lack of knowledge and expertise in financial feasibility analysis, risk identification, assessment and allocation, and effective financial engineering and contractual arrangements. Some of these projects had been postponed or abandoned by the sponsors and others had to be bailed out by the host governments (Ogunlana 1997; Abdul-Aziz 2001). This causes significant political, social, and economic consequences to the public sector and economic losses to the private sector, with an overall impairment to the interests of the general public.

Accompanying the mixed results mentioned in the above, substantial controversy, criticism and conflict exist over PPPs. The division in thinking over PPPs is as wide as the world itself. Opponents argue that (1) the profit-making objective of the private sector motivates them to seek cost savings at the expense of quality services, and therefore, is antithetical to the public's well-being; and (2) the involvement of private companies in public services results in loss of jobs of public employees and consequently a counterproductive relationship with unions of public employees (NCPPP 2002). In contrast, proponents contend that the profit motive of the private sector does not necessarily comprise service quality or reduce public jobs. Instead, improved level of service via cost effective solutions are possible as the private sector can become more accountable to the public through well-designed PPPs, which provide the public sector sufficient control over the works and services being provided by the private sector while allowing the management skills, technologies and financial resources of the private sector to come into play. NCPPP (2003) also provides successful PPP examples in transportation, urban development, schools, water/ wastewater and other infrastructure sectors to support these contentions.

The worldwide interest in PPPs, problems encountered in many countries and the substantial controversy over PPPs call for an improved methodology for improved infrastructure and service delivery. This research has thus been launched to respond to this call.

OUTLINE OF RESEARCH OUTPUTS

In this research, the following outcomes are achieved:

1. The development of an integrated general framework for effective and efficient delivery of public infrastructure and services through systematic approaches to PPPs.
2. The identification of critical issues in the developed general framework in which little research has been done and there is an urgent need in the industry for such issues to be solved for improved practices. These critical issues are

(1) financial evaluation, (2) determination of concession period, (3) concessionaire capital structure optimization, and (4) improvement of contractual arrangements to minimize risks.

3. The development of an innovative financial evaluation methodology that reflects the characteristics of project financing, incorporates simulation and financial analysis techniques, and aims at win-win results for both public and private sectors.
4. The development of a mathematical model that determines the appropriate length of the concession period that demarcates the rights and responsibilities between public and private sectors in a project's life cycle.
5. The development of a mathematical model that optimizes the concessionaire's capital structure when it is subject to various risks and financial viability requirements.
6. The development of a relational concession framework for the establishment of a cooperative and collaborative working environment to minimize opportunism and transaction costs associated with the wide scope of risks/ uncertainties and incomplete information in the long-term concession.

These research outputs make significant contributions to the knowledge body of public works and services provision, to overcoming the various problems currently encountered in international PPP practices and to improving future practices toward effective and efficient public works and service delivery.

BRIEF INTRODUCTION TO RESEARCH OUTPUTS

Systematic Framework for Infrastructure Delivery

This systematic framework is proposed for the delivery of public works and services in general on the realization that although there are many aspects that are project-, sector-, and/or country-specific, the concept, process and key principles in infrastructure and service delivery through PPPs are essentially identical. Justified by public procurement principles, aimed at a public-private win-win solution, and based on worldwide best industrial practices and lessons from unsuccessful projects, this framework integrates the four broadly divided stages that repeat over time possibly as long as the service is needed: (1) design of a workable concession, (2) competitive concessionaire selection, (3) economic regulation, and (4) periodic reconcession and rebidding.

The scenario of the framework is as follows. The public procurement principles and public-private win-win solution act somewhat as guidelines or constraints for decisions made in each of the four stages of the framework. The four-stage framework takes into account the requirements of public services, realignment of responsibility and reward among multiple project participants in PPPs, the monopolistic rights of the concessionaire, and the wide range of risks and uncertainties in the long-term contract period. The design of the right concession forms the base on which other stages are implemented, in addition to planning the project and allocating risks for enhanced efficiency. The economic regulation allows the government to address changing conditions and regulate the concession for efficient operation with due discretion, whereas the competitive concessionaire selection and periodic rebidding play an important role in achieving innovation, efficiency and cost effectiveness through direct competition which extracts monopoly rents without government discretionary intervention.

Varying competition elements are incorporated in each of the four stages for continuous performance improvement of the concessionaire in the delivery of infrastructure and services. In the concession design stage, risks are effectively controlled through appropriate risk allocation and right selection of a PPP model. In the concessionaire selection stage, the most competent consortium available is chosen through competitive bidding, which also forces the chosen concessionaire to offer cost-effective services at required quality standards. During the concession, the economic regulation maintains a competition environment to address potential efficiency problems related to the incumbent concessionaire's monopolistic rights and to ensure its continuous efficiency improvement. By periodic rebidding at the end of each concession, new entrant is allowed to compete for the concession and this enhances competitive efficiency for the following concession by choosing a new concessionaire (if available) that is more competent than the incumbent. Periodic rebidding also keeps incumbent concessionaire under pressure to improve performance during the term of the current concession in order to raise its chances of keeping the following concession, and to offer competitive service in the following concession if selected.

Financial Evaluation Methodology

The financial evaluation of a privatized infrastructure project is complex and challenging because of the risks and uncertainties related to the large size, long contract duration, non-recourse financing, multiple project participants that have different motives and interest, and the complexity of the contractual arrangements. The radical reallocation of risks among project participants make the concessionaire undertake much more and deeper risks than a mere contractor. Construction and economic risks are the two major risks to the concessionaire. Successful development of a privatized project necessitates the effective management of these risks and the use of improved financial engineering techniques to overcome the limitations of traditional financial analysis techniques in addressing risks and uncertainties.

This proposed financial evaluation model reflects the characteristics of project financing, incorporates simulation and financial analysis techniques, and takes a win-win perspective for all parties involved. In addition to the financial viability indicators used in a traditional project evaluation, the proposed model examines the equity level, types of equity participation, equity at project risk, ratio of equity at project risk, self-financing ability, project bankruptcy probability during construction, and the value of government loan guarantee. This model also evaluates the impacts of governmental guarantees and supports and addresses the issue of the equity holders' commitments to project success.

Capital Structure Optimization Methodology

The capital structure affects the allocation of responsibilities and risks among project participants, the total life cycle project cost, and consequently the financial viability of the project. The capital structure also affects the motivations and commitments of different project participants to the success of the project. The proposed optimization model optimizes the capital structure when it is under construction risk, bankruptcy risk and various economic risks and is subject to other constraints as imposed by different project participants.

The financial evaluation and capital structure optimization models significantly facilitate both public and private participants in evaluating a privatized project's financial viability and collectively determining an optimal capital structure that safeguards their respective interests.

Methodology for Concession Period Determination

Concession period is one of the most important issues to be addressed in private sector provision of public works and services through concession arrangements as it, to some extent, demarcates the rights and responsibilities between public and private sectors in a project's life cycle and it also is critical to the project's sustainable development. Different projects will incur different cash flow profiles during their operations. In general, a shorter concession period benefits the public client with reduced interests to the private sector when the unit service charges from the private sector are the same. If the concession period is too short, the private sector parties may lose interest in the project, set up high tariff/ toll levels, or require the public client to grant them the right to adjust tariff/ toll levels in the operation period so that they can recover their investment and gain a certain level of profit. High tariff/ toll levels often encounter strong pubic oppositions. At present, in most countries, the general public is not used to the idea of "users pay" for infrastructure projects, not to mention high tariff/ toll levels. Frequent adjustments of service fees can also result in public complaints/ oppositions. If the concession period is too long, the public sector's benefits may be sacrificed.

A concession period should protect the interests of both the public and private sectors. It is a common practice in PPP infrastructure projects that the government predetermines a "fixed" concession period and invites the private sector to bid for other aspects of a PPP project. This research proposes a methodology for the determination of an appropriate length of the concession based on a win-win principle for parties involved and exercises simulation techniques in measuring and reasoning construction and economic uncertainties and risks. This methodology allows the public client to determine an appropriate range of the concession period based on its own cost and revenue projections and let the private sector participants to bid for a "flexible" concession period that is within this interval. The determination of this concession interval is based on the principle that the private sector's level of profit should be reasonable but not excessive, and takes into consideration of: (1) total project development costs; (2) cash flows in the operation period; (3) construction and economic risks; and (4) current and predicted levels of service prices of comparable projects.

A case study of a hypothetical infrastructure project is provided to demonstrate the application of the proposed methodology, mathematical model and simulation techniques.

Relational Concession Framework

Different types of concessions have been in practice in worldwide infrastructure development as a means to create competition in industrial sectors that are naturally monopolistic where ordinary competition would not work effectively. For projects that require substantial up-front capital investments, pure concessions (concessions *stricto sensu*) are often exercised, which include the build-operate-transfer (BOT) scheme for greenfield projects and the rehabilitate-operate-transfer (ROT) scheme for projects requiring considerable rehabilitation investments. In practice, a long fixed-length complete contract is usually used in these pure concessions. However, there are well known problems in complete contracts, which are most amenable to full specification *ex ante* for projects with relatively predictable outcomes and clear lines of authority and responsibility. A complete contract lacks flexibility to adapt to a changing environment, and failure to design complete contracts fully in advance is all too likely to lead to disaster in the future. In addition, high transaction costs are often incurred to develop long-term complete contracts. As concessions *stricto sensu* typically last many years, with fundamental realignment of risks, responsibilities and rewards among multiple participants and via a project finance principle, the potential changes in a wide range of areas (political, social, technical, economic and environmental) over the long concession period may render a complete contract impractical and unworkable.

The proposed relational concession framework deals with problems related to traditional "complete" contractual arrangements in order to establish a cooperative and collaborative working environment to minimize opportunism and transaction costs associated with the wide scope of risks/ uncertainties and incomplete information in the long-term concession. This framework mainly focuses on the following three key aspects: (1) enhancing economics of public procurement, (2) creating a favorable relational contracting environment and (3) applying appropriate relational concession principles.

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CHAPTER 2: SYSTEMATIC FRAMEWORK [1]

INTRODUCTION

There is a huge demand on public infrastructure and services worldwide, whereas the government budget of any country is always limited and it may be not desirable to increase taxes to generate the required money. In addition, the public sector often lacks the technologies, skills and expertise required for efficient infrastructure development. Furthermore, civil servants often have less incentive to invest wisely than private project managers (World Bank and Inter-American Development Bank 1998). Facing these problems, governments worldwide are exploring innovative means for improved infrastructure development, and consequently different types of public-private partnerships (PPPs) have been practiced. In the USA, the federal government calls for an increasing use of outsourcing to strengthen the quality and cost-efficiency of government services. Besides, the federal government is aggressively rating each public agency to assess their progress toward this goal [National Council for Public-Private Partnerships (NCPPP) 2003]. In the United Kingdom, it is mandatory that all public capital projects should explore potential private finance options (Private Finance Panel 1995). In many developing countries such as China (Zhang and Kumaraswamy 2001), Egypt (Askar and Gab-Allah 2002), and Mexico (Vazquez and Allen 2004), build-operate-transfer (BOT) type infrastructure projects have been developed across a wide range of industrial sectors, including power, water and transportation.

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PPPs play an important role in bringing private sector competition to public monopolies in infrastructure development and service provision, and in merging the resources of both public and private sectors to better serve the public needs that otherwise would not be met. A great number of infrastructure projects have been successfully developed through PPPs with significantly increased value and substantial cost savings. For example, it is reported that U.S. state and local governments have routinely experienced 10 – 40% cost savings and improvements in service quality and asset management through PPPs (NCPPP 2003). On the other hand, many privatized projects suffered disastrous consequences because of construction cost/ duration overruns, changing market demand, depreciation of local currencies and/ or reduction in tolls/ tariffs by utilities. Some of them had been postponed or abandoned by the sponsors, and others had to be bailed out by host governments (Ogunlana 1997; Ye and Tiong 2000; Abdul-Aziz 2001).

Accompanying the mixed results mentioned in the above, substantial controversy, criticism and conflict exist over PPPs. The division in thinking over PPPs is as wide as the world itself. Opponents argue that (1) the profit-making objective of the private sector motivates them to seek cost savings at the expense of quality services, and therefore, is antithetical to the public's well-being; and (2) the involvement of private sector in public services results in loss of jobs of public employees and consequently a counterproductive relationship with unions of public employees (NCPPP 2002). In contrast, proponents contend that the profit motive of the private sector does not necessarily comprise service quality or reduce public jobs. Instead, improved level of service via cost effective solutions are possible as the private sector can become more accountable to the public through well-designed PPPs, which provide the public sector sufficient control over the works and services being provided by the private sector while allowing the management skills, technologies and financial resources of the private sector to come into play. The NCPPP (2003) provides successful PPP examples in transportation, urban development, schools, water/ wastewater and other infrastructure sectors to support these contentions.

The worldwide interest in PPPs, problems encountered in many countries and the substantial controversy over PPPs call for an improved methodology for improved infrastructure and service delivery through PPPs. The writer has thus conducted a research corresponding to this call. This research results in a better understanding of PPPs and the development of a framework that integrates different stages in the delivery of public works and services and systematically addresses the key issues in each stage in order to achieve continuous efficiency improvement. This framework is based on worldwide best industrial practices and lessons from unsuccessful projects, aimed at public-private win-win outcomes, and justified by public procurement principles. Details of the research outputs are provided in the following sections.

PUBLIC PRIVATE PARTNERSHIPS AND CONCESSIONS

The Canadian Council for Public-Private Partnerships (http://www.pppcouncil.ca) defines the PPP as "a cooperative venture between the public and private sectors, built on the expertise of each partner, that best meets clearly defined public needs through the appropriate allocation of resources, risks and rewards." Typically in a PPP, the government entrusts through a concession a private entity (hereinafter referred to as the concessionaire) with predefined exclusive rights to (1) implement a project, in which the concessionaire is responsible for and has some freedom to choose the means for achieving specified performance targets related to construction of infrastructure facilities, long-term operation and maintenance of these facilities, and provision of relevant services; and (2) to collect fees for its services.

Concessions are most suitable to naturally monopolistic infrastructure sectors rather than potentially competitive sectors for which ordinary competition may be more appropriate. Concessions are deployed to promote infrastructure development and increase efficiency by two means. First, concessions play a key role in bringing competition to public monopoly by substituting competition for the market for competition in the market for a monopolistic infrastructure sector where ordinary competition may be not workable or even inefficient and wasteful. For example, in the nineteenth century, competing companies laid parallel water pipes in the United Kingdom and parallel railway lines in Germany (World Bank and Inter-American Development Bank 1998). Second, as a flexible mechanism, concessions may overcome many obstacles to private finance initiatives and thus enable the public sector to use private funds, technology, knowledge and expertise, especially in developing countries where there is usually a shortage of funding and inadequate legal framework for private finance, for example, (1) by leaving formal ownership of the project assets to the government in a country where the law excludes private ownership of specific infrastructure assets; and (2) by making the concession agreements as specific as required and allocating risks in a way to give investors the comfort they need to venture their capital in specific countries and markets where the general and vaguely defined regulatory approaches would deter investors (Guislain and Kerf 1995).

FRAMEWORK FOR A SYSTEMATIC APPROACH

Four-Stage Framework

A systematic approach is taken in the proposed framework for infrastructure development through PPPs in general. Basically, the proposed framework (please see Figure 2.1) integrates four broadly divided stages in the infrastructure and service delivery process, including (1) design of a workable concession, (2) competitive concessionaire selection, (3) economic regulation of the selected concessionaire during the concession period, and (4) periodic reconcession and rebidding to allow changes and adjustments of the concession, and new entry for the concession. This general framework is proposed on the realization that although there are many aspects that are project-, sector-, and/or country-specific, the concept, process and key principles in infrastructure and service delivery through PPPs are essentially identical, which is supported by the World Bank and Inter-American Development Bank (1998).

Public Procurement Principles

The acquisition of public works and services should follow relevant procurement principles, mainly including accountability, transparency, value for money and fair competition (Department of Finance and Personnel for Northern Ireland 2002). Accountability requires clarity in assigning responsibilities to project participants and answerability of the concessionaire to the government, regulator, and the general public. Transparency necessitates an open approach to decision-making, which enables the establishment of a mutual trust between public and private sectors. For example, the government must make explicit its objective and requirements in a business transaction, key assumptions about risk definition, assessment and allocation, the format of the tender

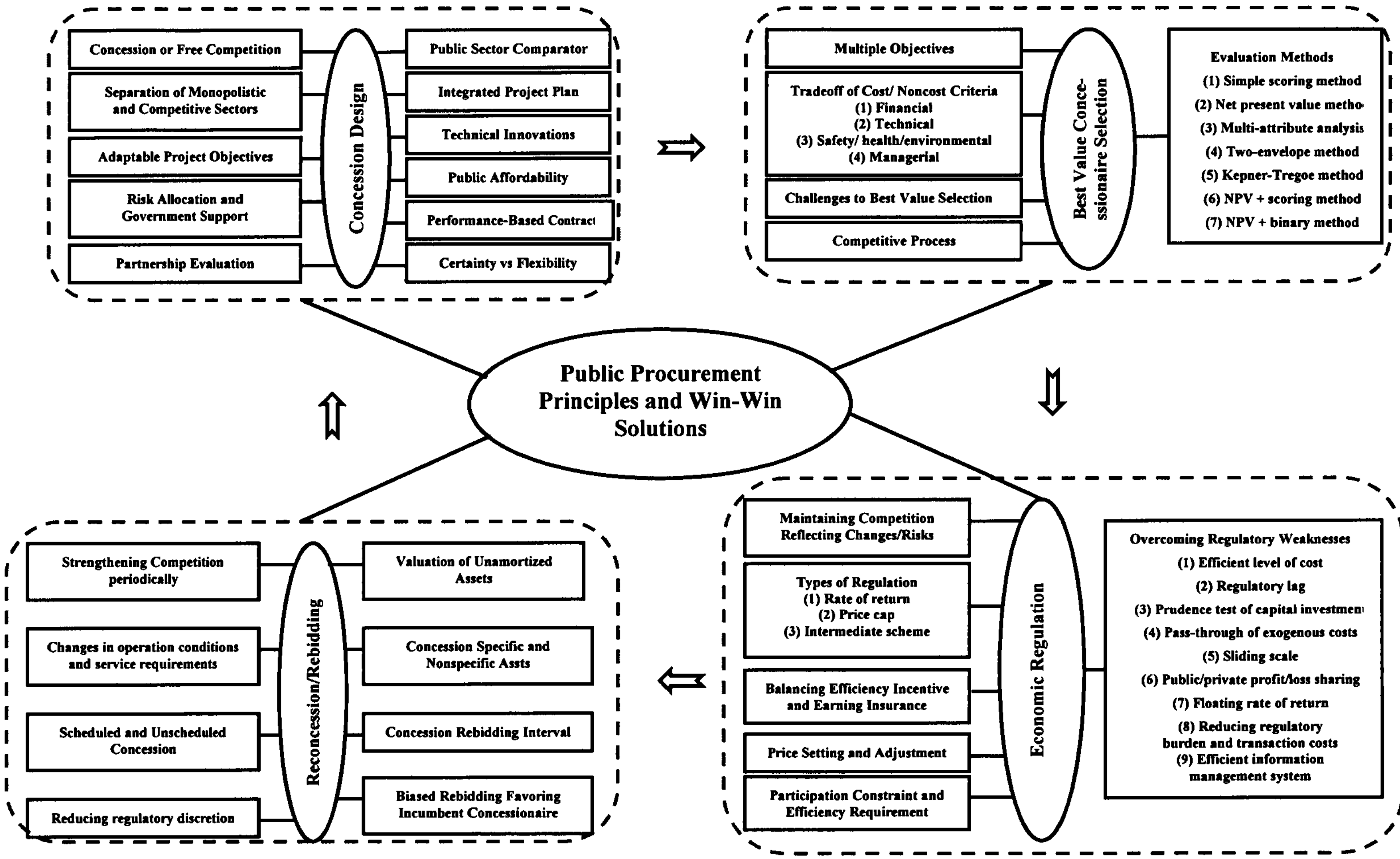

Figure 2.1 Four-stage systematic framework for PPPs in infrastructure development

proposal and the definition of a non responsive proposal, the tender evaluation criteria and their relative importance, contracting monitoring methods, payment methods, incentive schemes, etc. Value for money requires that costs associated with the acquisition of a public work and/or service should be justified by the value generated from such a business transaction. Measures should be taken to ensure that the profit motive of the private enterprise does not lead to an undermining of the public good.

Public-Private Win-Win Solutions

Public and private sectors have different objectives and concerns in a PPP project. Private parties seek to make adequate returns to their investments in a stable environment and are concerned with the large amount of capital expenditure that is usually sunk and subject to social, political, economic, technical and environmental risks. For example, the service price is subject to political pressures and public regulation, and there may be risks related to the convertibility and transfer of revenues in a project that involves foreign currencies whereas revenues are raised in local currency. On the other hand, the government seeks to eliminate/ minimize abuses of monopoly power by the private sector in order to maximize productive and allocative efficiencies, maintain appropriate quality, environmental, and health standards, and achieve social objectives. Successful infrastructure development through PPPs necessitates the adoption of a public-private win-win solution that adequately addresses the concerns and guarantees the interests of both sectors.

The requirement of a win-win solution is confirmed by Laffont and Tirole (1993), who maintain that the regulator should design a contract that is (a) acceptable to the regulated firm and (b) as good as possible for society as a whole. This equivalently means that a concession agreement should satisfy the "participation constraint" to prevent the concessionaire from bankrupting and to provide it with incentives to be efficient (Ergas and Small 2001).

This win-win solution should combine the strengths of both sectors, allocate risks to the parties best able to manage them, incorporate the best industrial practices, draw relevant lessons, and explore new technologies and innovations through flexible procurement policies and creative financial engineering techniques. This solution should enable the private sector to make a reasonable level of profit through user fees and/ or revenues from project-related property development while allows the public sector to utilize private capital to build desperately needed infrastructure facilities and provide cost-effective services. Furthermore, the public sector should have a reasonable share of the efficiency gains from infrastructure privatization. Otherwise, there may be a strong opposition to PPPs from the general public, as in Chile, the Congress became reluctant to endorse a new wave of privatization in the water and ports sectors, arguing that users benefited too little from earlier waves of infrastructure privatization (Burns and Estache 1999). In a word, PPPs should enhance the public good cost-effectively while allowing the private sector to make "reasonable" money.

Rationale of the Framework

The public procurement principles and public-private win-win solution act somewhat as guidelines or constraints for decisions made in each of the four stages of the framework, which repeat over time possibly as long as the service is needed. The four-stage framework takes into account the requirements of public services, realignment of responsibility and reward among multiple project participants in PPPs, the monopolistic rights of the concessionaire, and the wide range of risks and uncertainties in the long-term contract period. The design of the right concession forms the base on which other stages are implemented in addition to planning the project and allocating risks for enhanced efficiency. The economic regulation allows the government to address changing conditions and regulate the concession for efficient operation with due discretion, whereas the competitive concessionaire selection and periodic reconcession and rebidding play an important role in achieving innovation, efficiency and cost effectiveness through direct competition which extracts monopoly rents without government discretionary intervention.

Varying competition elements are incorporated in each of the four stages for continuous performance improvement of the concessionaire in the delivery of infrastructure and services. In the concession design stage, risks are effectively controlled through appropriate risk allocation and right selection of a PPP model. In the concessionaire selection stage, the most competent consortium available is chosen through competitive bidding, which also forces the chosen concessionaire to offer cost-effective services at required quality standards. During the concession, the economic regulation maintains a competition environment to address potential efficiency problems related to the incumbent concessionaire's monopolistic rights and to ensure its continuous efficiency improvement. By periodic reconcession and rebidding at the end of each concession, new entrant is allowed to compete for the concession and this enhances competitive efficiency for the following concession by choosing a new concessionaire (if available) that is more competent than the incumbent. Periodic rebidding also keeps incumbent concessionaire under pressure to improve performance during the term of the current concession in order to raise its chances of keeping the following concession, and to offer competitive service in the following concession if selected.

DESIGN OF CONCESSION

Concession or Not

As discussed in the above, concessions are maneuvered to achieve one or both of the two main purposes: (1) bringing competition to government monopolies and (2) attracting private funds, technology, knowledge and expertise. The concession option should be evaluated against other two alternatives, i.e., one that completely relinquishes government monopoly and allowing direct competition in the market, and the other that continues government self-provision through a traditional public procurement approach. If it is determined that concession is the best option, then the next step is to focus on designing an appropriate concession that reflects the country and sector specific conditions and demonstrates the best value. Several key issues need to be dealt with in concession design and these are discussed in detail in the following sections of this part.

Separation of Monopolistic Sectors from Competitive Ones

Concessions are most suitable for naturally monopolistic infrastructure sectors. Therefore, there is a need to differentiate monopolistic industries from competitive ones. The World Bank and Inter-American Development Bank (1998) list (1) the following sectors as natural monopolies and therefore the most suitable candidates for concessions: water distribution, power transmission and distribution, gas transmission and distribution, railway infrastructure, and roads; and (2) the following sectors as potentially competitive and therefore ordinary competition should be considered first before using concessions: power generation and supply, gas production and supply, long-distance and mobile telecommunications and rail services. Furthermore, an infrastructure sector may contain potentially competitive and inherently monopolistic segments. Competitive segments (e.g., power generation and retail supply) may be separated from monopolistic ones (e.g., power transmission and distribution). In general, it is advisable that the government allow ordinary market competition to play in the potentially competitive sectors/ segments and design competitive concessions for sectors/segments that are naturally monopolistic. However, please note that concessions may not necessarily be the wrong option for potentially competitive sectors/segments. For example, if the industry is too small to support effective competition, a competitively awarded concession may be an appropriate option. Nonetheless, before turning to a concession option, the ordinary market competition alternative should be examined to see whether it works or whether it can be made to work by reforming and restructuring the industry.

Adaptable Project Development Objectives

Whether privatized or not, each proposed public infrastructure project has established development objectives that reflect the needs of the public and the missions of the government authority concerned. These objectives should be realistic and flexible so that they are adaptable to possible changes in the long concession period. The project scope may be related to the situations of market demand and different investment scenarios planned for alternative market possibilities instead of fixing the milestones of investments. Overly ambitious and rigid objective may cause problems. For example, in 1993, the government of Argentina partitioned its national freight rail network through 30-year concession contracts, in which the concessionaires were required to invest about $1.2 billion in the network over 15 years. Some of the concessionaires failed to make the scheduled investments and even abandoned some lines due to the lower-than-expected traffic levels. It was apparent that the initially designed project scope and investment milestones were unnecessary and uneconomic as the actual traffic levels were only 60 to 70 percent of the initial projections and actual revenues only about half of the initial projections. However, the lack of flexible mechanism for contract renegotiation rendered the government in a dilemma of enforcing the contracts to penalize the concessionaires for not meeting the milestones to the detriment of the concessionaires and the national rail system, or ignoring the investment requirements of the concession agreements, which undermines the credibility of the concession program (Estache and Carbajo 1996).

Risk Allocation and Government Support

Allocation of risks among project participants is at the core of concession design. Public and private sectors have different capabilities and may deploy different measures to mitigate different types of risks. In general, risks should be allocated to the party who is best positioned to manage them, for example, in terms of possession of information and accessibility to necessary risk hedging instruments. World Bank and Inter-American Development Bank (1998) summarize the main types of risks encountered in infrastructure projects and the way in which they should normally be allocated, not only between the government and concessionaire, but also between other parties, such as contractors, suppliers, insurers, and users.

The government should only transfer risks that can be better managed by the private sector, and retain risks that are beyond the control of the private parties. Furthermore, private sector investors are usually risk averse. The government may even share some of the risks that are supposed to be better managed by the private sector to encourage more private parties to take part in the bidding process, thereby enhancing competition and consequently increasing the chance of obtaining the best offer. However, the government should limit its contingent liabilities, and ensure that the risk sharing mechanism should not result in concessionaire's weak incentives to take measures to minimize risks or adopting other types of uneconomic behavior. One case to the point is the highway concessions in Mexico, in which construction companies tended to both underbid and exaggerate their "sweat equity" when the government granted concessionaires the right for concession extension if cost overruns surpassed 15% of the original project budget. This was part of the reason that brought about the financial collapse of most of the projects, and consequently half of the concessions had to be bailed out by the government who contributed US$8 billion (Vazquez and Allen 2004).

Evaluation of Partnership Models

Concessions are defined by the underlying contractual arrangements of the particular PPPs adopted. There is a spectrum of contractual models for PPPs with different scenarios of responsibility and risk allocation among project participants. For example, United States General Accounting Office (1999) has defined the following models of PPPs: build-own-operate, build-operate-transfer, buy-build-operate, design-build-operate, and build-develop-operate. However, please note that these PPP models are not always used consistently across countries or even within a country. What matters most are the risk allocation and incentives built into a specific PPP scheme. Therefore, designing a scheme that strikes the right balance between the interests of the public and private sectors and that fits the conditions of the industrial sector and the country concerned is pivotal (Guislain and Kerf 1995).

In partnership evaluation, the government compares different PPP models and consequently chooses an appropriate one for the project under consideration. For this purpose, the Treasury Taskforce (1997) suggests the following approaches: (1) checking each PPP model against the public client's business needs, policy objectives and available resources; (2) estimating the potential cost savings and/or service quality improvement of each PPP model; and (3) and examining the likelihood of successful development of each model in the light of the particular conditions of the project, such as the operational needs, risk structure, the proposed scope of risk transfer to the private sector, and the interest and capacity of the private sector.

Comparison with Traditional Procurement Approaches

The chosen PPP model may need to be compared with a public sector comparator (PSC) to demonstrate value for money and enhance the partnership evaluation. This is practiced in the United Kingdom. The PSC describes a traditional public procurement option for the project under consideration. However, the PSC does not necessarily mean the government providing all assets and services directly, but assuming some greater degree of involvement in project development. The key issue for the PSC is to identify all the costs and benefits to the public if the project were to be provided by a traditional means the full range of services required under the chosen PPP model. In this regard, one point needs to pay attention is that the PSC should include the quantified costs of risks being retained by the government such as construction cost overruns, and technological obsolescence in addition to the capital expenditure, operation and maintenance costs. Such comparison should be made over the whole contract life and reflect all the constituents of the contract. Alternative benchmarks may be used as the PSC for financial comparisons with the PPP approach. This may be a "do nothing" option, the costs and rates of return available in the current market, a similar project recently developed, or a quite different way to achieve same objectives as required under the PPP model (Higher Education Funding Council for England 1997; Construction Industry Council 1998; Treasury Taskforce 2000).

Integrated Project Plan

Two approaches may be taken to integrate projects for improved concession design and consequent better infrastructure development and management. One is to package a new project or projects to an existing project or projects. The Yan'an Donglu tunnel project in Shanghai, China provides an example. The 30-year long BOT project includes two tunnels, Yan'an Donglu 1st Tunnel, which has been in operation since 1988, and Yan'an Donglu 2nd Tunnel. The concessionaire is a joint venture of the Chinese state-owned Shanghai Huangpujiang Tunnel Company and Hong Kong Jingli Company Ltd, with each company contributing 50% of the total investment in the project. The investment of the former was the asset value of Yan'an Donglu 1st Tunnel while the latter input in cash (Zhang et al. 1998). The other is to bundle non-profitable and/ or less-profitable projects to profitable projects so that profitable projects cross-subsidize less-profitable and/ or non-profitable ones. For example, in Japan, a toll revenue pooling system is adopted, where tolls are set at equal levels for the entire national expressway network regardless of the costs or traffic levels on the individual segment (Vazquez and Allen 2004). The private sector usually lacks interest in developing a non- or less-profitable project on their own. Without bundling, they would call on the government to provide part of the finance and/ or charge prohibitive prices for services provided by the project. In the former the government may not have money while in the latter public opposition may be incurred by the unaffordable price.

The practices of packaging and bundling projects allow for expansion and improvement of the network at a faster pace and produces economies of scale, reduce transaction costs, diversify risks, and provide flexibility to the design of concession. They enable projects that lack self-financing ability due to low levels of usage and/ or high construction costs to be developed without government financial inputs that are often straitened. These practices also increase the usage of infrastructure facilities due to reduced prices. However, please note that cross-subsidies may be distortionary and anticompetitive, and measures should be taken to counter this negative effect.

Technical Innovations

The government often provides a preliminary or complete design for the project to be developed through PPPs. This way the government loses the opportunities of exploring the knowledge and expertise of the private sector for a potentially improved design that may significantly reduce project life-cycle costs and increase efficiencies, and even bears some construction risks related to changes to the original design. To counter these problems, the government may require the private sector to design the project, or initiate a design competition to solicit innovative designs. In either case, a value engineering process may be conducted in the early design stage, where the government and the private sector participants (e.g., designer, contractor and operator) meet to generate innovative ideas to improve the constructability, operationability and maintainability.

Affordability

PPP projects often involve large amounts of construction costs and long-term service delivery. The government needs to specify its affordability threshold for a proposed PPP project. This affordability threshold acts as a price target for the private sector bidders to evolve innovative solutions. A bid that exceeds the government's affordability will surely lose ground and should be dropped in the selection process (Treasury Taskforce 1999). The affordability criterion works like a two-edged sword in maximizing the value of the proposed project. On the part of the clients, it moves their attention concerning consortium selection away from lowest price to other issues, one of which is value for money. On the part of private sector consortia, criteria other than price are used to endear the clients, of which innovation is usually invoked heavily in an attempt to provide solutions that surpass other competitors, yet meeting the government's affordability threshold (Akintoye et al. 2003).

Performance-Based Contracting

Performance-based contracting relates payments, bonuses and penalties to performance levels of the concessionaire in the current concession and even to future contract award decisions. It creates a powerful incentive for the concessionaire to achieve excellence and customer satisfaction (Office of Federal Procurement Policy et al. 1998). For example, in Argentine road concessions, a serviceability index was used to measure performance (Estache and Carbajo 1996) and in highway concessions in the United Kingdom, payments are linked to performance measures, e.g., availability of carriageways and footways, road accidents, operational standards, bus journey time reliability, junction delays and queue lengths (United Kingdom Highways Agency 1997).

Certainty versus Flexibility

Although the concession can be designed in detailed and strict terms on the rights and responsibilities of both public and private sectors, there is a need of certain degree of discretion for the government to address possible changes and new developments of the project in the long concession period. Three main factors affect the level of government discretion: (1) level of country risk, (2) reputation of the private parties involved in the project, and (3) characteristics of the infrastructure sector and the particular conditions in which the project will operate. High level of discretion is allowed when the country has a stable political, social, legal and economic environment for private investments, and the private parties involved have good reputation. In a country without a sound legal system, high level of discretion may significantly increase the private sector's perceptions of risks and, consequently the increase in the cost of capital. The private sector is usually concerned with that the government's discretionary power may be misused. To alleviate this concern, necessary recourses may be provided to the private sector against the government's possible inappropriate discretionary decisions.

BEST VALUE CONCESSIONAIRE SELECTION

Best Value Source Selection and Its Challenges

The best value source selection (BVSS) is a multi-criterion evaluation methodology that allows tradeoffs among cost and non-cost criteria. The BVSS enables the government to select a higher priced project proposal instead of the lowest priced one provided that the increased benefits merit the additional cost. The BVSS encourages creativity and innovation from interested parties in meeting the requirements of a public project and provides the public client flexibility to select a project proposal that offers the best value.

The BVSS has been increasingly used in various types of PPPs in worldwide procurement of public works and services in order to address the multi-objectives of public clients in formulating such partnerships with the private sector and the radical realignment of risks, responsibilities and awards among project participants. However, the BVSS is open to wide criticism by many contracting specialists from both the private and public sectors who think that the process is used with broad discretion to award public contracts and usually subjective (Mickaliger 2001). For example, strong challenges to the BVSS have occurred from private sector participants, who (1) question how the government has made its decision based on price and non-price criteria, and whether it has conducted a thorough analysis and fully documented the contract award decision; (2) doubt whether they have received fair evaluation during a BVSS process; (3) question what are, and argue against, the discriminators that led to their nonselection; (4) allege that the increased value of the chosen proposal does not merit its additional cost; and (5) criticize the government of using the best value technique to ensure the party of its choice receive the contract.

Best Value Source Selection Methodology

The courts have considered the challenges to the BVSS and the legal decisions have upheld the BVSS as long as the government documents its rationale for the tradeoff between cost and non-cost criteria (Mickaliger 2001). Therefore, the public client should develop a sound BVSS methodology that meets the requirement of the legal decisions in order to withstand any protest proceeding concerning a contract award in a BVSS.

The essence of a sound BVSS methodology lies in (1) the adoption of a competitive source selection process that encourages innovative solutions; (2) the establishment of a set of cost and non-cost evaluation criteria that effectively "predict" the private sector participants' capability and their potential contributions to the public client's best value objectives; (3) the development of a sound evaluation method that ensures the right "tradeoff" between these criteria such that a defensible contract is awarded to the right private sector partner, whose proposal is perceived to be able to maximize the outcome of the project under consideration.

Competitive Source Selection Process

A competitive environment should be maintained throughout the BVSS process to motivate the private sector toward innovative and cost-effective solutions, efficient management of risks, and quality service. A competitive process has the potential to significantly increase the outcomes of the acquisition. This is corroborated by the US federal government, which has realized cost savings between 20 to 50 percent when federal and private sector service providers compete for the provision of public works and services. However, in many countries, competition between public and private sources remains an unfulfilled government promise as public agencies as a whole rarely subject commercial tasks traditionally performed by them to private sector competition (The National Council for Public-Private Partnerships 2003).

Governments should change their mind setting and encourage private sector competition. One measure is to invite the express of interest from a wide range of industrial sectors by publishing a notice in newspapers and/or journals/ magazines. For example, PPP projects in the UK that are above a specified threshold project value are required to advertise in the *Official Journal of the European Community*. Another measure is to compensate for an appropriate level of the tendering costs of the private sector participants whose proposals are not successful. Compared to traditional design-bid-build projects, greater efforts and resources are needed in putting up and maintaining a multi-participant consortium and developing an innovative and cost-effective PPP proposal, because of the additional estimates/evaluation, risk assessment and mitigation, advancement of services, and the complexity of contractual and financial arrangements. In view of the large amount of tendering costs, potential private sector participants may be not willing to take part in the competition and as a result the chance of the public client to get the best offer is reduced. However, while the compensation should be adequate to cover the substantial design effort of private sector participants in preparing proposals, it should not be set so high that parties will offer proposals merely to make a profit on the compensation. It is argued that a reimbursement at one-third of the auditable design hours of the party making an offer will offset the designers' actual costs without decreasing competition (Akintoye et al. 2003; Molenaar and Johnson 2003).

Transparent and Valid Evaluation Criteria

The public client's best value objective should be translated into an appropriate set of effective evaluation criteria that measure a private sector party's capability and predict its potential level of contributions to the public client's best value objective. The criteria should be unambiguous. This not only provides transparency in the award process, but also avoids unnecessary complications resulting from tradeoffs between offers on multiple criteria by competing bids (Estache and Carbajo 1996). The criteria and their weighting should also be justified. Otherwise, the best value objective of the public client may be impaired in addition to the possible protests filed by unsuccessful tenderers. Therefore, actual project data need to be collected and correlated to the completed project value, and sensitivity analysis conducted to determine the appropriate value of technical weighting and the cost weighting in order to achieve the "real" best value through an equitable BVSS process (Molenaar and Johnson 2003).

Through a systematic research approach, Zhang (2005) has developed a four-package evaluation criterion set for PPP projects in general. The four packages are (1) financial, (2) technical, (3) safety, health and environmental, and (4) managerial. Statistical analyses of the responses from a structured questionnaire survey of international experts on the relative weighting of the four packages and the relative significance of the criteria within each package have concluded that the four-package criterion set may be used as a common set of evaluation criteria for PPP projects in general, and be tailored for a specific PPP project by making appropriate adjustments to reflect the uniqueness of the project, such as the type and scope of the project, the PPP model chosen, and the allocation of responsibilities and risks among project participants.

Suitable Evaluation Methods

A number of tender evaluation methods for PPP projects are currently in use. These include the simple scoring method, net present value method, multi-attribute analysis, Kepner-Tregoe decision analysis technique, two envelope method, net present value (NPV) method + scoring method, and binary method + NPV method. Zhang (2004) provides a brief discussion of these methods. The binary method, simple scoring method and two-envelope method may be more appropriate for small and simple projects. For projects in which technical issues are not a problem and there exists proven construction technology, the NPV method may be more suitable. For complex projects, the multi-attribute analysis and the Kepner-Tregoe decision analysis technique may be more fitting. Furthermore, financial aspects are the most important issue that needs to consider in concessionaire selection. Hence, the financial package is usually assigned a much higher weight than other evaluation packages, and the NPV method is often used in conjunction with other evaluation methods to enhance the appraisal of financial aspects.

ECONOMIC REGULATION

Objective of Economic Regulation

In general, the objective of economic regulation is to maximize the incentive of the concessionaire to operate efficiently while respecting the participation constraint (discussed in detail in a following section) for continued provision of services in order to safeguard the interests of both public and private sectors. This objective is achieved through the following measures: (1) preventing the concessionaire from abusing its monopoly rights associated with the concession to realize supra normal profits; (2) maintaining a fair competition environment to ensure cost-effective and quality services; (3) sustaining a relatively stable and public-affordable price regime; and (4) addressing either ex ante or ex post the changes in the concession period to enable the concessionaire to achieve a "reasonable but not excessive" level of profits.

Types of Economic Regulation

Economic regulation mechanisms may be broadly divided into three categories: (1) rate of return, (2) price cap, and (3) intermediate scheme that lies in between (1) and (2) (Burns and Estache 1999).

Rate of Return

Rate of return regulation is also called cost of service regulation in that it essentially allows the concessionaire to pass through those costs which are deemed necessary for the concessionaire to provide the required services at the specified quality. Pure form of rate of return regulation protects the concessionaire against any economic loss and guarantees a predetermined rate of return to the investments of the concessionaire in each period of the concession. The rate of return is determined in part based on the cost of capital to the industry to which the project belongs (Energy Information Administration et al. 1997). These "necessary" costs are the base on which to derive the required level of revenues, which in turn determines the prices to be charged for services provided by the concessionaire. The price is regulated to ensure that the resultant revenues are just sufficient to cover the costs incurred. If the revenues are less than the required amount, the price will be increased and/or the excessive revenues in previous years used to compensate for the revenue shortage in the current year, and to ensure adequate revenues for future years. Conversely, revenues in excess of the required amount are revert to the public sector and/or prices frozen or even reduced for the following years (World Bank and Inter-American Development Bank 1998). Therefore, as the price is regulated up or down to reflect such changes, fluctuations in demand and costs will not affect the concessionaire's level of profit.

Price Cap

The price cap regulation limits the highest price the concessionaire could possibly charge in each year of the concession for the services it provides at the minimum required standards, usually taking into consideration of inflation (which is measured by the consumer price index) and efficiency improvement in that year. The World Bank and Inter-American Development Bank (1998) provide the following mathematical definition of the price cap regulation:

$$P_t \leq P_{t-1}[1 + I_t - X_t] \tag{2-1}$$

where P_t = price in year t; I_t = inflation in year t; X_t = efficiency improvement in year t. As shown in equation (1), it is important to set an appropriate level of price for the first year of the concession. This is usually done based on the capital expenditure (actual or estimated), predicted values of the key components of the operation and maintenance costs, the predicted average demand of services, the affordability of the users, the length of the concession, and a reasonable level of return to the investments of the concessionaire.

Except for the price cap and the requirements on service standards, the revenues of the concessionaire are unconstrained. The concessionaire can keep the profits resulting from reduced costs, improved efficiency and/ or increased demand. Conversely, if these parameters go in the opposite direction, the concessionaire assumes the consequent losses no matter how severe these losses are. This is true even though at the beginning of the concession the price are set to a level high enough to cover the cost of service based on the estimates of key variables that affect the project's profitability (e.g., costs, efficiency gains and revenues) because the concessionaire is fully exposed to the variability between the estimate and the actual value of these variables (Ergas and Small 2001).

Intermediate Scheme

Both advantages and disadvantages exist in either the rate of return or the price cap regulation. Under the rate of return regulation, private sector investors are guaranteed a fixed level of return to their investments no matter what amount the cost is, and any gains from cost savings are reverted to the public sector. This enables necessary but risky transactions to be made, and usually leads to low cost of capital. However, the concessionaire lacks incentives for efficiency in terms of (1) reducing capital expenditure and operation and maintenance costs; (2) overcapitalization (known as the Averch-Johnson effect) – the concessionaire tends to overinvest when the rate of return of the concession is higher and/ or securer than that of alternative investment options (Averch and Johnson 1962); (3) gold-plating – to supply too high a level of service; and (4) demanding information required and regulatory burdens (Burns and Estache 1999).

Price cap is a high-powered regulatory mechanism, under which the concessionaire assumes high level of risks and has strong incentives to improve efficiency and lower costs. However, the price cap regulation also has disadvantages: (1) the concessionaire tends to underestimate profits, and excessive profits of the concessionaire impairs the interest of the public sector and may lead to political sustainability problems; (2) with monopolistic power, the concessionaire may lower quality to reduce costs without the risk of reducing demand; (3) private parties may lose interest in a project urgently needed but risky if the risks they are required to take are too high; and (4) high cost of capital because high level of risks.

In practice, most regulatory regimes are variants or hybrids of the two extremes designed to achieve a balance between efficiency incentives and earnings insurance (Ergas and Small 2001). For example, an intermediate scheme may set the price at a level that enables the concessionaire to recover an efficient level of costs ex ante, but ex post the concessionaire is given incentives to improve efficiency as the prices will not be reviewed for a certain period. At the beginning of a following price review period, the price is adjusted to reflect the efficiency improvement achieved in the previous period, but the benefits of the concessionaire made in the previous period are not clawed back.

Please note, although theoretically rate of return and price cap regulations differ considerably, in practice, the two methods have tended to converge (Energy Information Administration 1997). For example, when price reviews are not frequent and forward-looking, the rate of return regulation will take on aspects of the price cap regulation, and conversely, if price reviews are frequent enough, excessive profits in a previous period partly or fully clawed back, and the concessionaire's efficiency improvement over the year taken into account in setting the new level of price cap, the price cap will have similar effects to those of a rate of return regulation (Ergas and Small 2001).

Price Setting and Adjustment Mechanism

Central to an economic regulation regime is the price setting and adjustment mechanism, as all regulation must have regard to the participation constraint and implement it through price setting and adjustment. A workable price setting and adjustment mechanism should (1) establish clear rules on defining the price structure of different categories of users, the concessionaire's freedom to vary the price structure such as surcharging tariffs and interrupting services to some types of users in times of high demand, and redistributing profits or losses between the concessionaire and the government, and (2) develop a sound methodology to assess the impacts of main factors that affect the cost structure/ total costs, revenue structure/ total revenues, efficiencies and profitability of the project in order to allow the concessionaire to achieve a "reasonable but not excessive" level of return. These factors include project costs (capital expenditure, operation and maintenance costs, etc.), the reasonable level of return to investments, concession period, types of users and their demand of services, efficiency improvement, and integration with the overall pricing system.

Participation and Incentive Compatibility Constraints

The concession arrangement is a principal-agent maximization problem (Laffont and Martimort 2001), in which the principal is the government and the agent is the concessionaire. In solving such a problem, various requirements have to be met. In particular, there are two generic constraints that should be satisfied: one is the participation constraint and the other is the incentive compatibility constraint (Nelson et al. 1998).

The participation constraint requires that a PPP model provide the concessionaire with a minimum compensatory return on its capital investments, under which investors and lenders will withdraw from the project and turn to other more profitable opportunities. This may mean a "no entry" condition when it is perceived that the level of commercial risks might be aggravated if new entry were allowed (Chisari and Ferro 2004). Satisfying the participation constraint would reduce/ avoid the premiums charged by the concessionaire on regulatory risks, i.e., the concessionaire may go bankrupt as a result of the government's regulatory decisions. The government will not want the concessionaire to become bankrupt, except where this is necessary to emphasize the prudential responsibility borne by the concessionaire (Ergas and Small 2001). This implies that in setting the level of prices the government must take into account the costs that are incurred by the concessionaire, or would be incurred by an efficient benchmarked company providing the same service. The incentive compatibility constraint requires that the concessionaire prefer to act in accordance with a defined solution in the interest of the public. For example, the concessionaire may be required to share efficiency gains with consumers. Without the incentive compatibility constraint, the solution might be economically meaningless for even though the solution could produce an optimal outcome, the concessionaire might choose not to act in accordance with it (Nelson et al. 1998). Therefore, a concession model that satisfies the two constraints would have a built-in mechanism, which ensures that the concessionaire benefits if it behaves in the public interest and suffers if it does not.

Measures to Overcome Regulatory Weaknesses

Some measures (Table 2.1) may be taken to overcome the weaknesses of regulations to achieve a balance between minimized risks and maximized efficiency incentive. These include (1) efficient/ average level of costs, (2) regulatory lag, (3) prudence test of capital investment, (4) pass-through of exogenous costs, (5) sliding scale, (6) public-private profit/loss sharing, (7) floating rate of return, (8) reducing regulatory burden and transaction costs, and (9) efficient information management.

Further Improvements in Economic Regulation

The following points are useful in further improving economic regulatory practices. First, the regulatory framework should provide the right pressure and incentives for the concessionaire to continuously improve efficiency, cost-effectiveness, and service quality. Second, the regulation should be performance-based focusing on end results to be achieved rather than on the means to be used. Flexible performance targets and appropriate measures need to be established to increase the adaptiveness of the concessionaire to possible changes and to facilitate regulation over the concession period.

Table 2.1 Measures to overcome regulatory weaknesses

Measures	Remarks
Efficient/average level of costs	Key cost components of the concessionaire can be referenced to those of an "efficient company." This efficient company may either be a real one existing in the industry, or a virtual one formulated based on historical data of companies in the industry, existing and expected technical developments, and the particular conditions in which the project operates. Another option is to use the average level of costs of the industry. These approaches ensure that increasing the price to cover cost does not reward inefficiency, for at least the industrial average cost level is achieved.
Regulatory lag	In the rate of return regulation, lengthening the period between price reviews (known as the "regulatory lag") and allowing the concessionaire to keep the economic profits made from managerial initiatives and technical innovations in the previous period instead of retroactively reverting them to the public sector increase the concessionaire's incentive to improve efficiency and reduce costs.
Prudence test of capital investment	To overcome the overcapitalization problem related to the rate of return regulation, a "prudence test" may be conducted to examine whether an investment is essential. An investment is included in the capital base for determination the rate of return only if it was used and useful. This test provides incentives for the concessionaire to focus on the needs of the customers and make efficient investments instead of gold-plating.
Pass-through of exogenous costs	The concessionaire usually lacks incentives to control risks that are covered by the regulation. A regulatory mechanism should cover only exogenous risks such as inflation and fluctuation of exchange rate and let the concessionaire to manage risks that are within its control. Exogenous costs can be directly included in the price structure of a price cap regulation, for example, by indexing domestically purchased equipment/material to the inflation rate and imported equipment/material to the exchange rate, to reduce the risks that are beyond the control of the concessionaire while maintaining its incentive for efficiency.
Sliding scale	A glide-path may be put in place when prices are above costs so that they fall to costs over time. This provides the concessionaire economic incentives to make efficiency improvement by allowing it to keep the consequent profits longer (Burns and Estache 1999).
Public-private profit/loss sharing	This method allows profit and loss sharing between the concessionaire and the government, and therefore, reduces both incentives for efficiency and risks. This measure is used to regulate the New York Telephone Company. When the actual rate of return R is between 13% and 15%, there is no price adjustment; if it is under 13%, the revenue is raised by $0.5(13-R)$ percent; and if it is above 15%, the revenue is reduced by $0.5(R-15)$ percent (Laffont and Tirole 1993).
Floating rate of return	A floating rate of return may be used in the rate of return regulation. The price is not adjusted when the rate of return falls within a predetermined interval [a, b]. Otherwise, the rate is adjusted up to reach upper limit a or down to reach lower limit b.
Reducing regulatory burden and transaction costs	To reduce regulatory burden and transaction costs, a balance between rigidity and flexibility should be maintained depending on the degree of unpredictability of key factors affecting costs and revenues, particularly, in the indexation rules and the frequency to revise these rules.
Efficient information management	Time-consuming and costly disputes often result from controversies over information used as the basis for regulation. Adequate, accurate and timely information are a prerequisite to right regulatory decisions and avoidance of disputes. A sound methodology needs to be developed regarding data requirements, collection, extracting, processing and reporting. Pro forma accounts for different cost and revenue items are useful to (1) evaluate the concessionaire's performance and benchmark industrial practices, (2) identify adverse situations and evaluate their cost effects, (3) evaluate efficiency gains and their causes, and (4) evaluate the financial soundness of the concessionaire.

Third, a balance should be achieved in granting essential discretion to the regulator and providing the concessionaire certain necessary recourses against the decisions of the regulator. Fourth, the regulatory process should be protected from both industry and short-term political pressures. It is better to be conducted by a body that is politically and financially independent from the government or the concessionaire. This minimizes the negative effects of the government's role as regulator and as a project party, and protects customers from abuse of power by the monopolistic concessionaire. Fifth, the regulation should be credible. Members of the regulatory body should be acknowledged professionals, who would benchmark performance, set tolls and ensure the rationalization of the existing system (Estache and Carbajo 1996; World Bank and Inter-American Development Bank 1998; Vazquez and Allen 2004).

RECONCESSION AND REBIDDING

Scheduled/Unscheduled Reconcession

Reconcession refers to the contractual arrangements to terminate the original concession and design a new concession to reflect changes and new needs. This may be classified into two categories: (1) scheduled reconcession, corresponding to the case in which the current concession ends at the scheduled termination date as defined in the original concession agreement; and (2) unscheduled reconcession, which is deemed necessary to deal with significant changes happened before the expiration of the current concession, for example, the concessionaire becomes bankrupt or fails to fulfill its obligations that justifies the government's termination of the concession, and a force majeure risk makes it difficult to implement the initial concession. The government usually reserves the right to terminate the concession before its scheduled end, and it may terminate the concession in terms of the general interest of the public even though the concessionaire has fulfilled its contractual obligations.

Periodic Concession Rebidding

Periodic rebidding allows new competitors to challenge the incumbent concessionaire for the concession periodically. Theoretically, there is no big difference between a rebidding and the initial bidding of the concession. Rebidding usually focus on the unamortized assets of the current concessionaire, new construction, rehabilitation and maintenance of existing and newly built facilities, and the prices offered to consumers. Periodic rebidding is sometimes called a Chadwick-Demsetz auction, as Edwin Chadwick proposed this idea in 1859 and Harold Demsetz resurrected it in 1968 (Guislain and Kerf 1995). For example, in the power distribution sector in Argentina, although the concessions are for a period of ninety-five years, they are rebid after the first fifteen years and every ten years thereafter.

Generally, periodic rebidding of concession is more economical than either free entry or a long-lasting concession for an infrastructure sector that is natural monopolistic (Guislain and Kerf 1995). There are several specific reasons for periodic rebidding. First, the initially chosen concessionaire may not still be the most competitive at the end or even before the end of the current concession period even though economic regulation is implemented over the concession period to maintain the incumbent concessionaire's operational efficiency. This is partly because the exclusive rights of the concessionaire to provide relevant services may lead to its lack of incentive to improve efficiency, and technical advancements result in the obsolescence of the technologies and the management practices of the incumbent concessionaire. Second, periodic rebidding serves as a means to reduce regulatory discretion of the government as it provides the government with better information for price setting and adjustments. This may also reduce the premiums required by the private sector on regulatory risks (Klein 1998). Third, periodic rebidding forces the private companies to reduce costs and charge lowest profitable price for the services provided and maintains pressure on the concessionaire for continuous quality service. Fourth, periodical rebidding facilitates contract adjustments to significant changes.

Valuation of Incumbent's Unamortized Capital

In addition to the initial construction costs, substantial capital investments may also be needed for rehabilitation of existing facilities and possible new construction during the concession period. These capital costs may not be adequately predicted at the beginning of the concession. The initial construction costs and the capital investments made during the concession, particularly those made toward the end of the concession, may not be fully amortized before the concession expiration date. If the incumbent loses the concession in rebidding, its unamortized assets should be reimbursed either by the government or the new concessionaire. The unamortized assets include both concession specific and non-specific assets. Concession specific assets refer to those that are difficult if not possible to use for purposes other than the concession such as underground water systems, and assets that are not specific to the concession refer to those that can be easily transferred/ sold to use for other purposes other than the concession, for example, vehicles and equipment used to maintain highways (Klein 1998).

A sound asset valuation methodology including advanced measurement instruments is needed to reasonably determine the value of the unamortized assets and to factor them into the new concession before putting it out for bidding (Klein 1998). This is particularly important for concession-specific assets whose physical conditions are difficult to observe, as the incumbent may be forced to sell to the new entrant the unamortized concession-specific assets at prices much lower than they are actually worth if the former loses the concession in rebidding. Appropriate valuation and compensation of unamortized assets provide incentives for the incumbent to make proper capital investments for necessary new construction and rehabilitation, and to maintain infrastructure facilities timely, which would lead to a low life cycle cost of services. This in essence ensures fair competition and the long-time viability of the periodic concession rebidding, which aims to achieve continuous efficiency improvement.

A well-designed asset valuation and compensation mechanism should encourage the incumbent concessionaire to undertake all desirable investments without motivating it to over-invest, i.e., to invest solely for the purpose of getting compensation. For example, the unamortized assets may be valuated by a mutual agreement between the government and the incumbent concessionaire, or based on the estimate of an independent expert.

Concession Rebidding Interval

Governments tend to set equal interval for the concession to be rebid, for example, every ten years in power distribution in Argentina. However, the concessions to be rebid do not have to be of equal length. The suitable length of a concession depends on many factors, including (1) capital investments required, (2) bidding costs to the industry, and (3) the level of complexity in the transfer of concession from the incumbent to the new winner.

Normally, the higher the capital expenditure is expected from the new entrant (e.g., related to major rehabilitation of existing facilities and the unamortized assets of the incumbent), the longer the concession should be. A short concession is usually advisable if the new concessionaire is only required to be responsible for routine operation/maintenance.

The bidding costs for a concession project is usually much higher than those of a traditional public procurement approach such as the design-bid-build. To save costs to the industry the frequency of concession rebidding needs to be reduced if it is perceived that high bidding costs will be involved.

A varying number of issues need to be addressed in the transfer of concession, depending on the features of the specific industry and the concession model of the particular project. High transaction costs may be incurred if complicated issues are involved, for example, the settlement of the possibly large number of employees of the incumbent concessionaire. In addition, the transfer of concession may interrupt the services to the public. Therefore, more frequent concession rebidding may be practiced if the transfer process is not complex, and vice versa.

Biased Rebidding Favoring the Incumbent

Recognizing that it may lose the concession in the upcoming rebidding, the incumbent concessionaire tends to skimp on capital investment and maintenance especially toward the end of the concession and in assets whose quality is hard to measure. In addition, any investment or improvement by the incumbent in the concession's assets (including both human capital and physical assets) would benefit the new winner, further reducing the incumbent's interest in investing and maintaining the assets. For example, the incumbent may have weak incentive in training its employees as the winner in a concession rebidding is normally required to hire the employees of the incumbent. Klein (1998) argues that a biased rebidding in favor of the incumbent is generally advisable to deal with the incentive of the incumbent to make necessary investments timely. This approach gives the incumbent a greater chance to keep the concession as the concession is awarded to a competitor only if its bid beats the incumbent's by more than a specified margin. Such a biased bidding has been used for traditional contracts for equipment and civil works in the United States. However, this margin should not be too large so that the competitive efficiency is lost.

CONCLUSIONS

PPPs play an important role in bringing private sector competition to public infrastructure monopolies and in merging the resources of both public and private sectors to better serve the needs of the public that otherwise would not be met. The worldwide interest in PPPs, problems encountered in many countries and the substantial controversy over PPPs call for an improved methodology for improved infrastructure and service delivery through PPPs. This chapter proposes a systematic framework for infrastructure development through PPPs in general, on the realization that although there are many aspects that are project-, sector-, and/or country-specific, the concept, process and key principles in infrastructure and service delivery through PPPs are essentially identical. This framework integrates four broadly divided stages in the infrastructure and service delivery process, including (1) design of a workable concession, (2) competitive concessionaire selection, (3) economic regulation of the selected concessionaire during the concession period, and (4) periodic concession rebidding to allow new entry for the concession.

The public procurement principles and public-private win-win solution act somewhat as guidelines or constraints for decisions made in each of the four stages of the framework, which repeat over time possibly as long as the service is needed. The four-stage framework takes into account the requirements of public services, realignment of responsibility and reward among multiple project participants in PPPs, the monopolistic rights of the concessionaire, and the wide range of risks and uncertainties in the long-term contract period. The design of the right concession forms the base on which other stages are implemented in addition to planning the project and allocating risks for enhanced efficiency. The economic regulation allows the government to address changing conditions and regulate the concession for efficient operation with due discretion, whereas the competitive concessionaire selection and periodic reconcession and rebidding play an important role in achieving innovation, efficiency and cost effectiveness through direct competition which extracts monopoly rents without government discretionary intervention.

Varying competition elements are incorporated in each of the four stages for continuous performance improvement of the concessionaire in the delivery of infrastructure and services. In the concession design stage, risks are effectively controlled through appropriate risk allocation and right selection of a PPP model. In the concessionaire selection stage, the most competent consortium available is chosen through competitive bidding, which also forces the chosen concessionaire to offer cost-effective services at required quality standards. During the concession, the economic regulation maintains a competition environment to address potential efficiency problems related to the incumbent concessionaire's monopolistic rights and to ensure its continuous efficiency improvement. By periodic rebidding at the end of each concession, new entrant is allowed to compete for the concession and this enhances competitive efficiency for the following concession by choosing a new concessionaire that is more competent than the incumbent. Periodic rebidding also keeps incumbent concessionaire under pressure to improve performance in order to raise its chances of keeping the following concession.

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CHAPTER 3: FINANCIAL EVALUATION AND CAPITAL STRUCTURE [1]

INTRODUCTION

Governments worldwide have shown increasing initiatives in private finance, among which are the BOT (build-operate-transfer) type project procurement models, where concessions are granted to private sector consortiums to design, build, finance and operate public works and services. Improved delivery of many major public works and services have been achieved through private finance, across a wide range of industries and sectors, including power, transportation, water supply and disposal, telecommunications, oil and gas, mining, schools and hospitals. On the other hand, a number of privatized projects suffered disastrous consequences because of construction cost overruns, changing market demand, depreciation of local currencies and/ or reduction in tolls/ tariffs by utilities. Some of them had been postponed or abandoned by the sponsors, and some had to be bailed out by the host governments (Ye and Tiong 2000).

The financial evaluation of a privatized infrastructure project is complex and challenging because of the complexity of the non-recourse financing technique and a variety of risks and uncertainties related to project finance, which make the forecasting of cashflows very difficult. The radical reallocation of risks among project participants

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make the concessionaire undertake much more and deeper risks than a mere contractor. Construction and economic risks are the two major risks to the concessionaire. Successful development of a privatized project necessitates the effective management of these risks and the use of improved financial engineering techniques.

The financial evaluation and capital-structure optimization model developed in this chapter evaluates the project and optimize its capital structure when it is subject to construction risk, bankruptcy risk and various economic risks. It also assesses the impacts of governmental guarantees and supports, and addresses the issue of equity holders' commitment to project success. This model aims to achieve a public-private win-win result, i.e., it optimizes the capital structure such that the internal rate of return to equity (*IRRE*) is maximized while satisfying other project participants' interest and requirements. Combining simulation and financial analysis techniques, this model would facilitate both public clients and private developers in the development of an appropriate financial package for the successful procurement of a privatized infrastructure project.

INFRASTRUCTURE PRIVATIZATION AND PROJECT FINANCE

Governmental Initiatives in Privatization

Laws and regulations have been enacted in different countries to facilitate infrastructure privatization for improved productivity and efficiency in infrastructure development. The claim that privatization can improve infrastructure development efficiency is based on the following arguments: (1) the private sector is less bureaucratic and more operationally efficient than the public sector and, therefore, can make timely decisions for better allocation and utilization of resources; (2) additional funds from the private sector to overcome governmental budgetary restraints; (3) enhanced utilization of expertise, managerial skills, and innovative technologies from the private sector; (4) reducing government monopolies and increasing competition from the private sector in public works and services; (5) the market mechanism increase the incentives toward efficiency in public organizations; and (6) sensible PPPs can minimize the competitive inequities between public and private sectors.

Project Finance

Project finance refers to the financing of stand-alone public works and services on a non-recourse or limited recourse financial structure, where debt and equity used to finance the project are paid back from the cashflows generated by the project. Unlike corporate finance where lenders examine a company's general credit and uses the cashflows generated by its entire asset portfolio for debt service, in project finance, lenders look primarily to the revenue stream generated by the project for repayment and to the assets of the project as collateral for the loan. Lenders have no recourse or only limited recourse to the general funds or assets of the project sponsors. The project company is a distinct legal entity; project assets, project-related contracts, and project cashflows are segregated to a substantial degree from the sponsoring entities (Project 1999; Merna and Dubey 1998).

Project finance provides a useful technique for the private sector to finance the project outside their balance sheet, because project sponsors may (1) be unwilling to expose their general funds/ assets to liabilities to be incurred in connection with the project or are seeking to limit their exposure in this regard; (2) try to avoid the conditions or restrictions on incurring debt contained in existing loan documents or not enjoy sufficient financial standing (i.e. inadequate creditworthiness or borrowing capacity) to borrow funds on the basis of their general assets (Merna and Dubey 1998; Benoit 1996).

BOT Model

A number of methods have been explored in international infrastructure privatization, including asset sale, contracting out, deregulation, BOT and other types of public-private partnerships. BOT is a popular approach in infrastructure privatization. A BOT project can be described as a project based on a concession that is granted by a public client to a consortium, the concessionaire, who is required to "Build" the project with its own financial arrangement, "Operate" it during the concession period to recover its investments and obtain a certain level of profits and to "Transfer" the facilities of the project in an operational condition at no cost to the client at the end of the concession period. The term BOT has generated a string of related acronyms that reflect variations of governmental interest and preference in procurement approaches: BBO (Buy-Build-Operate), BLT (Build-Lease-Transfer), BOO (Build-Own-Operate), BOOM (Build-Own-Operate-Maintain), BOOT (Build-Own-Operate-Transfer), BT (Build- Transfer), BTO (Build-Transfer-Operate), DBFO (Design-Build-Finance-Operate), DBOM (Design-Build-Operate-Maintain), DOT (Develop-Operate-Transfer), LDO (Lease-Develop-Operate), MOT (Modernize-Operate-Transfer), ROO (Rehabilitate-Own-Operate), ROT (Rehabilitate-Operate-Transfer) and TOT (Transfer-Own-Transfer).

It is seen that BOT generates a special purpose vehicle (SPV) for project finance - the concessionaire is an independent legal entity created under the government-granted concession. Project sponsors as shareholders invest equity into the SPV and are responsible for the finance, design, construction and operation of the project.

Central to BOT are the complex contractual arrangements that are designed to fit within the overall legal framework of the host country - the concessionaire enters into contracts with a variety of project participants as shown in a figure in (Merna and Dubey 1998). These contractual arrangements define each party's roles, liabilities and apportionment of risks. Contractual items include those dealing with construction methods, financial arrangement, project operation, and agreed implementation procedures in the event of default, delay or failure of construction completion, substandard performance in the operational period and *force majeure*.

CAPITAL STRUCTURE IN PROJECT FINANCE

Capital Cost of Infrastructure Projects

The capital cost of a project is the combined cost of equity (permanent capital), debt (temporary capital) and mezzanine finance (quasi-equity) required for the acquisition of fixed assets of a privatized infrastructure project. The mix of these financial instruments and their cost constitute the cost of capital to the project. Equity includes common stock, retained earnings (money not paid out as dividends but reinvested in business or used to pay off debt) and unappropriated profits. Equity has the lower rank and the last claim on the assets and cashflows of the project. Debt is often structured in the form of senior debt or subordinated debt. Senior debt has higher priority than all other claims on project cashflows and assets. Subordinated debt ranks behind other unsecured loans in payment obligations. Mezzanine finance refers to a kind of financial instruments that are primarily in the form of debt but also share some qualities of equity capital. It occupies an intermediate position between debt and common equity. Mezzanine finance includes convertible bonds and preferred stock. Convertible bonds can be exchanged for a given number of shares. Preferred stock is classified as an equity security but is paid at a fixed dividend. The project company can choose not to pay the dividend on its preferred stock without being considered in default, whereas a failure to make a promised interest payment on a debt issue will constitute an event of default. Preferred stock is a perpetual debt apart from the nonpayment option. Only when the project company runs into trouble do the equity-like features of these hybrid claims kick in. Therefore, preferred stock does not reflect a proportional claim on the project's net assets. There are also other types of instruments such as leasing and venture capital and aid (Culp 2002; Merna and Dubey 1998).

Capital Structure and Equity Level

Here the capital structure of the project company is defined as the combination of various financial instruments, which includes (1) the relative amounts, (2) the sources of, and (3) the corresponding contractual conditions on equity, debt and mezzanine finance. Each of the three aspects can affect the total project cost and consequently the financial viability and/ or bankablility of the project. For example, the cost of equity is usually higher than debt because the equity holders normally require a higher rate of return to their money than the debt interest rate. However, lower equity level means higher risks to debt. There are also advantages and disadvantages in the use of bond and commercial debt. Debt interest rate can be fixed or floated, while bonds are generally fixed. With a grace period and floating interest rates bank debt allows more financial flexibility. This can be critical for the success of project finance that is subject to construction risks and fluctuation of revenue streams in the long-term concession period. But debt is usually more expensive and has shorter maturity period than bonds. Long-term financial instruments are important in project finance because the project generates no revenues during the construction phase and tends to build up cashflows slowly. Furthermore, in developing countries and countries with weak economies, commercial lenders may require sovereign guarantees from the project's host government and/ or the involvement of Export Credit Agencies and multilateral agencies such as the World Bank and International Finance Corporation to cover political and economic risks.

In the capital structure optimization model only the first aspect of the capital structure is considered, as quantitatively modeling of the other two aspects is very difficult if not possible. Here, for simplicity, the "equity level", which is defined as the proportion of equity in the total financing package, is used to reflect the capital structure. It is further assumed that the privatized project is financed by equity investments from private developers and debt from different banks and financial institutions, without involving other types of financial instruments. Under this assumption, the capital structure of the project company refers to the equity percentage and debt percentage of the project's capital costs. In practice, equity levels ranging from 0 to 100% have been used in different types of projects. For example, power projects tend to have an equity level of 10% to 30%.

Different Parties' Perspectives of Equity Level

The equity level is the most relevant variable that concerns major project participants. Three major parties are concerned with the equity level: the sponsors (who are the shareholders of the project), lenders (who lend money to the project) and the government (who privatized the project and may provide guarantees or other types of support to the project). These parties have different views as to what is the appropriate equity level. Their perspectives should be taken into consideration in capital structure optimization.

For project sponsors, their equity is recovered together with an expected level of profit from different activities related to the project, including advisory, design, construction and operation activities and project-related property developments. They will consider the project "financially viable" if the *IRRE* is greater than their expected level. Therefore, sponsors will maximize the *IRRE*. There are two reasons that sponsors usually do not want to put a high level of equity. One reason is to avoid risks and allocate money in more profitable projects. The other is that decreases the equity level increases the *IRRE* since the interest rate of debt is usually fixed at a lower level than the *IRRE*.

Lenders prefer a higher equity level to reduce risks to them as debt has higher rank in repayment than equity investment. A bankable project should satisfy a minimum level of annual debt service cover ratio (*DSCR*) as required by lenders. The cashflows of the project depend on annual revenues, construction cost and duration, operation and maintenance costs, fluctuations in currency exchange rate and inflation rate, and the tax structure. There can be high fluctuations in annual cashflows during the operation period. Lower equity level means increased risks that the minimum level *DSCR* may not be satisfied. Lenders may require higher risk premiums for a lower equity level. Another important reason lenders require a high equity level is that a high equity level will result in a great "ownership" of the project by equity holders and consequently, an increased incentive and commitment of them to ensure the project a success. A robust and stable revenue stream is critical to the project's debt carrying capacity because debt is serviced through long-term revenues over the concession period. Beyond sound project fundamentals, a strong revenue stream depends on the effective and efficient management of the project, which requires the long-term commitment of equity holders.

Three main issues concern the government in a privatized project (1) timely completion of construction at the budgeted cost, (2) smooth operation and quality performance in the operation period, and (3) low total life-cycle cost. The achievement of these goals requires the long-term commitment of the project sponsors. Failure during project development will cause significant political cost to the government. Therefore, the government will require a certain minimum equity level for long-term commitment of sponsors. However, other conditions being the same, a low total life-cycle cost means a low equity level, as rate of return to equity required by project sponsors is usually higher than the interest rate of debt.

Equity at Project Risks

In addition to the relative amount of equity to debt, the types of equity participation are also a concern to lenders and the government as well. Both lenders and the government would examine the incentives of key equity holders before committing their own funds or providing sovereign guarantees. For example, an equity holder whose earnings are primarily from equity dividends will have a longer-term view than an equity holder who obtain substantial returns for consulting and/or construction services, because the latter can get their returns at the beginning of the project development. Short-term view equity holders tend to exaggerate the debt carrying capacity of a project and thus raise its long-term riskiness. Furthermore, they may abandon or neglect the project once a reasonable return on their risk capital is earned even when they apparently have higher equity participation. The continued presence of project sponsors whose equity is at project risks assures more realistic cashflow projections and their realization through good project management. The lack of long-term financing for projects may reflect the lack of a long-term commitment by project sponsors.

Equity at project risks (*EPR*) can be defined as part or total of the equity funds, the recovery of which will be dependent on the long-term revenues of the project. In other words, equity at project risks includes only that part of the equity, which is exposed to the long-term project risks, especially market risks. For example, it does not comprise that part of the equity that is provided by an equity holder who is part of the construction consortium of the project and that is recovered from earnings on the construction activities.

The ratio of equity at project risks (*REPR*) is defined as the ratio of the amount of equity that is at project risks to the total amount of equity. Therefore, higher *REPR* ensures increased long-term commitment by equity holders to the success of the project. The payback period for the *EPR* is a clear signal of the underlying interests of the equity holders: the shorter the pay back period, the less the commitment of equity holders.

$$EPR = E - \omega \times C_T \qquad (3\text{-}1)$$

$$REPP = \frac{EPR}{E} \qquad (3\text{-}2)$$

where EPR = equity at project risks; $REPP$ = ratio of equity at project risks; E = the amount of total equity; ω = the profit margin on the construction activity; and C_T = total construction cost. Zero or negative *EPR* or *REPP* means that there is no equity at project risks.

FINANCIAL VIABILITY ANALYSIS

Assumptions

The following are assumptions in the financial evaluation of a privatized project:

1. The privatized project is procured through a BOT scheme, with a concession period of N_c years (including a construction period of m years and an operation period of n years) and a designed life cycle of N_d years.
2. The BOT project follows the non-recourse principle of project finance.
3. All the financial instruments available in the project are broadly divided into equity and debt. Equity and debt are drawn at the beginning of each year of the construction period according to their relative percentage in the total cost of the project.
4. There are unlimited sources of debt, and there is no upfront and commitment fee. Debt from different sources has different interest rates, but has the same grace period (that is equal to the construction period m) and the same term of annual equal installments (that is N years). Under this assumption, the weighted average interest rate of all the debt sources can be used as the interest rate for the debt in general.
5. The lower the equity level, the higher the interest rate to be charged by the creditors, according to a predetermined formula.
6. The construction cost and construction duration are independent without correlation. The base construction cost is uniformly distributed in the construction duration.
7. Only income tax is considered.

8. The total project cost is depreciated over the design life cycle of the project.
9. Financial evaluation and capital structure optimization are conducted from the equity holders' perspective, subject to a number of constraints, including the requirements of other project participants. This means that, subject to these constraints, the project is financially viable if the *IRRE* is greater than or equal to the minimum *IRRE* as required by the equity holders, and that the objective of the capital structure optimization is to find the optimal equity level that maximizes the *IRRE.*

Project Bankruptcy during Construction

Construction risk is one of the major risks in project finance. It encompasses cost overruns, duration overruns and completion risk. Construction risk is a serious concern to all major project participants. Successful completion of construction depends on a wide range of factors. Weather conditions, ground conditions, technical difficulties, equipment breakdowns, labor issues, financial and managerial capabilities and other external factors have a combined impact on the construction process. Construction cost overruns and/or duration overruns affect the profitability and, consequently, the debt repayment ability of the project. For example, delays of construction completion not only increase interest expenses and lead to cost overruns but also defer the generation of revenues. Serious cost overruns and/ or duration overruns could result in a project's being never completed. This would be a disaster to all project participants.

The loan agreement to a BOT project usually includes a grace period, which is normally the length of the predetermined construction duration as there is no revenue generated from the project during the construction phase. However, this does not mean that the project will not be subject to bankruptcy before project completion. Lenders may impose construction-related conditions to trigger bankruptcy should adverse events occur, especially in a large infrastructure project with huge costs and a long construction period. Lenders may specify the upper limit of cost overrun or the milestone upon each loan drawdown during the construction phase as the bankruptcy condition (Ho and Liu 2002). They can terminate the loan when this condition is not satisfied. Under such circumstances, unless the developer can justify the cost overrun or schedule delay, or has the ability to arrange other funding sources, such as new equity injection or government rescue, the BOT project will be bankrupted.

To avoid project bankruptcy before construction completion, the construction cost and duration should be examined carefully taking into consideration of various risks and uncertainties, and adequate financing facilities should be arranged to avoid re-financing risks and a workable construction schedule made to ensure in-time project completion.

Monte Carlo simulation (Morre and Weatherford 2001) and project evaluation techniques such as the program evaluation and review technique (PERT) can be used to establish the distributions of construction cost and duration. Given these distributions, construction cost and duration at a given confidence level can be determined. The use of a high confidence level will greatly reduce the probability and extent of cost and duration overruns and thus the bankrupt probability of the project. It should also be noted that an underestimate of construction cost and/ or duration might either reduce quality or simply increase the probability of an overrun because this underestimate makes the in-time project completion an impossible task, which may become a powerful demotivator to the employees of the project.

Self-Financing Ability

Once the construction cost (at a certain confidence level) is determined, the project sponsors need to examine the self-financing ability (*SFA*) of the project, as defined in the following equation (Chang and Chen 2001). *SFA* indicates what percentage of the construction cost can be recovered through the net revenues earned in the operation period, subject to the financing conditions of the capital market and the equity holders' requirements of the return to their investments. A high *SFA* represents a robust revenue-generating ability and consequently a stable financial status of the project in the operation period.

$$SFA = \frac{NPV_R}{NFV_C} \times 100\% \tag{3-3}$$

where NPV_R is the net present value of the net revenues in the operation period at the end of the construction period; and NFV_C is the net future value of the construction costs at the end of the construction period.

A suitable discount rate should be determined in the calculation of NPV_R and NPV_C. The selection of the discount rate is one of the crucial aspects of engineering economic analysis. The discount rate is the opportunity cost of money to the party considering some investment. From the equity holders' point of view, it is the interest rate earned in a capital market. The market price of risk is the premium that investors must receive over the risk free rate to incur the market risk (Bakatjan et al 2003; Birge and Zhang 1999).

Equity holders can determine the approximate percentage of the construction cost that they are willing to take based on the *SFA*. They are only responsible for the arrangement of finance (either through equity or debt) to the amount at the *SFA* level.

The non-self-financing part would then be paid by the government. Here is an example of the PFI (private finance initiative) projects in the United Kingdom. For a financially freestanding project (i.e., SFA = 100%), the concessionaire provides full finance through a DBFO (design-build-finance-operate) procurement model, and recovers investments and obtains profits entirely through direct charges on end users. The government only provides necessary assistance in statutory procedures without assuming other risks. For projects whose costs cannot be recovered entirely through charges on end users (i.e., SFA < 100%), the government provides subsidies for social benefits not reflected in the project cashflows, e.g., environment improvement and economic regeneration (Blackwell 2000).

NPV_P and IRRE

From equity holders' point of view, the net present value of their total net profit at a specific equity level R (hereinafter referred to as NPV_P as defined in the following equation) and the $IRRE$ are the most common and fundamental financial decision criteria. The $IRRE$ is the value of the discount rate at which the NPV_P is equal to zero.

$$NPV_P = \sum_{j=1}^{n} \frac{NCI_j}{(1+r)^{j+m}} - \sum_{i=1}^{m} \frac{E_i}{(1+r)^{i-1}} \quad \text{for } j = 1, 2, \ldots, n;\ i = 1, 2, \ldots, m \qquad (3\text{-}4)$$

where NPV_P = the net present value of the equity holders' total net profit at a specific equity level; n = the operation period; m = construction duration; E_i = equity drawing in the i^{th} year of construction; NCI_j = annual net cash inflow in the j^{th} year of operation; and r = the discount rate.

For the project to be financially viable, NPV_P must be greater than or equal to zero or $IRRE$ must be greater than or equal to $IRRE_{min}$, where $IRRE_{min}$ is the minimum value required by equity holders.

In the calculation of NPV_P, construction cost and duration are fixed at values corresponding to a certain percentile as required by the project. NPV_P is also dependent on a number of other stochastic variables such as market demand, level of tolls/ tariffs (hereinafter generally referred to as sale price), operation and maintenance cost, inflation and debt interest rate. Assuming that probability distributions of these variables are known, then Monte Carlo simulation can be applied to determine the distributions of NPV_P. Consequently, the NPV_P at a certain confidence level can be derived.

Debt Service Coverage Ratio and Loan Life Coverage Ratio

The calculation of NPV_P or *IRRE* is based on the accumulated annual net cash inflows in the operation period, construction cost at the required confidence level and a specified equity level. However, this is somewhat an "overall" view of the project's financial viability in the concession period. The annual financial status of the project should also be examined. Although the project may seems financially viable from a long-term overall view, variation of annual cash flows and bad financial status in certain years can seriously affect the financial viability. An important indicator of the annual financial status is the annual debt service cover ratio (*DSCR*), which is the ratio of annual cash available to annual total debt service as defined in the following equation. The *DSCR* reflects the project's debt carrying ability and thus it is the lender's main criteria for a project's financial viability. Higher annual *DSCR* reflects stronger debt carrying ability. The more variable the revenue stream during the operation period is, the less debt that can be carried by the project. Reducing the variability (for instance, by a take-and-pay contract with a public utility) increases the project's debt carrying ability. The minimum *DSCR* required by lenders ($DSCR_{\min}$) depends on the site country, the commercial sector of the project and the types of lenders involved. Generally, the *DSCR* should be at least equal to or larger than 1.0 to be acceptable. A project is bankable when *DSCR* is in the range of 1.10 to 1.25, satisfactory and comfortable when *DSCR* is 1.30 to 1.50, and above 1.50 is preferable. The preferred minimum average *DSCR* by international financial authorities is 1.50 (Brigham et al. 1997; Koh et al 1999; Bakatjan et al 2003).

$$DSCR_j = \frac{PBIT_j + DE_j - TAX_j}{D_j} \quad \text{for } j = 1, 2, \ldots, N \tag{3-5}$$

where $DSCR_j$ = the debt service cover ratio, $PBIT_j$ = profit before interest and tax, DE_j = depreciation, TAX_j = tax, D_j = debt installment in the j^{th} year, and N = debt repayment period.

Another indicator to dynamically check the project's debt carrying ability is the loan life cover ratio (*LLCR*). *LLCR* measures periodically (e.g., annually) the net present value for future project income over the maturity of the loan against the amount of debt until the debt is totally repaid. *LLCR* should be at least greater than 1 for the project to be bankable.

$$LLCR_k = \frac{\sum_{j=k}^{N} \frac{(PBIT_j + DE_j - TAX_j)}{(1+r)^{j-k+1}}}{\sum_{j=k}^{N} \frac{D_j}{(1+r)^{j-k+1}}} \tag{3-6}$$

where $LLCR_k$ = loan life coverage ratio as measured in the k^{th} year of the loan repayment period.

Governmental Loan Guarantee

In addition to investing money for the non-self-financing part of the construction cost, the government may also provide a loan guarantee for the project company when the project is too risky to be undertaken by private parties. This loan guarantee will assure lenders that the debt will be fully or partially repaid by the government if the project fails. This would reduce lenders' risk premiums that are associated with a loan. Usually, under full governmental guarantee, lenders will consider the debt risk free and that the debt interest rate will be the risk free rate. Since the debt is risk free, lenders will continue to support the project even when adverse events occur. Therefore, there is little completion risk with a governmental loan guarantee (Ho and Liu 2002). In addition, a project that is financially unviable when there is no governmental guarantee may become financially viable when there is a government loan guarantee.

The loan guarantee is a liability to the government and an asset to the project company. For equity holders, the project financial viability is measured by the *IRRE*. They should reflect the value of the governmental loan guarantee in the equity value. Otherwise, they would underestimate the value of their equity. For the government, if the value of the guarantee is too large, the government oversubsidizes the project company. In this case, the government may require the share of benefits from the project with private parties corresponding to the guarantees it provided. The value of the guarantee is worth at least the risk premiums reduced by lenders.

CAPITAL STRUCTURE OPTIMIZATION

The capital structure of a privatized infrastructure project affects the total life cycle cost of the project and therefore, affects the financial viability of the project. In addition, the capital structure also affects the motivations and commitments of different project participants to the success of the project, as discussed in the previous sections that different project participants have different views on the equity level. The capital structure is one of the critical issues in project finance. Capital structure optimization should achieve ''win-win'' results for all participants, reflecting their respective interest and requirements. Equity holders are the most active players, being responsible for the financial arrangement, construction and operation of the project in the concession period. They play a key role toward the success of the project. In the optimization of the capital structure, equity holders attempt to maximize the return on their equity, while having to satisfy the requirements of the lenders and government.

Figure 3.1 shows the flowchart for capital structure optimization. In the optimization of capital structure, attention should be paid to the following issues:

1. Capital structure is optimized based on the self-financing part of the construction cost.
2. It is important to select an appropriate discount rate, cost escalation rate and the required confidence levels for construction cost and duration.
3. *IRRE*, *REPP* and *DSCR* are dependent on the equity level R and debt interest rate r_D and r_D is dependent on R. Therefore, *IRRE*, *REPP* and *DSCR* can be expressed as functions of R. However, these functions are not linear.
4. Equity holders attempt to minimize their equity contributions such that maximum *IRRE* can be achieved, while lenders seek a comfortable equity level to ensure equity holders' serious commitment to and a vested interest in the project.
5. The *REPP* is also a key indicator to the level of commitment of equity holders.
6. The debt interest rate r_D is risk-free rate if there is a government loan guarantee and the host country has a high credit rating.

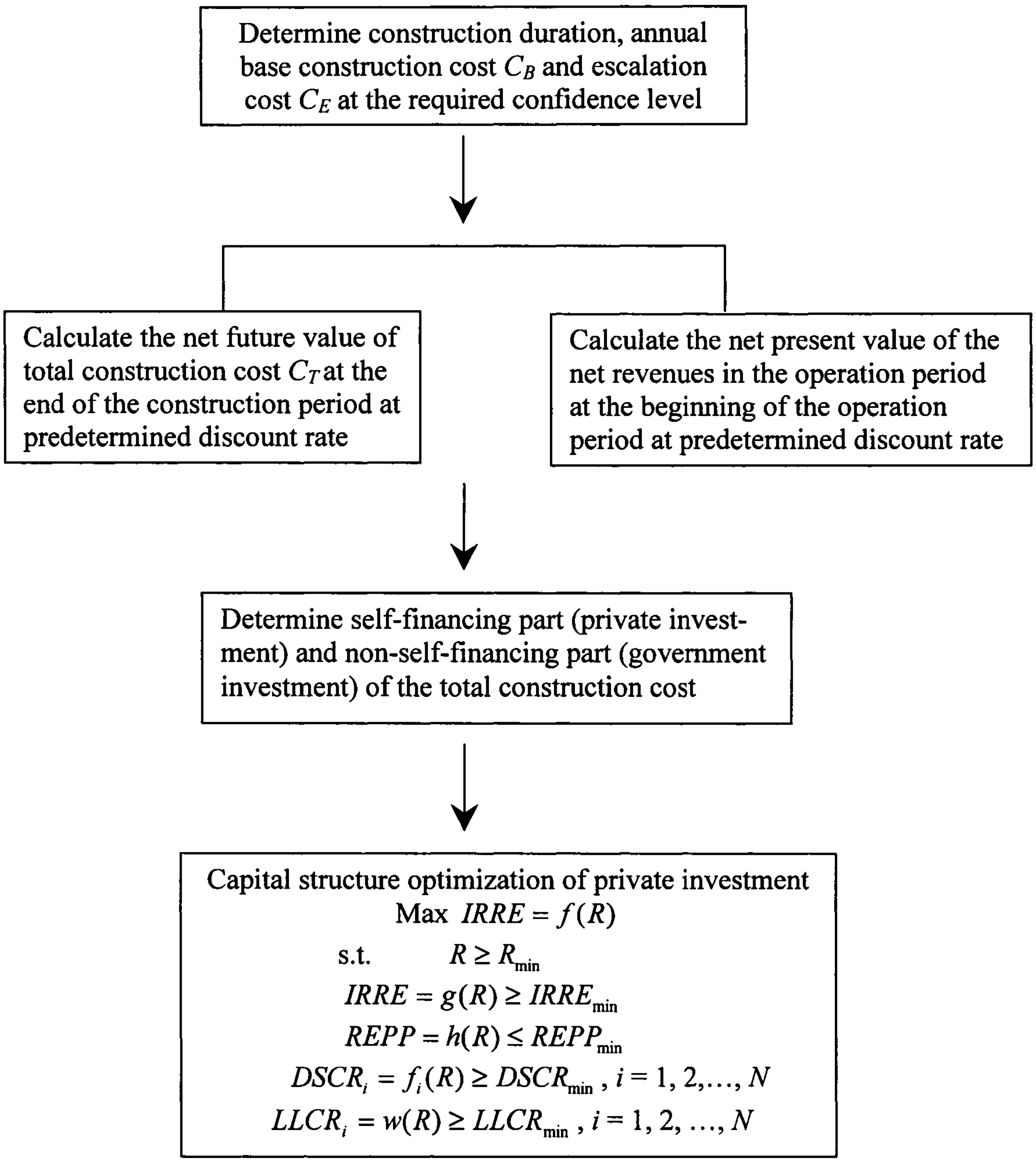

Figure 3.1 Flowchart for capital structure optimization

7. Without government guarantee, r_D is the risk-free rate plus a risk premium. The lower the equity level is, the higher the risk premium. r_D may be expressed as a function of the equity level R and the risk-free rate or the base interest rate r_B: $r_D = f(r_B, R)$.
8. Equity holders' profits from advisory services and construction activities should not be more than a certain percentage of the total amount of equity to ensure their long-term commitment to project success.
9. If $DSCR_{min}$ and $LLCR_{min}$ (minimum value of $LLCR$ required by the lenders) are the same, then satisfying $DSCR_{min}$ requirement will satisfy the $LLCR_{min}$ requirement. However, the reverse is not true.

CALCULATION OF FINANCIAL VARIABLES

This part discusses how to calculate various financial variables that are needed to determine the financial viability indicators, such as *SFA*, NPV_P, *IRRE, DSCR* and *LLCR*. As most of these variables are treated as stochastic ones, the values of these variables and the financial indicators are corresponding to a certain confidence level as required by the project.

Total Construction Cost

Ranasinghe (1996) has developed a simplified model to calculate the total construction cost C_T of an infrastructure project: $C_T = C_B + C_E + C_I$, where C_B = base construction cost estimated at a predetermined year (year 0); C_E = cost escalation during construction; and C_I = interest cost incurred during construction.

For a BOT project, C_T can be calculated in the following set of equations:

$$C_T = C_B + C_E + C_I \quad (3\text{-}7)$$

$$C_B = \sum_{i=1}^{m} C_B^i \text{ for } i = 1, 2, \ldots, m \quad (3\text{-}8)$$

$$C_E = \sum_{i=1}^{m} C_B^i [\prod_{k=0}^{i} (1+e_k) - 1] \text{ for } i = 1, 2, \ldots, m \quad (3\text{-}9)$$

$$C_I = (1-R) \sum_{i=1}^{m} [C_B^i (1+r_D)^{g-i+1} \prod_{k=0}^{i} (1+e_k) - C_B^i \prod_{k=0}^{i} (1+e_k)] \quad (3\text{-}10)$$

where C_B^i = base construction cost in i^{th} year of construction; m = construction period; e_k = escalation rate for the k^{th} year of the construction and $e_o = 0$; R = the equity level; g = grace period of debt, which is usually equal to m; and r_D = interest rate of debt.

Annual Equity and Debt Drawings during Construction

Equity and debt are drawn annually at the beginning of each year of the construction period according to the relative percentage of equity and debt:

$$E^i = RC_B^i \prod_{k=0}^{i} (1+e_k) \quad (3\text{-}11)$$

$$D^i = (1-R) C_B^i \prod_{k=0}^{i} (1+e_k) \quad (3\text{-}12)$$

$i = 1, 2, \ldots, m$

where E^i and D^i are the equity and debt drawings in the i^{th} year of construction.

Annual Net Cash Inflow in the Operation Period

Revenues are generated from tariffs/ tolls in the operation period, ***n***. It is the after-tax cashflow that determines the decision on investment. The annual net cash inflow in current value can be estimated as

$$NCI_j = PBIT_j + DE_j - D_j - TAX_j \qquad j = 1, 2, \ldots, n \quad (3\text{-}13)$$

$PBIT_j$

$$PBIT_j = RE_j - OM_j - DE_j \text{ for } j = 1, 2, \ldots, n \tag{3-14}$$

where RE_j = annual revenue, $RE_j = P_jQ_j$, P_j = price (tariff/ toll level) of the product of the project (e.g., the unit price of electricity in a power plant or the ticket price in a transportation project) and Q_j = annual production (e.g., annual energy production in a power plant or annual traffic throughput in a transportation project); OM_j = operation and maintenance cost.

Market and currency risks can significantly affect the revenue stream of the project. Changes in demand and price for project output have been the leading cause of revenue and profitability problems. Variation of costs of necessary inputs for the normal operation of the project is another major market risk. Currency risks arise whenever foreign currencies, in the form of equity or debt, are used to finance the project. Such risks are associated in part with foreign exchange convertibility and the foreign exchange rate.

DE_j

Depreciation is the cost of a useful asset over its estimated life. As a reflection of a sunk cost, it does not represent a cash outflow from the company. Instead, it provides an annual tax advantage by reducing the company's taxable income that is equal to the product of depreciation and the (marginal) tax rate. A number of depreciation methods are now in use, including straight-line, declining-balance, sum-of-the-years'-digits, double-declining-balance and the modified accelerated cost recovery system. The benefit, in terms of net present worth of choosing one depreciation method rather than another, depends on the taxpayer's opportunity cost of capital (Steiner 1996). The simplest method for depreciation is straight-line depreciation, where annual depreciation equals a constant proportion of the initial investment. Assuming that C_T is entirely depreciable in the design life n_d ($n \le n_d$) of the project, then

$$DE_j = \frac{C_T}{n_d} \quad \text{for } j = 1, 2, \ldots, n_d \tag{3-15}$$

D_j

Annual debt installment D_j can be calculated using the capital recovery factor $(A/P, r_D, N)$:

$$(A/P, r_D, N) = \frac{r_D(1+r_D)^N}{(1+r_D)^N - 1} \tag{3-16}$$

where r_D = the interest rate of debt.

Assuming that the grace period is equal to the construction period, then P_D, the net present value of the total debt (including interest) at the end of the construction period, can be cacalculated in the following equation:

$$P_D = (1-R)\sum_{i=1}^{m}[C_B^i(1+r_D)^{m-i+1}\prod_{k=0}^{i}(1+e_k)] \tag{3-17}$$

Therefore,

$$\begin{aligned} D_j &= P_D(A/P, r_D, N) \\ &= (1-R)\frac{r_D(1+r_D)^N}{(1+r_D)^N - 1}\sum_{i=1}^{m}[C_i(1+r_D)^{m-i+1}\prod_{k=0}^{i}(1+e_k)] \qquad j = 1, 2, \ldots, n \end{aligned} \tag{3-18}$$

TAX_j

Tax is a cost to the project company. For simplicity, here only income tax is considered. Business income is the total revenue received minus the total cost. Interest and depreciation are tax-deductible. Income tax is levied by means of percentages of increments of income as shown in the following equation:

$$\begin{aligned} TAX_j &= r_{tax}^j (PBIT_j - I_j) \\ &= r_{tax}^j (R_j - OM_j - DE_j - I_j) \end{aligned} \qquad j = 1, 2, \ldots, n \qquad (3\text{-}19)$$

where r_{tax}^j = income tax rate corresponding to the income level (or bracket of income); and I_j = debt interest in the j^{th} year.

Assuming that there are equal annual installments of debt D_j, then the annual interest can be calculated using the following equation (White et al 1989):

$$\begin{aligned} I_j &= D_j - DP_j \\ &= D_j - \frac{D_j}{(1+r_D)^{(N-j+1)}} \\ &= D_j[1 - \frac{1}{(1+r_D)^{(N-j+1)}}] \end{aligned} \qquad (3\text{-}20)$$

$$j = 1, 2, \ldots, n$$

where DP_j = payment for the debt principal in the j^{th} year.

SIMULATION AS A RISK MANAGEMENT TOOL

Main Risks in Project Finance

A BOT infrastructure project is characterized by high capital outlay, long lead-time, and long operating period. The project is subject to a variety of risks and uncertainties in the concession period, among which construction risk and economic risk are two major risks. The construction risk is characterized by cost overrun and schedule delay. For example, the construction cost of the Channel Tunnel project doubled although it was expected to be less risky because of its technical simplicity (Finnerty 1996). The economic risk includes demand risk (quantity and price), variation of *OM* costs, fluctuation in currency exchange rates and interest rates, and inflation risk. Understanding these stochastic risk variables will result in informed decision-making regarding suitable toll/ tariff levels and equity level, better forecasting of cashflows, and consequently sound financial viability analysis. This necessitates the use of suitable risk analysis techniques.

Monte Carlo Simulation

Capital structure optimization and financial viability analysis are based on the values of a set of stochastic variables. This necessitates modeling the project development (construction and operation) process as a stochastic process that behaves according to pre-specified laws of probability. Each infrastructure project is unique. However, most of the activities are not as there are many management similarities. Monte Carlo simulation is a useful tool to model a stochastic process where the input data are random following certain statistical distributions. In such a simulation, the computer generates large sets of outputs after running a large number of iterations with random inputs. These outputs are then statistically analyzed to measure their uncertainties/ risks.

The following sections discuss the use of Monte Carlo simulation in the management of construction and economic risks.

Construction Cost Range Estimating

A range estimate is performed to (1) determine the probability of achieving this estimate and (2) derive a value to use for contingencies. The following steps are necessary for construction cost range estimating.

1. *Define the project scope and divide it into manageable work components.* This can be represented by a work breakdown structure (WBS), which is usually in a chart

form incorporating a number of distinct work packages. Many types of projects have standard WBSs that can be used as templates for a project under examination. It there does not exist such a WBS for the project, then a decomposition method can be employed to subdivide the major project deliverables into smaller more manageable components until the deliverables are defined in sufficient detail to support development of project activities (planning, executing, controlling and closing) (*A guide* 2000).

2. *Classify each work package into two types of items*: (1) items with certainty and (2) items that are uncertain.

3. *Establish the statistical distributions of uncertain items.* Meaningful simulation of construction costs requires the establishment of appropriate probability distributions for uncertain cost items. Historic cost data of these uncertain items of previous similar projects can be used as sample data, based on which the distributions of these cost items can be determined empirically. Historic cost data can be obtained from records of previous projects and/ or commercial databases. Then a statistical distribution can be fitted to this collected sample data. Goodness of fit test should be performed (1) by taking either the chi-square test or the Kolmogorov-Smirnov test, or (2) by visually comparing either the empirical cumulative distribution function (CDF) to the fitted (theoretical) CDF, or the histogram of the sample data to the theoretical probability density function (PDF). However, if there are not enough data to derive the distributions, expert knowledge can be explored to assign subjective distributions to cost items. Some commonly used distributions are presented in Table 3.1.

4. Establish the statistical distribution of the total cost of the project. These takes the following steps: (1) Generate uniform random number on the interval [0,1] as shown

Table 3.1 Distributions and random variates (based on Ahuja et al 1994; Taylor and Karlin 1998)

Distr. type	PDF and CDF	Random variate X	Remarks
Uniform	$f(x)=\begin{cases}\frac{1}{U-L} & L\le x\le U\\ 0 & Otherwise\end{cases}$ $F(x)=\begin{cases}0 & x<L\\ \frac{x-L}{U-L} & L<x\le U\\ 1 & x>U\end{cases}$	$X=L+Y(U-L)$	This distribution reflects an equal likelihood of expected values ranging from a minimum *L* to a maximum *U*. It can be used whenever user decides on a lowest and highest value for an item, but is not sure how values are distributed.
Normal	$f(x)=\frac{1}{\sqrt{2\pi}\sigma}e^{-(x-\mu)^2/2\sigma^2}$	$X=\mu+\sigma\cos 2\pi Y_1\sqrt{-2\log Y_2}$ $X=\mu+\sigma\sin 2\pi Y_1\sqrt{-2\log Y_2}$	Normal distribution is described by the mean μ and standard deviation σ. It is suitable for items where values are clustered around μ, equally likely to be either above or under μ.
Triangular	$f(x)=\begin{cases}\frac{2(x-L)}{(M-L)(U-L)} & L\le X\le M\\ \frac{2(U-x)}{(U-M)(L-M)} & M\le x\le U\end{cases}$ $F(x)=\begin{cases}\frac{(x-L)^2}{(M-L)(U-L)} & L\le x\le M\\ 1-\frac{(U-x)^2}{(U-L)(U-M)} & M\le x\le U\\ 0 & x<L\\ 1 & U<x\end{cases}$	$X=\begin{cases}L+\sqrt{Y(M-L)(U-L)} & 0\le Y\le\frac{M-L}{U-L}\\ U-\sqrt{(1-Y)(U-M)(U-L)} & \frac{M-L}{U-L}<Y\le 1\end{cases}$	This distribution shows values ranging from a minimum *L* to a maximum *U* with a clustering around an expected value (mode) that is different from the mean. The range from *L* to *M* is often different from *M* to *U*.
Exponential	$f(x)=\begin{cases}\frac{1}{\mu}e^{-x/\mu} & 0\le x\le\infty\\ 0 & Otherwise\end{cases}$ $F(x)=\begin{cases}1-e^{-x/\mu} & 0\le x\le\infty\\ 0 & Otherwise\end{cases}$	$X=-\mu\ln(1-Y)$	This distribution is described by the mean μ. It is commonly used in reliability engineering, because it represents both phenomenological and empirical behaviors.
Beta	$f(x)=\begin{cases}\frac{\Gamma(\delta+\gamma)(x-L)^{\delta-1}(U-x)^{\gamma-1}}{\Gamma(\delta)\Gamma(\gamma)(U-L)^{\delta+\gamma-1}} & L\le x\le U\\ 0 & Otherwise\end{cases}$ $\Gamma(z)\equiv\int_0^\infty t^{z-1}e^{-t}dt$ for all $z>0$	This is somewhat complicated. See Ahuja et al (1994) for details.	Beta distribution is defined by the minimum value *L*, maximum value *U*, and two shape parameters δ and γ. The PDF of beta distribution can attain varied shapes to represent cases where the most likely value is close to the pessimistic or optimistic value. The beta distribution is also bounded between two points, making it more suitable for finite modeling of activity times as used in PERT.

Note: Y, Y_1, Y_2 are random numbers on [0, 1].

in Table 1; (2) Transform the random number into relevant statistical distributions of the uncertain cost items and calculate the corresponding costs of these items. (3) Calculate the total project cost on this iteration by adding all cost items including both uncertain and certain ones. (4) Repeat steps (1) to (3) for a great number of iterations. (5) Establish the PDF and CDF of the total project cost and calculate relevant statistics.

5. *Calculate the construction cost at a given confidence level and predict percent overrun probability*. Assume that the PDF and CDF of the base construction cost are $f(C_B)$ and $F(C_B)$, respectively. Then, the base construction cost at a confidence level a can be calculated as $C_B^a = \int_0^a f(C_B)d(C_B) = F^{-1}(a)$, and the percent overrun probability of C_B^a is 1 - a.

Simulation of Construction Duration

CPM

The most commonly used tools for scheduling are network-basked, one of which is the critical path method (CPM). The CPM breaks down the project into activities, arranges them into a logical sequence and estimates the duration of each activity and displays the work plan using precedence diagrams or arrow diagrams. It then determines the minimum possible duration of the project using forward pass and backward pass calculations based on the logic and criticality for the activities. The CPM is a deterministic tool in that it assumes only one value (the expected value) for the duration of each activity and thus it does not provide a measure of uncertainty associated with the estimate of a particular milestone in a project or the project completion time.

Simulation of PERT Networks

Monte Carlo simulation can eliminate the limitations of the PERT in addressing risks and uncertainties. It uses the statistical distribution of the time for each activity and considers activity criticality rather than path criticality. Once the project schedule network is finalized either by a precedence diagram or an arrow diagram, and the duration distribution for each activity in the network established, Monte Carlo simulation can be used to establish the statistical distribution of the minimum construction duration based on a random set of durations of all activities.

Simulation of Economic-Risk-Related Variables

Fluctuations in market demand (price and quantity), OM costs, interest rate, currency exchange rate and inflation constitute the economic risks for the project. Sample data of OM costs can be generated from historical data of similar projects with appropriate adjustments, while sample data of other economic variables can be derived by analyzing the economic data of the country where the project is located. Statistical distributions of these economic variables can then be established using Monte Carlo simulation based on their sample data.

FINANCIAL ANALYSIS FRAMEWORK

A framework for capital structure optimization and financial viability analysis (Figure 3.2) has been developed based on the discussions in the previous sections. This framework can be divided into three steps: (1) Step 1: simulation of construction risks; (2) Step 2: simulation of economic risks; and (3) Step 3: financial analysis and capital structure optimization.

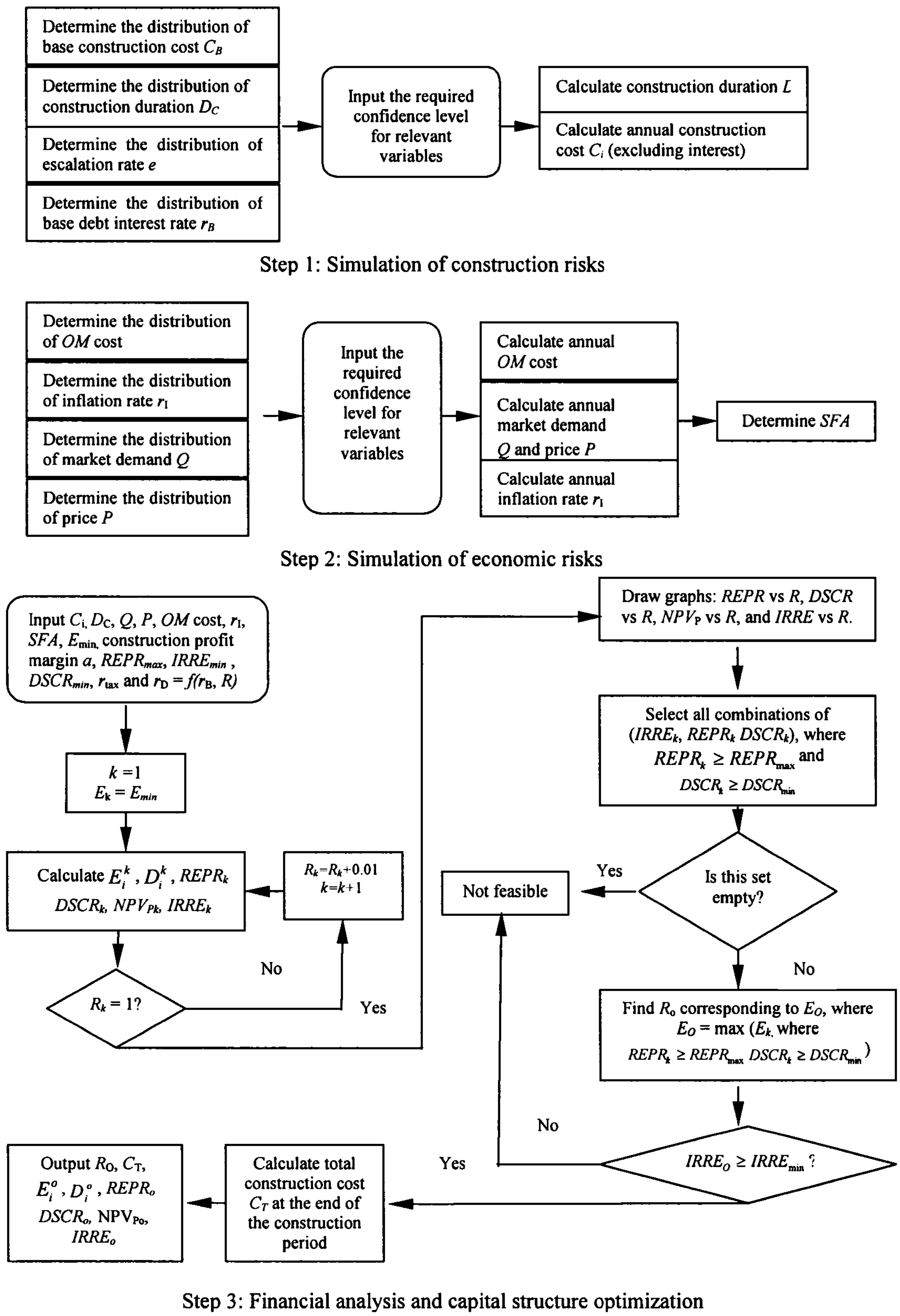

Figure 3.2 Framework for capital structure optimization and financial evaluation

Simulation of Risk Variables

The simulation techniques needed for step 1 and 2 have been discussed in the section "Simulation as a Risk Management Tool." The main purposes of these two steps are: (1) To determine the statistical distributions of various construction and economic risk variables using Monte Carlo simulation, including base construction cost C_B, construction duration D_C, construction cost escalation rate e, base debt interest rate r_B, OM cost, inflation rate r_I, market demand Q and price P. (2) To determine the value of these risk variables at the required confidence level. (3) To determine the SFA at an appropriate discount rate.

Capital Structure Optimization and Financial Viability Analysis

In Step 3, optimization and financial viability analysis techniques (as discussed in previous sections) are deployed to determine the optimal equity level that maximizes the $IRRE$ and satisfies the requirements as imposed by the government and lenders. This takes the following procedures:

(1) Input data: annual construction cost C_i (not including interest cost), construction duration D_C, market demand Q, price P, OM cost, base debt interest rate r_B, self-financing ability SFA, minimum equity level required R_{min}, construction profit margin ω, maximum allowable ratio of equity at project risks $REPR_{max}$, minimum allowable debt service cover ratio $DSCR_{min}$, r_{tax}, and debt interest r_D as a function of base interest r_B and equity level R.

(2) Let $k = 1$ and $R_k = R_{min}$.

(3) Calculate annual equity drawing E_i^k, debt drawing D_i^k, $REPR_k$, $DSCR_k$, net present value of the net profit to the equity holders NPV_P, and $IRRE_k$.

(4) Let $k = k+1$ and $R_k = R_k+1\%$. If $R_k = 1$ go to step (5). Otherwise, go to step (3).

(5) Draw following graphs: *REPR* vs *R*, *DSCR* vs *R*, NPV_P vs *R* and *IRRE* vs *R*.

(6) Selection all combinations of (R_k, $REPR_k$, $DSCR_k$), where $REPR_k \geq REPR_{max}$ and $DSCR_k \geq DSCR_{min}$. If this set is empty, then the project is not financially viable. Otherwise, let $R_o = \max(R_k)$. R_o would be the optimal equity level.

(7) Calculate C_T that is corresponding to R_o.

(8) Output the results corresponding to R_O: C_T, E_i^o, D_i^o, $REPR_o$, $DSCR_o$, NPV_{PO}, $IRRE_O$.

CONCLUSIONS

Infrastructure projects across a wide range of industries and sectors have been privatized worldwide to promote their development and increase efficiency by encouraging private sector involvement. BOT is an underlying concept in a variety of privatization scenarios. Innovative risk management and financial engineering techniques are needed to address the radical reallocation of risks, responsibilities and rewards in project finance. The capital structure optimization and financial viability analysis should follow a public-private win-win principle, reflecting the interest and requirements of different project participants. The economic return to equity holders is maximized subject to the requirements of minimum equity level, minimum *DSCR*, maximum *REPR* and other constraints that may be imposed by the lenders and the government. Furthermore, the effects of governmental loan guarantee and supports on the financial viability should be taken into consideration.

The capital structure affects not only the total life cycle cost of the project that in turn affects the financial viability, but also affects the motivation and commitment of project participants to a successful project development. Long-term commitment of equity holders is a prerequisite to effective and efficient project management. The *EPR* can measure this commitment quantitatively and indirectly.

Construction and economic risks are the two major types of risks in project finance. These risk variables can be better modeled by Monte Carlo simulation. A meaningful simulation requires the establishment of appropriate statistical distributions of these risk variables.

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APPENDIX 3.1: LIST OF PARAMETERS

C_i: construction cost in the i^{th} year of construction

C_B^i: base construction cost in the i^{th} year of construction

C_T: total construction cost

D_C: construction duration

D^i: debt drawing in the i^{th} year of construction

D_j: debt installment in the j^{th} year

DE_j: depreciation in the j^{th} year

DP_j: payment for the debt principal in the j^{th} year

$DSCR$: debt service coverage ratio

$DSCR_j$: debt service coverage ratio in the j^{th} year

$DSCR_{\min}$: minimum value of $DSCR$ required by the lender

E: amount of total equity

E^i: equity drawing in the i^{th} year of construction

e_k: escalation rate for the k^{th} year of the construction

EPR: equity at project risks

g: grace period of debt

I_j: debt interest in the j^{th} year

$IRRE_{\min}$: minimum value of $IRRE$ required by equity holders

$LLCR$: loan life coverage ratio

$LLCR_k$: loan life coverage ratio as measured in the k^{th} year of the loan repayment period

$LLCR_{\min}$: minimum value of $LLCR$ required by the lender

m: construction duration

n: operation period

n_d: design life of the project

N: debt repayment period

NCI_j: annual net cash inflow in the j^{th} year of operation

NFV_C: net future value of construction cost as discounted at the end of the construction period

NPV_P: net present value of the equity holders' total net profit at a specific equity level

NPV_R: net present value of the net revenues in the operation period as discounted at the end of the construction period

OM_j: operation and maintenance cost in the j^{th} year

P_D: net present value of the total debt

P_j: price in the j^{th} year

$PBIT_j$: profit before interest and tax in the j^{th} year

Q_j: annual production in the j^{th} year

r: discount rate

r_B: base interest rate of debt

r_D: interest rate of debt

r_{tax}^j : income tax rate corresponding to the income level (or bracket of income) in the j^{th} year

R: equity level

R_{min}: minimum equity level required by the public client

RE_j: annual revenue in the j^{th} year

$REPR$: ratio of equity at project risks

$REPR_{max}$: maximum allowable value of $REPR$

SFA: self-financing ability

T_c: project completion time

T_o: operation period

TAX_j: tax in the j^{th} year

ω: profit margin on construction activities

CHAPTER 4: CONCESSION PERIOD [1]

INTRODUCTION

Governments around the world have in general shown interests in private sector finance and provision of public works and services. Since 1985, more than 1370 infrastructure projects with estimated capital costs of over $US575 billion have been developed or proposed to be developed with private finance in more than 100 countries (Reinhardt Communications Corporation 2000; Ye and Tiong 2003), in which Build–operate–transfer (BOT)-type contractual models have been popular in both developed (National Council for Public-Private Partnerships 2002) and developing countries (International Finance Corporation 1999).

Under a BOT scheme, a project is developed through a concession agreement between a public authority and a private company (the concessionaire), in which the public authority grants the concessionaire the rights to build and operate the project for a certain period (the concession period). The concessionaire pays back the loan (principal and interest) and recovers its investment with an expected level of profit through revenues from the project within the concession period, and at the end of the concession transfers the project that should be in operational condition to the public authority usually at no cost. The concession agreement also generally specifies the payment structure, covenants restricting the conditions under which the public authority or the concession-

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[1] A paper version of this chapter is accepted for publication in *Canadian Journal of Civil Engineering*.

aire may terminate the concession, and any compensation to be paid by one party to the other in the event of unilateral termination of the concession. BOT schemes are discussed in detail in Delmon (2000).

In practice, a long-term fixed concession period is the most common approach, although there may be a mechanism for extending it for a limited additional period in order to compensate the concessionaire for risks it is not prepared to bear, such as *force majeure* and market demand that is far below the expected level. Some countries include the construction phase as part of the concession period while others do not. In the former, the concession period starts when construction begins. For example, the first eight design-build-finance-operate roads in the United Kingdom have a fixed concession period of 30 years (Highways Agency 1997). In the latter, the concession period begins at the completion of the construction. For example, the Shajiao B power project in China has a predetermined construction period of 33 months and operation period of 10 years. The concessionaire can still operate the project for 10 years even if the project is completed behind schedule (Ye and Tiong 2000). There are also a few examples of concession whose terms are variable depending on the date when the lenders recover their principal and interest, and equity holders earn a certain level of return. In addition, some countries have legislative provisions limiting the duration of infrastructure concessions to a maximum number of years and/or requiring that the concession expire once the debts of the concessionaire have been fully repaid and a certain level of revenue/ production/ usage has been achieved even if this maximum number of years has not been reached. For example, the Dartford bridge project has a maximum concession period of 20 years, within which facilities of the project are required to be handed back to the government once debt charges and other costs have been recovered (Walker and Smith 1995). A variable concession period is more likely to be used where (1) the scope of the project has not been clearly defined, (2) the project company is financially high-leveraged, (3) construction activities of the project are very complex with substantial risks, and (4) the cash flows in future operation are very difficult to predict.

Different projects will incur different cash flow profiles during their life cycles. BOT-type projects usually require a great amount of upfront investment in the construction of infrastructure facilities, the recovery of which is through revenues from the project over the concession period. One important issue for the government considering using a BOT scheme to develop a particular infrastructure project is the determination of the appropriate length of the concession period. This length depends on a number of factors, such as the type of the project, the size and complexity of construction activities, operational life of the project facility, the capital structure of the concessionaire company, and the market situation and revenue stream in the future operation. There are many uncertainties and risks in construction and future operation, which have significant impacts on the length of the concession period.

This research proposes a methodology for the determination of the length of the concession period based on a public-private win-win principle. That is, the concession period should be long enough to enable the concessionaire to achieve a "reasonable" return to its investment, but not too long such that the concessionaire's return is "excessive" and the interests of the public sector are impaired. A mathematical model has been developed to reflect this "reasonable but not excessive" concept. Monte Carlo simulation technique is exercised to model the impacts of risks and uncertainties on the length of the concession period. A case study based on hypothetical data is provided to illustrate the application of the proposed methodology, mathematical model and simulation techniques.

CONCESSION PERIOD

Design of Concession Period

Tiong and Ye (2003) have identified three major elements in the design of the concession period: (1) structure, (2) length, and (3) incentive scheme. There are two period structures. One is the single-period concession that combines the construction period and operation period, and the other is the two-period concession that separates the operation period from the construction period. The single-period concession fixes the length of the concession and thus transfers the construction time-overrun risk to the concessionaire. This means that the operation period is shorter if the construction period is longer, and vice versa. The concessionaire benefits from revenues generated from earlier operation if the project is completed ahead of schedule, or otherwise bears the loss of revenues resulting from delayed and reduced operation time. In the two-period concession, the concessionaire will have a fixed operation period regardless of actual completion time of construction. Possible incentive schemes include early completion bonus (the concessionaire shares a percentage of the revenues generated in the period ahead of the scheduled completion time) and late completion penalty (the concessionaire bears a percentage of the losses resulting from delay of completion).

Essence of Concession Period

As mentioned in the previous section, BOT-type projects usually require a large amount of project development costs, which are intended to be recovered through revenues in the future operation period. In general, a longer concession period will allow the concessionaire to collect more revenues with reduced interests to the public sector, and vice versa. Therefore, the concession period divides the revenues in the project life cycle between the public and private sectors.

The length of the concession period is determined by two time variables: construction period and operation period. Construction schedules are always estimates because a great number of factors affect construction activities. The operation period is the time needed for the concessionaire to pay back loans (principle and interest) and recover its investment with a certain level of return based on projected revenues which are subject to market risks. A shorter concession period may mean higher initial tariff/ toll levels and/or future increases of tariffs/ tolls in the operation period. High tariff/ toll levels and their increases often encounter strong pubic oppositions. Therefore, the essence of an appropriate length of the concession period lies in (1) an informed estimation of the project completion time within which an experienced contractor can complete the project on schedule and (2) a sound prediction of the operation period that allows the concessionaire to obtain a "reasonable but not excessive" level of return.

For the private concessionaire, the length of the concession period should be long enough to allow the concessionaire to recoup its investment costs and obtain a "reasonable" return within that period, taking into consideration of the scope and severity of risks involved in the particular project, and the opportunity costs in the current and future markets. For the public government, the concessionaire's return should not be "excessive", compared to its commitments and efforts and benchmarked with information on costs and rates of return that are available in the current and future markets.

In addition, a BOT scheme should achieve a better result than a traditional public procurement approach. This is often examined by introducing a public sector comparator (PSC). The United Kingdom Treasury Taskforce (1999) defines the PSC as a hypothetical, risk-adjusted costing by the public sector as a supplier, to an output specification produced as part of a procurement exercise. The PSC is expressed in net present value terms based on the required output specifications and taking into full account the risks which would be encountered by that style of procurement. The PSC is used (1) to determine if the project is affordable to government by ensuring full life cycle costing at an early stage; (2) as a means to test whether a PPP project is viable and demonstrates value for money; (3) as a management tool to communicate with partners on such key aspects as output specifications and risk allocation; and (4) as a means to encourage broader competition by creating greater confidence in the bidding process (Industry Canada 2003).

Mathematical Definition of Concession Period

According to the "reasonable but not excessive" principle, the concession period T is defined as

$$T = T_c + T_o \tag{4-1}$$

where T_c= project completion time; T_o =operation period; and T_c and T_o satisfy conditions (4-2) to (4-4):

$$T_c \leq T_{c\max} \tag{4-2}$$

$$T_o \leq T_{oe} \tag{4-3}$$

$$NPV_I(1+R_{\min}) \leq NPV\big|_{T_o=t} \leq NPV_I \times (1+R_{\max}) \tag{4-4}$$

where $T_{c\max}$ = maximum allowable project completion time; T_{oe} = designed economic operation life of the project; NPV_I = net present value of the total project development cost; $R_{\min}$ = minimum rate of return required by the private sector in the development of a certain type of projects; $R_{\max}$ = maximum rate of return to the total project development cost that is acceptable to the public sector; and $NPV|_{T_o=t}$ = net present value of net revenues generated from a operation period $T_o = t$.

All T in which T_c and T_o satisfy conditions [2] to [4] constitutes the concession interval. Any point within this interval is considered to be an appropriate length of the concession period.

SIMULATION-BASED APPROACH

Risks Affecting Concession Period

From equations (4-1) to (4-4) it is obvious that the determination of an appropriate concession period T requires a good estimation of the construction period T_c and the operation period T_o. T_c is dependent on the durations of various construction activities, their relationships, planning and scheduling. Various construction risks may occur in the project site, relationships of contractual parties, contractual arrangements, technical specifications and other areas. These include archaeological discoveries, delays in resolving site construction problems, adverse environmental conditions such as hazardous wastes, permits and licenses, varying subsurface conditions (e.g., difficult soils, rock and groundwater, and underground utilities), design changes, extreme weather or natural disasters, insufficiency of plans and specifications, construction cost escalation, inadequacy of resources (e.g., labor force, material and funding), changes in legal requirements, delays in delivery of critical equipment and supplies, labor strife/jurisdictional disputes, political involvement and interference, subcontractor capability, protracted disputes, and third-party litigation (American Consulting Engineers Council and Associated General Contractors of America 1998). These risks have significant impacts on project completion time.

T_o depends on the project development cost (NPV_I) and the net present value of the net revenues in the operation period ($NPV|_{T_o=t}$). NPV_I depends on the costs of various construction activities. The various construction risks mentioned in the above may also greatly increase the project development cost. For example, the construction cost of the Channel Tunnel project doubled although it was expected to be less risky because of its technical simplicity (Finnerty 1996). $NPV|_{T_o=t}$ depends on the construction period T_c and many risks that may be encountered in future operation of the project, particularly, economic risks such as service/product demand (quantity and price), project operation and maintenance costs, exchange rate (if foreign currency is involved), interest rate and inflation rate.

Framework of the Simulation-Based Approach

As mentioned in the above, a PPP infrastructure project is subject to a variety of risks and uncertainties. Therefore, to facilitate decision-making, it is necessary to quantify these risks and model the project development as a stochastic process that behaves according to certain laws of probability. Risk analysis and modeling and consequent re-engineering of the project development process can lead to informed decisions in the procurement of pubic works and services. Computer simulation is a useful tool for decision-making under uncertainties and risks. The advances in simulation methodologies, development of special-purpose simulation languages, and massive computing capabilities of modern computers have made computer simulation one of the most widely used tools in operations research and systems analysis over the last two decades (Banks et al. 2001). For example, computer simulation has been used in many areas of the construction industry including process modeling and simulation, claims analysis and dispute resolution, and project planning, scheduling, estimating and control.

One useful and often used simulation tool is Monte Carlo simulation (Binder and Heermann 2002), which models a stochastic process with random input data that follows certain statistical distributions. In such a simulation, the computer generates large sets of outputs after running a large number of iterations with random inputs. These outputs are then statistically analyzed to measure their uncertainties and risks. For example, Monte Carlo simulation has been used in the risk analysis of new business ventures (Wright 2002) and in life-cycle costing analysis with uncertainties (Emblemsvag 2003).

In this research, Monte Carlo simulation is used to quantify and reason with the risks affecting the length of the concession period of a BOT-type project. Project development parameters are assumed to be random variables following certain statistical distributions instead of being deterministic values. Major risk variables considered here are construction period T_c, project development cost NPV_I, market demand, sale price, project operation and maintenance costs, and discount rate (combing interest rate and inflation rate). The procedures of the simulation-based approach are shown in Figure 4.1. Details of each step are discussed in the following sections.

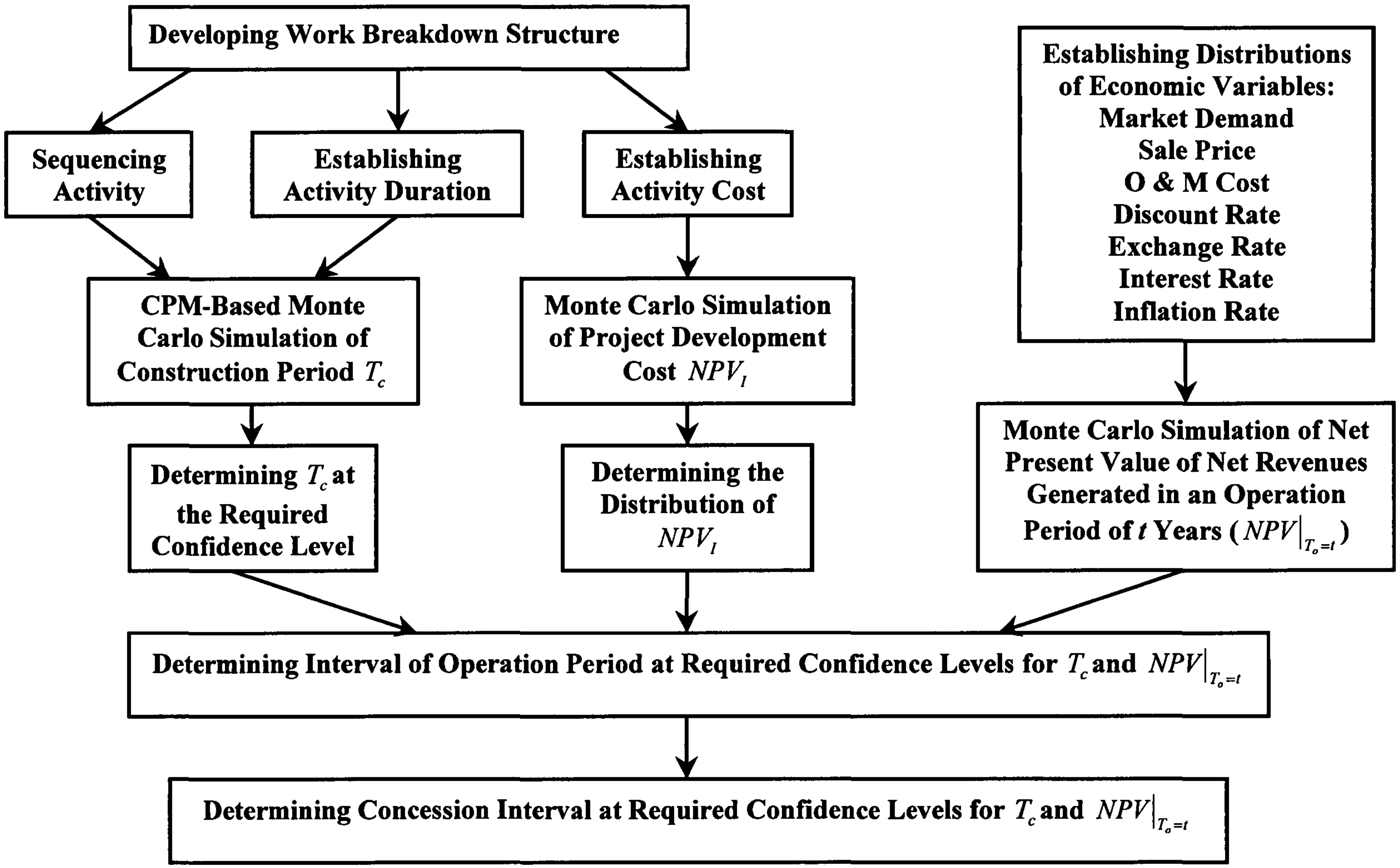

Figure 4.1 Procedures of the proposed simulation approach

CPM-Based Monte Carlo Simulation of Project Completion Time T_c

The critical path method (CPM) is the most commonly used technique in the determination of the minimum possible duration of a construction project. The CPM breaks down a construction project into distinct work activities, arranges them into a logical sequence, estimates the duration of each activity, and displays the work plan using precedence diagram, arrow diagram, or conditional diagram. It then determines the minimum possible construction duration using forward pass and backward pass calculations based on the logic and criticality of the activities (Project Management Institute 2000). The CPM is a deterministic tool in that it assumes only one value for the duration of each activity and thus it does not provide a measure of uncertainty associated with the estimate of a particular milestone or of the overall project completion time. Monte Carlo simulation can eliminate the limitations of the CPM in addressing risks and uncertainties (Ahuja et al. 1994). Instead of determining the path criticality of a construction project as in the CPM, Monte Carlo simulation examines activity criticality based on the statistical distribution of the duration of each activity. The criticality of an activity is measured by the ratio of number of runs in which this activity is critical to the number of total simulation runs. The higher the ratio is, the more critical the activity. Therefore, once the project schedule network is finalized and the time distribution of each activity in the network established based on historical data and/ or expert knowledge, Monte Carlo simulation can be used to establish the statistical distribution of the project completion time using the CPM based on a randomly generated set of durations of all work activities. Then, the project completion time at a particular percentile can be calculated using this established distribution. Furthermore, the distribution of the project completion time also provides a basis on which the maximum allowable project completion time ($T_{c\max}$) is determined.

Monte Carlo Simulation of Operation Period T_o

T_o must satisfy the condition $NPV_I(1+R_{\min}) \leq NPV|_{T_o=t} \leq NPV_I \times (1+R_{\max})$. To determine operation period T_o requires good estimation of the total project development cost NPV_I and efficient prediction of $NPV(T_o)$. The procedures for simulating NPV_I and $NPV(T_o)$ and for determining T_o are discussed in the following sections.

Simulation of NPV_I

Monte Carlo simulation technique can be employed to determine the probability of achieving an estimate of the total project development cost that is within a certain range based on the statistical cost distributions of major project development activities. The following steps are followed in this simulation analysis: (1) define the project scope and establish its work breakdown structure; (2) classify the work items of each work package into two groups: group one – work items with high degree of cost certainty and group two – work items with uncertain costs; (3) establish or assume the statistical cost distributions of uncertain work items; (4) establish the statistical cost distribution of each work package; (5) establish the statistical distribution of the total construction cost of the project; and (6) calculate the total project development cost at a required percentile (Zhang 2005).

Simulation of $NPV|_{T_o=t}$

$NPV|_{T_o=t}$, the net present value of the net revenues generated in a specific operation period $T_o = t$, is calculated using the following formula:

$$NPV\big|_{T_o=t} = \frac{1}{(1+r)^{T_c}} \sum_{i=1}^{t} \frac{NCF_i^o}{(1+r)^i} = \frac{1}{(1+r)^{T_c}} \sum_{i=1}^{t} \frac{(I_i^o - C_i^o)}{(1+r)^i} \quad (4\text{-}5)$$

$$I_i^o = Q_i^o \times P_i^o \quad (4\text{-}6)$$

where NCF_i = net cash flow; I_i^o = income; C_i^o = operation and maintenance cost; Q_i^o = quantity of demand; and P_i^o = sale/service price in the i^{th} year of operation; and r = annual discount rate.

$NPV\big|_{T_o=t}$ is dependent on T_c, I_t^o, C_t^o and r. As discussed in the above, the distribution of T_c is estimated using CPM-based Monte Carlo simulation. T_c corresponding to a specific percentile α_c can be calculated based on this established distribution. If the statistical distributions of I_t^o, C_t^o and r can be established based on historical data, or reasonably assumed based on expert knowledge, then the statistical distributions of $NPV\big|_{T_o=t}$ can be established using Monte Carlo simulation. $NPV\big|_{T_o=t}$ can be reasonably assumed as a normal distribution with mean μ_o and standard deviation σ_o. μ_o and σ_o can be determined by a large number of simulation runs. $NPV\big|_{T_o=t}$ corresponding to a specific percentile α_o can be calculated based on this established normal distribution.

Interval of Operation Period

$NPV\big|_{T_o=t}$ corresponding to different percentiles can be calculated based on the established distributions of $NPV\big|_{T_o=t}$. Let $(T_o^l\ T_o^u)\big|_{\alpha_o}^{\alpha_I}$ denotes the interval of the operation period at α_I percentile of NPV_I and α_o percentile of $NPV\big|_{T_o=t}$. Then, T_o^l is the minimum t that satisfies $NPV_I^{\alpha_I}(1+R_{\min}) \le NPV^{\alpha_o}\big|_{T_o=t}$ and T_o^u is the maximum t that satisfies $NPV^{\alpha_o}\big|_{T_o=t} \leq NPV_I^{\alpha_I}(1+R_{\max})$, where $NPV_I^{\alpha_I}$ is the net present value of the total project development cost at α_I percentile and $NPV^{\alpha_o}\big|_{T_o=t}$ is the net present value of the total annual net cash flows from operation year 1 to t at α_o percentile.

CASE STUDY

A hypothetical BOT infrastructure project is used to demonstrate the application of the proposed methodology, mathematical model and simulation-based approach discussed in the above. Please note that this project is intentionally simplified for the purpose of demonstration. In this case study, the package *CRYSTAL BALL* was used for conducting Monte Carlo simulations. A total of 20,000 simulation analyses were conducted in each required simulation variable, such as construction time, project development cost, and the accumulative net present value of the net revenues up to a particular operation year in the designed economic operation life of the project.

Statistical Distributions of Key Project Variables

The estimates on key project variables are given probability distributions. These variables are project development cost, activity duration, market demand, sale price, operation and maintenance (O&M) cost, and discount rate.

Activity Costs and Durations

The project is divided into four major work activities (1 – 4). It is assumed that the distributions of the costs (in million dollars at the beginning of the first year of construction) and durations of the four activities are already established based on historical data, using the methods mentioned in the sections "Simulation of NPV_I" and

"CPM-Based Monte Carlo Simulation of Project Completion Time T_c," respectively. These distributions are shown in Table 4.1.

Table 4.1 Construction cost and duration distributions of different activities

Activity	Cost distribution	Duration distribution
1	Normal distribution, with mean \$150,000,000 and standard deviation \$15,000,000.	Triangular distribution, with most likely duration of 1.5 years, minimum duration of 1 year, and maximum duration of 2 year.
2	Normal distribution, with mean \$200,000,000 and standard deviation \$30,000,000.	Uniform distribution, with minimum duration of 1 year, and maximum duration of 2 years.
3	Triangular distribution, with most likely value of \$200,000,000, minimum value of \$100,000,000, and maximum value of \$300,000,000.	Normal distribution, with mean of 1.5 years and standard deviation of 0.2 years.
4	Uniform distribution, with minimum value of \$100,000,000 and maximum value of \$300,000,000.	Triangular distribution, with most likely duration of 1 year, minimum duration of 0.5 year, and maximum duration of 1.5 years.

Market Demand and Price

The designed annual production capacity of the project is 10×10^8 units. In the operation period, the annual market demand of the product follows a normal distribution, with mean value of 8×10^8 units and standard deviation of 2×10^8 units. The sale price of the product follows a normal distribution with a mean of \$0.4/unit and a standard deviation of \$0.04/unit.

Operation and Maintenance Cost

The designed economic operation life of the project is 30 years. It is assumed that the O&M cost is increasing over this operation life. For simplicity, it is assumed that the annual O&M cost is 20% of the total annual sales revenue in the first ten years of operation, 30% in the second ten years, and 40% in the third ten years. As the annual demand quantity and sale price are random variables, the annual O&M cost is also random.

Annual Discount Rate

Discount rate can be seen as the interest rate charged by financial institutions for the use of their money. It is used to discount cash flows to reflect risks and the time value of money. The discount rate r can be calculated in the following formula (Brealey et al. 2003):

$$r = (1 + r_r)(1 + r_I) - 1 \tag{4-7}$$

$$r \approx r_r + r_I \tag{4-8}$$

where r_r = real interest rate; and r_I = inflation rate.

Here it is assumed that the annual discount rate r follows a normal distribution with mean of 10% and standard deviation of 1%.

Simulation of Project Completion Time T_c

Assume that the four activities follow finish-start relationships from activity 1 to activity 4, then, T_c is a stochastic variable whose value is the summation of the randomly generated values of the durations of activities 1 to 4. The statistics of T_c are shown in Table 4.2. Figure 4.2 and Figure 4.3 are the frequency and cumulative charts of T_c. Based on the statistics and shapes of the frequency and cumulative charts, it is reasonable to assume that T_c follows normal distribution, with mean of 5.83 years and standard deviation of 0.48 years.

Table 4.2 Statistics of total construction time (year)

Statictics	Value
Mean	5.83
Median	5.83
Standard Deviation	0.48
Variance	0.23
Skewness	0.08
Kurtosis	2.78
Coeff. of Variability	0.08
Range Minimum	4.25
Range Maximum	7.56
Range Width	3.31
Mean Std. Error	0.00

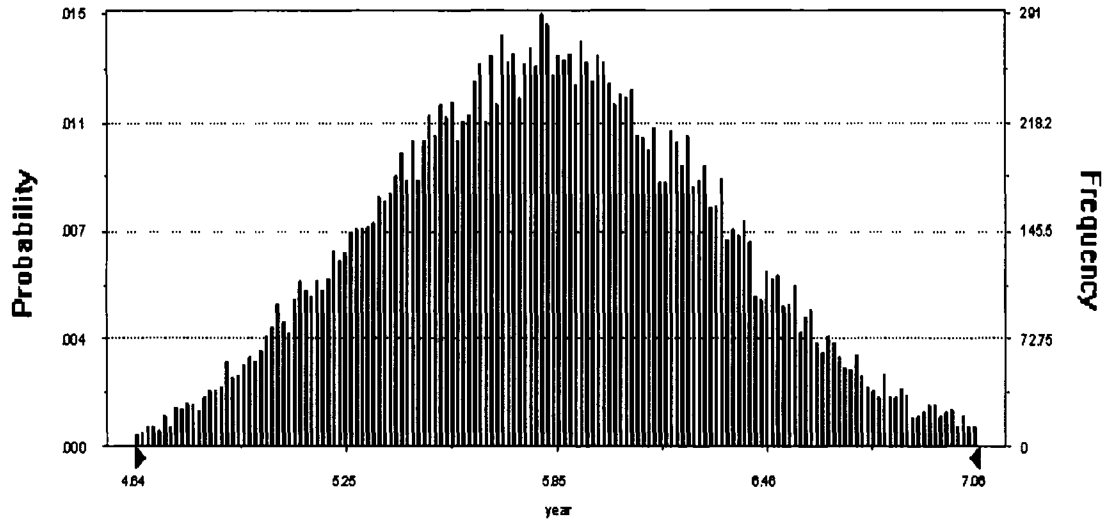

Figure 4.2 Frequency chart of total construction time

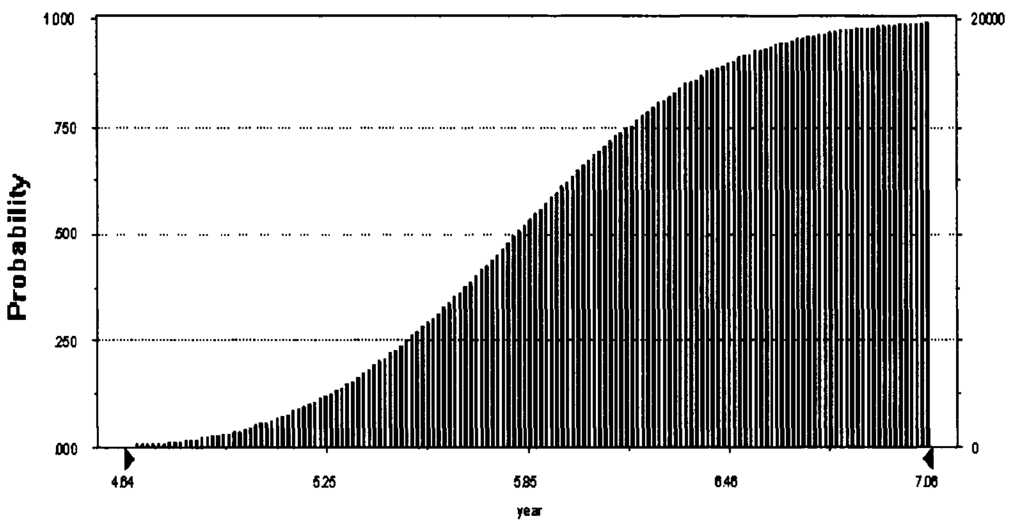

Figure 4.3 Cumulative chart of total construction time

Let $T_c|_a$ denote the a^{th} percentile of the random variable T_c, then

$$T_c|_a = \overline{T_c} + z_a\sigma \tag{4-9}$$

where $\overline{T_c}$ = mean of T_c; z_a = critical value of standard normal distribution at the specified percentile value a; and σ = standard deviation of T_c.

The project completion time can be derived according to equation [9] based on the risk tolerance of the decision maker. For example, if a decision maker of low risk tolerance sets the project completion time at the 95% percentile, denoted by $T_c|_{a=95\%}$, then

$T_c|_{a=95\%} = \overline{T_c} + z_a\sigma = 5.83 + 1.645 \times 0.48 = 6.62$ years.

Table 4.3 Statistics of total project development cost ($ million)

Statistics	Value
Mean	751.04
Median	750.27
Standard Deviation	78.97
Variance	6,236.21
Skewness	0.01
Kurtosis	2.59
Coeff. of Variability	0.11
Range Minimum	494.91
Range Maximum	994.96
Range Width	500.05
Mean Std. Error	0.56

Simulation of NPV_I

The total project development cost NPV_I is a stochastic variable, whose value is the summation of the randomly generated values of the costs of the four activities. The statistics of NPV_I are shown in Table 4.3. Figure 4.4 and Figure 4.5 are the frequency and cumulative charts of NPV_I. Based on the statistics and shapes of the frequency and cumulative charts, it is reasonable to assume that NPV_I follows normal distribution, with mean of \$751.04 million and standard deviation of \$78.97 million.

If the total project development cost is set at the 95% percentile, denoted by $NPV_I|_{a=95\%}$, then $NPV_I|_{a=95\%} = 751.04 + 78.97 \times 1.645 = \$880.95$ million.

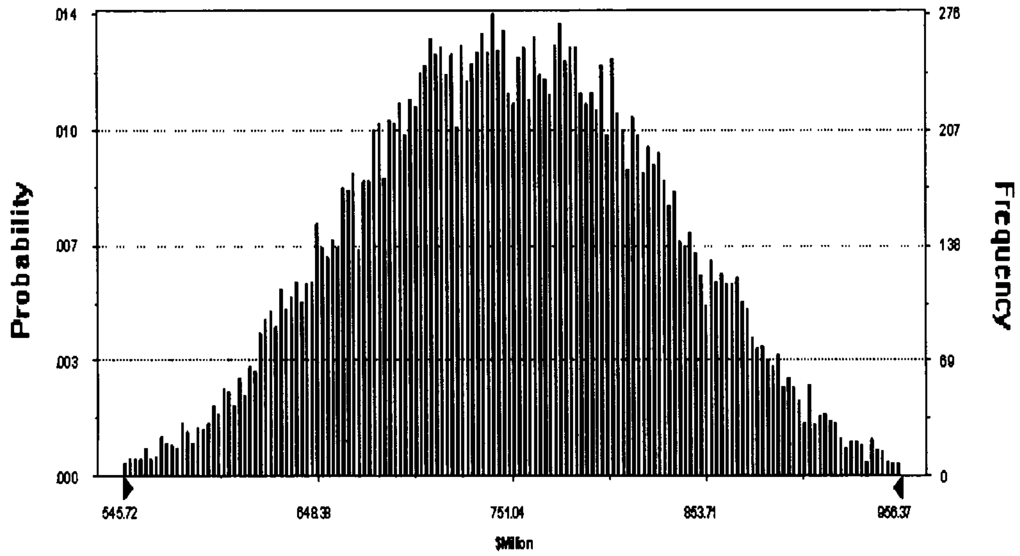

Figure 4.4 Frequency chart of total construction cost

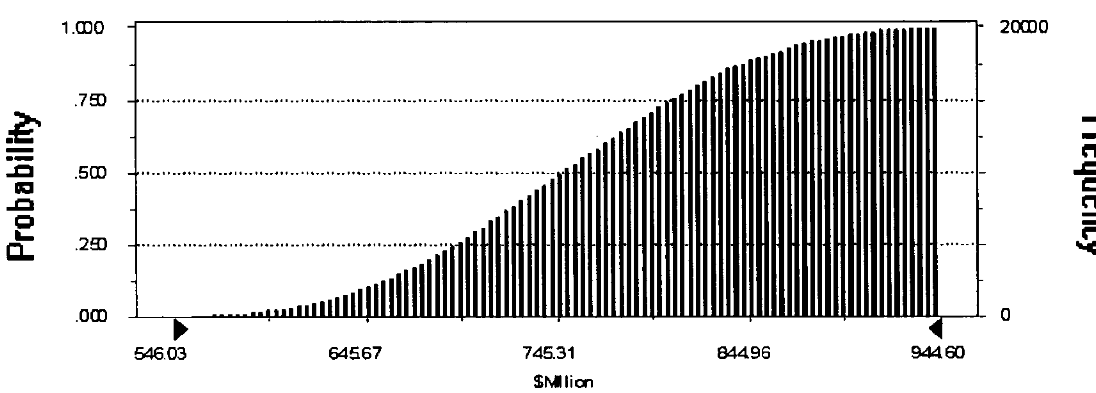

Figure 4.5 Cumulative chart of total construction cost

Simulation of $NPV|_{T_o=t}$

As shown in equation [5], $NPV|_{T_o=t}$ is a stochastic variable that depends on stochastic variables T_c, I_t^o, C_t^o and r. Here, T_c is set at the 95% percentile, that is, 6.62

years as calculated in a previous section. According to the assumption made in the section "*Operation and Maintenance Cost*", for year 1 to year 10 of the operation period, $NCF_i^o = I_i^o - C_i^o = I_i^o - 0.2I_i^o = 0.8I_i^o$; for year 11 to year 20 of the operation period, $NCF_i^o = I_i^o - C_i^o = I_i^o - 0.3I_i^o = 0.7I_i^o$; and for year 21 to year 30 of the operation period, $NCF_i^o = I_i^o - C_i^o = I_i^o - 0.4I_i^o = 0.6I_i^o$.

In the simulation process, the following condition is satisfied:

$$Q_i^o = q_i^o \qquad \text{if } q_i^o \le 10\times10^8;\ Q_i^o = 10\times10^8 \quad \text{if } q_i^o > 10\times10^8$$

where q_i^o = the randomly generated quantity of demand for the i^{th} year of operation.

For simplicity, it is assumed that there is no penalty to the concessionaire for not being able to satisfy a total demand that is beyond the designed capacity of the project. The mean, standard deviation, minimum, maximum, range width, and 75% percentile of $NPV|_{T_o=t}$ for t = 1 to 20 are shown in Table 4. Figure 6 shows the mean, minimum and maximum of $NPV|_{T_o=t}$.

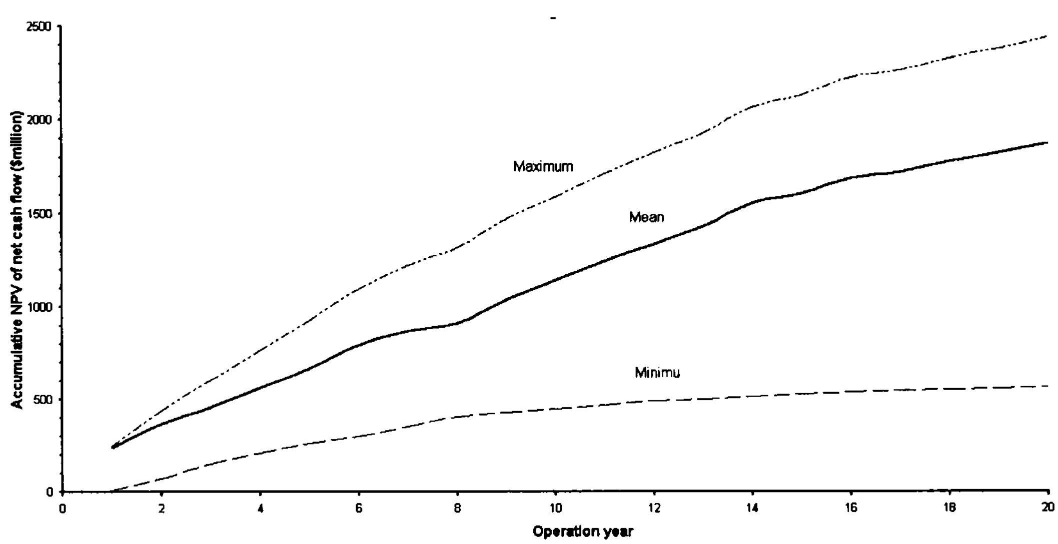

Figure 4.6 Mean, minimum and maximum of $NPV(T_o)$

Table 4.4 Statistics of $NPV|_{T_o=t}$ ($ million)

Year	Mean	Standard Deviation	Minimum	Maximum	Range width	75 percentile
1	122.02	31.20	11.82	247.79	235.97	143.92
2	232.61	44.92	71.60	437.51	365.90	262.48
3	333.56	56.39	151.30	604.66	453.36	370.56
4	425.35	66.59	209.30	769.43	560.13	469.39
5	508.70	76.35	258.80	928.91	670.11	558.33
6	584.84	85.88	296.79	1,096.07	799.28	640.09
7	654.16	95.25	350.30	1,224.02	873.72	715.70
8	717.30	104.43	401.43	1,318.71	917.28	784.36
9	774.58	113.03	428.91	1,468.52	1,039.61	846.30
10	826.85	121.50	446.48	1,590.76	1,144.28	902.97
11	874.64	129.93	464.06	1,711.03	1,246.96	956.60
12	918.15	138.01	486.70	1,825.46	1,338.76	1,004.59
13	957.73	145.89	499.07	1,931.43	1,432.37	1,048.79
14	993.77	153.37	512.72	2,067.69	1,554.97	1,089.07
15	1,026.82	160.60	526.52	2,134.81	1,608.29	1,125.71
16	1,056.82	167.52	537.69	2,227.87	1,690.17	1,159.10
17	1,084.12	174.20	545.47	2,268.51	1,723.03	1,190.33
18	1,109.11	180.59	551.05	2,330.29	1,779.24	1,218.37
19	1,131.84	186.70	556.37	2,382.94	1,826.57	1,245.13
20	1,152.63	192.55	562.83	2,441.72	1,878.88	1,268.99

Determination of Concession Interval

Assume the government decides to use the 95% percentile value of T_c and NPV_I, and the 75% percentile value of $NPV|_{T_o=t}$. As the project completion time $T_c|_{a=95\%}$ is already derived, the concession interval is known if the lower and upper limits (T_o^l and T_o^u) of the operation period are known.

Lower Limit of Operation Period T_o^l

Assume $R_{\min} = 12\%$, then, the minimum total net revenue required by the concessionaire as discounted at the beginning of the first year of construction is calculated as follows:

$$NPV_I|_{a=95\%}(1 + R_{\min}) = 880.95 \times (1 + 0.12) = 986.67 \text{ \$ million.}$$

From Table 4.4, it is known that $NPV|_{T_o=11} = \$956.60$ million and $NPV|_{T_o=12} = \$1{,}004.59$ million. Therefore, T_o^l is between 11 and 12 years. Assume there is a linear relationship between $NPV|_{T_o=t}$ and t in this short duration, then T_o^l is calculated as follows

$$NPV_I|_{a=95\%}(1+R_{\min}) = NPV|_{T_o=11} + \frac{(T_o^l - 11)}{(12-11)}(NPV|_{T_o=12} - NPV|_{T_O=11})$$

$$T_o^l = 11 + \frac{NPV_I|_{a=95\%}(1+R_{\min}) - NPV|_{T_o=11}}{NPV|_{T_o=12} - NPV|_{T_o=11}} = 11 + \frac{986.67 - 956.60}{1004.59 - 956.60} = 11.63 \text{ (years)}$$

Upper Limit of Operation Period T_o^u

Assume $R_{\max} = 20\%$, then, the maximum total net revenue allowed by the government as discounted at the beginning of the first year of construction is calculated as follows:

$$NPV_I|_{a=95\%}(1+R_{\max}) = 880.95 \times (1+0.2) = \$1057.14 \text{ million}$$

From Table 4, it is known that $NPV|_{T_o=13} = \$1{,}048.79$ million, and $NPV|_{T_o=14} = \$1{,}089.07$ million. Therefore, T_o^u is between 13 and 14 years. Again, assume there is a linear relationship between $NPV|_{T_o=t}$ and t in this short duration, then T_o^u is calculated as follows

$$NPV_I|_{a=95\%}(1+R_{\max}) = NPV|_{T_o=13} + \frac{(T_o^u - 13)}{(14-13)}(NPV|_{T_o=14} - NPV|_{T_O=13})$$

$$T_o^u = 13 + \frac{NPV_I|_{a=95\%}(1+R_{\max}) - NPV|_{T_o=13}}{NPV|_{T_o=14} - NPV|_{T_o=13}} = 13 + \frac{1057.14 - 1048.79}{1089.07 - 1048.79} = 13.21 \text{ years}$$

Therefore, the concession interval is

$(T_c + T_o^l, T_c + T_o^u) = (6.62 + 11.63, 6.62 + 13.21) = (18.25, 19.83)$.

CONCLUSIONS

Concession period is an important issue in infrastructure development through BOT-type arrangements as the concession period divides the rights and responsibilities between public and private sectors in the life cycle of the project. The essence of the methodology proposed in this chapter is that the concession should integrate construction and operation to encourage innovations, efficiency, cost savings and early project completion. The project completion time should allow a competent contractor to complete the project on schedule and the operation period should be long enough to enable the concessionaire to achieve a "reasonable" return, but not too long such that the concessionaire's return is "excessive" and the public sector's interests are sacrificed.

Informed assessments and analysis of risks and uncertainties are a prerequisite to the determination of an appropriate length of concession. Monte Carlo simulation is a useful tool to measure uncertainties and reason with construction and economic risks, including project development cost, project completion time, market demand and price of project services/products, operation and maintenance cost, interest rate, and inflation rate.

The proposed methodology, mathematical model and simulation-based approach would facilitate the public sector in the determination of a suitable concession period for a particular infrastructure project, and the private sector in determining whether to bid for a concession solicited by a public client. It would also facilitate the private sector to develop unsolicited concession proposals for potential infrastructure projects and the public sector to evaluate such unsolicited proposals.

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APPENDIX 4.1: LIST OF PARAMETERS

C_i^o : operation and maintenance cost in the i^{th} year of operation

I_i^o : income in the i^{th} year of operation

NCF_i :net cash flow in the i^{th} year of operation

NPV_I : net present value of the total project development cost

$NPV_I^{\alpha_I}$: net present value of the total project development cost at α_I percentile

$NPV|_{T_o=t}$: net present value of net revenues generated from a operation period $T_o = t$

$NPV^{\alpha_o}|_{T_o=t}$: net present value of the total annual net cash flows from operation year 1 to t at α_o percentile

$NPV_I^{\alpha_I}$: net present value of the total project development cost at α_I percentile

P_i^o : sale/service price in the i^{th} year of operation

q_i^o : randomly generated quantity of demand for the i^{th} year of operation

Q_i^o : quantity of demand in the i^{th} year of operation

r : discount rate

r_I : inflation rate

r_r : real interest rate

$R_{\max}$: maximum rate of return to the total project development cost that is acceptable to the public sector

$R_{\min}$: minimum rate of return required by the private sector in the development of a certain type of projects

T_c : project completion time

$T_c|_a$: a^{th} percentile of T_c

$T_{c\max}$: maximum allowable project completion time

T_o : operation period

T_{oe} : designed economic operation life of the project

T_o^l : minimum t that satisfies $NPV_I^{\alpha_I}(1+R_{\min}) \leq NPV^{\alpha_o}\big|_{T_o=t}$

T_o^u : maximum t that satisfies $NPV^{\alpha_o}\big|_{T_o=t} \leq NPV_I^{\alpha_I}(1+R_{\max})$

$(T_o^l\ T_o^u)\big|_{\alpha_o}^{\alpha_I}$: interval of the operation period at α_I percentile of NPV_I and α_o percentile of $NPV|_{T_o=t}$

μ : mean of T_c

μ_o : mean of $NPV|_{T_o=t}$

σ : standard deviation of T_c

σ_o : standard deviation of $NPV|_{T_o=t}$

z_a : critical value of standard normal distribution at a^{th} percentile

CHAPTER 5: RELATIONAL CONCESSION [1]

INTRODUCTION

Public infrastructure had been traditionally developed through the mainly price-based design-bid-build (DBB) route and relied on rigid "complete" contracts. While the DBB on complete contractual arrangements provides a measure of protection to public clients against potential contractors that lack professionalism, it has some inherent problems. First, the fragmented transactions in the DBB often lead to confrontational working relationships between contracting parties of diverse interests and agendas (Latham 1994; Mitropoulos and Tatum 2000). Second, the disintegrated functions in the DBB lack economies of scale. Third, some contracting parties may behave opportunistically to take their information advantage in the use of a complete contract that requires definitive allocation of risks among contracting parties but it is often difficult if not possible to do so as some risks cannot be foreseen clearly and/ or quantified accurately at the initial stage of project procurement (Macneil 1978). These problems often result in prolonged and costly disputes, time and cost overruns, and poor quality, which have been experienced worldwide. Many countries consequently advocate a move toward an integrated and nonadversarial procurement route that encourages cooperation, collaboration and synergy of contracting parties toward efficient infrastructure development. For example, in the United Kingdom, the 2002 "Strategic

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[1] A paper version of this chapter is published in *Proceedings of CIB W89 – International Conference on Building Education and Research*, Hong Kong, April 10-13, 2006.

Forum for Construction" recommended that 20% of construction projects by value should be undertaken by integrated teams and supply chains by the end of 2004 and be increased to 50% by 2007 (Kumaraswamy et al. 2005).

Public-private partnerships (PPPs) have been in practice worldwide in the past two decades where private sector participation is encouraged in the provision of public works and services with an aim to improve efficiency, increase the speed of infrastructure development, and expand the scope of services beyond what public organizations on their own could achieve (Parker and Hartley 2001). Lying between pure markets and hierarchies, PPPs are a kind of "network" that links public and private sectors (Powell. 1990; Gulati 1998; Jackson and Stainsby 2000). PPPs reverse the fragmentation of functions and divergent/ confrontational agendas of contracting parties associated with the DBB by integrating multiple functions (design, build, finance and operate) on a single private source, the concessionaire, improve the economies of scales, for example, through utilization of spare capacity and shared overheads, and provide incentives to reduce life cycle costs through innovations in different stages of the integrated project procurement process. For example, state and local governments in the United States have reported cost savings from 10 to 40% through PPPs with accompanying improvements in asset management and service provision (National Council for Public-Private Partnerships 2002). These estimated savings are expected to be achieved over a long contract period.

However, PPPs do not automatically generate nor guarantee better outcomes than a traditional contracting method. A PPP project is usually much more complicated than a DBB project because the former is multi-disciplinary and deploys a project financing technique over a long-term concession period that is subject to a wide range of risks and uncertainties. Potential high transaction costs exist in various stages of the project development process because of (1) incomplete information, asset specificity and potential opportunistic behavior (Parker and Hartley 2001); (2) the complicated contractual arrangements with different agreements between multiple project participants; (3) lack of adequate skills and expertise for such complicated contractual arrangements in both the public and private sector who have to rely somewhat of external financial, legal and technical consulting services, which are usually much higher than those for DBB projects because the consultant for a PPP project usually undertakes much broader roles than that for a DBB where the roles of the consultant are well defined (Blackwell 2000); and (4) political influence that often leads to over-protracted and wasteful project bidding and aborted projects (Parker and Hartley 2001). High transaction costs have a negative impact on the client's best value objectives. The cost of taking part in a PPP bidding process was estimated to be between £0.5m and £2.5m in the United Kingdom (National Audit Office 1997a; Parker and Hartley 2001). For example, consulting fees represented between 2.4% and 8.7% of the capital cost of the first fifteen NHS PPP hospitals in the United Kingdom (Whitfield 2001). There are concerns on whether PPP projects can achieve improved efficiency through the expected technical innovation and effective management on the part of the private sector (Ball et al. 2000) in view of the high transaction costs of PPP projects and the lower money-borrowing cost on the part of the public sector, being estimated 1-3% lower than the private sector in the United Kingdom (Parker and Hartley 2001). A study by Gaffney and Pollock (1999) even claims that the PPP approach has raised the overall costs of infrastructure development in the health service sector in the United Kingdom because the cost savings associated with the private sector involvement are not big enough to compensate for the increased cost of capital.

In addition, contractual relationships have a significant impact on the potential value to be achieved (Lingard et al. 1998) through PPPs in view of the multidisciplinary and multiparty transactions and the wide range of risks and uncertainties over the long concession period, for the transactors, the contracting parties in a PPP project, play important roles in the complicated transactions (Macneil 1980). However, the construction industry has been adversarial (Smyth 2003) and project partnering been largely tactical and short-term, mainly based on the self-interested trust (SIT) (Lyons and Mehta 1997). It is not self-evident that trust has been improved between the public and private sectors in PPPs compared with traditional public procurement practices (Parker and Hartley 2001).

Furthermore, governments often grant exclusive rights to the concessionaire or guarantee the concessionaire a minimum rate of return to encourage private sector participation. For example, in the defence industry in the United Kingdom, the concessionaire in a non-competitive contract is often guaranteed an industrial average rate of return of about 22% (Parker and Hartley 2001). In a tunnel project in China, the concessionaire is guaranteed a fixed rate of return of 15% although the concessionaire is chosen through a competitive tendering process (Zhang et al. 1998). This government guarantee practice does not provide the concessionaire with sufficient efficiency incentives.

Successful project development depends on a multitude of factors, including human related factors, project related factors, project procedures, project management actions, and external environment (Chan et al. 2004). Nonetheless, the problems discussed in the above need to be resolved before full efficiency can be achieved in infrastructure development. The writers have thus conducted a research toward overcoming these problems. One outcome of this research is a relational concession framework based on literature review, case studies of the experience and lessons from international PPP practices and communications with industrial experts and practitioners.

The proposed framework (as shown in Figure 5.1) includes four parts: (1) enhance economics of public procurement; (2) create favourable relational concession environment; (3) establish appropriate concession principles; and (4) take effective concession measures. Details of this framework and its underlying supportive arguments are provided in the following sections.

ECONOMICS OF PUBLIC PROCUREMENT

Types of Contracts

Various types of contracts may be used to govern the conduct of transactions between parties involved in public procurement. Macneil (1978) classifies contracts into three types: classical, neoclassical and relational. Classical contracting covers all future contingencies in which transactions tend to be selfliquidating. Neoclassical contracting involves trilateral governance in which a third-party is employed to resolve potential disputes and evaluate performance. Relational contracting emphasizes ongoing business relationship between contracting parties rather than transactions per se (Rahman and Kumaraswamy 2002). The strengths and weaknesses of these different types of contracts can be evaluated in terms of in-house resource availability, transaction costs, scope of opportunism, and efficiency (Parker and Hartley 2001).

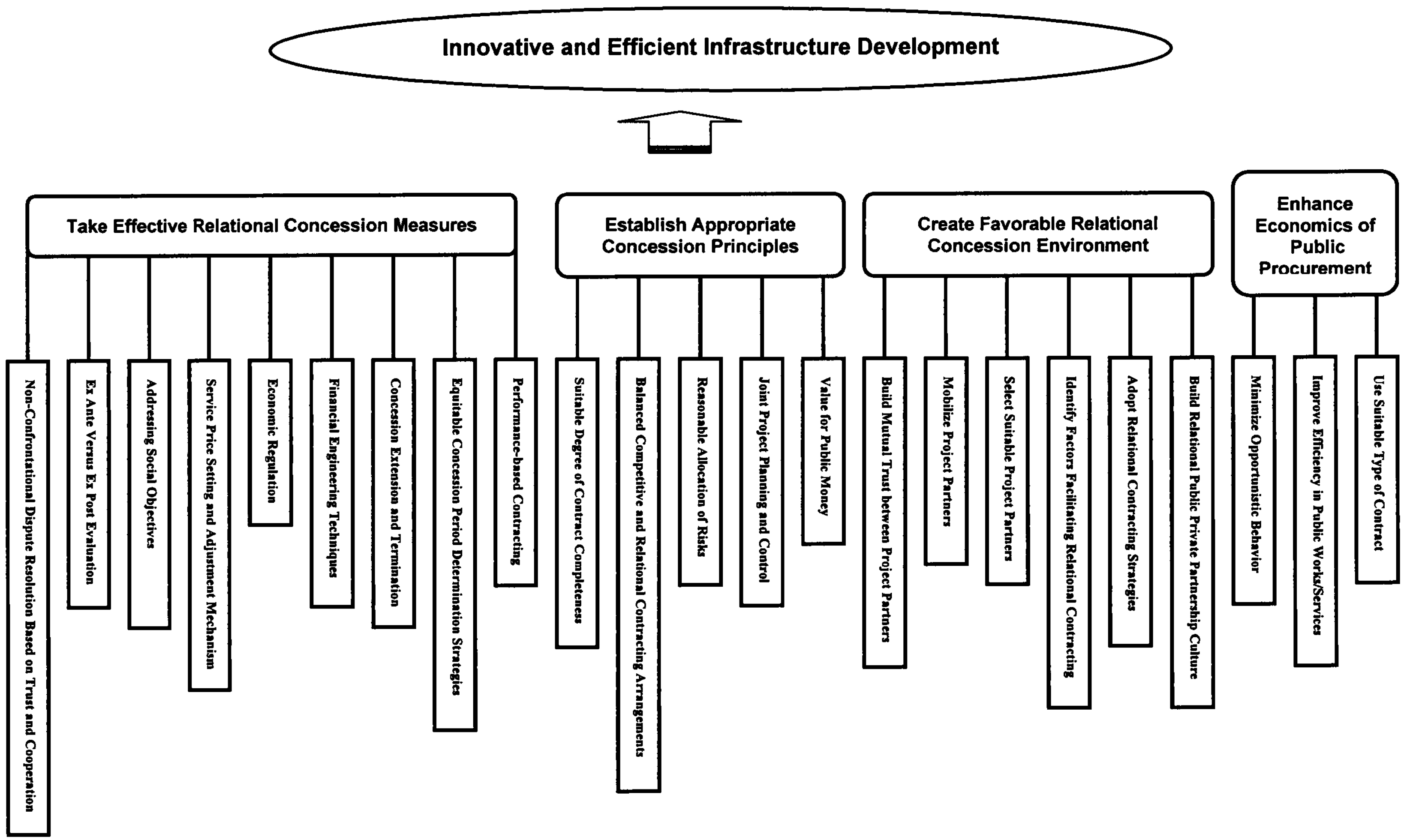

Figure 5.1 Relational concession framework

In-House Provision and Outsourcing

Public organizations usually are vertically integrated and take direct ownership and "in-house" approaches to the provision of public works and services under their jurisdiction (Grossman and Hart 1986; Hart and Tirole 1990). The scope of outsourcing depends on the resource availability and competences within the public organization. It is wide where transaction costs and internal capability are low, and vice versa. In-house provision minimizes opportunistic risks and the "hold up" problem. However, problems of inefficiency and lack of innovation may result from the monopolistic rights of the public organization and high costs from diseconomies of scale. Reasonably utilizing internal resources and encouraging private sector competition in outsourcing will reduce overall project costs and increase efficiency.

Transaction Costs

Three major dimensions define a transaction: asset specificity (non-specific, mixed or highly specific), frequency (one-off, occasional or recurrent) and risk/ uncertainty. Asset specificity refers to a specific investment either tangible (e.g., a power plant) or intangible (e.g., training) that has a reduced value if used for any other purpose. Transactions of high degree of asset specificity and uncertainty require flexible contractual arrangements in order to adapt to new conditions in the post-contract period and mutual trust among contracting parties to minimize opportunistic behavior (Williamson 1985; Lyons and Mehta 1997).

Transaction costs are the basis of transaction cost economics and determine the relative efficiency of different contractual arrangements (Williamson 1975). Transaction costs are those associated with seeking out buyers and sellers and arranging, policing and enforcing contracts in a world of imperfect information, including cost of identifying, explicating and mitigating contractual hazards, costs of negotiation and writing contingent contracts, costs of monitoring contractual performance, costs of enforcing contracts, and costs related to variation orders, breaches of contracts, claims and disputes, costs of acquiring and processing information, legal costs and organizational costs (Joskow 1985; Winch 1989; Williamson 1996; Rahman and Kumaraswamy 2002).

In transaction cost economics, the underlying behavior of the contracting parties in the transactions of a contract is assumed to be opportunistic and therefore, it emphasizes an "appropriate contractual form" to minimize risks related to transactions instead of dealing with issues related to transactors, the contracting parties.

Efficiency in Public Works and Services

Efficiency means to obtain the most consumer satisfaction from the available resources. Efficiency may be defined in terms of technical efficiency and allocative efficiency. Technical efficiency aims to get the most production from available resources or produce a good at the lowest possible opportunity cost whereas allocative efficiency addresses the problem of scarcity of resources in order to achieve the most consumer satisfaction from limited resources (Fried et al. 1993; Baldwin and Caves 1997). In the procurement of public works and services, allocative efficiency seeks an optimal level of output/service whereas technical efficiency seeks the most cost-effective solution to this optimal level of output/service requirement. The challenge for a public client in the provision of public works and services is the development of a procurement strategy to achieve both allocative and technical efficiencies at minimized transaction costs and optimized utilization of internal/external resources. A common approach is that the public client first defines the level of output/service in light of its mission goals and business objectives and then chooses the party that offers the best solution to the predefined output/service requirement through a competitive tendering and negotiation process. This approach usually achieves technical efficiency on the predefined output/service level through innovative solutions. However, the question is whether the client-defined level is an optimal level (Parker and Hartley 2001). One useful way to overcome this problem is to initiate a best value source selection approach (Mickaliger 2001) in which the client allows the private sector to compete for different levels of output/service, which enables the client to assess the costs and benefits of different output/service levels and consequently select the best level available. Theoretically, the "optimal" level is one at which the marginal benefit is equal to the marginal cost.

Potential Opportunistic Behavior in PPPs

Not all information needed for effective contracting are available at the time of contracting. In addition, this incomplete information is often asymmetrically distributed among contracting parties. Incomplete and asymmetrical information between contracting parties lead to "bounded rationality" in decision making in contractual arrangements and potential opportunistic behavior of some party to hide, mislead, or distort information to seek its own interest (Williamson 1985; 1996) and cause a information-disadvantaged party to buy a "lemon" (Akerlof 1970). Opportunism of one party and the resultant retaliation of another party may result in huge costs and serious delay of project completion.

PPP projects usually have a long contract period, frequently 15 to 30 years. Some last even longer, for example, the town of Loiret in France signed a 99-year BOT water contract with the Compagnie Generale des Eaux in 1931 (World Bank and Inter-American Development Bank 1998). There are a wide range of risks and uncertainties associated with a PPP project and the contractual arrangements that govern a PPP project are very complicated. In addition, PPP projects often involve large amounts of investment in highly-specific tangible/ intangible assets (e.g., underground piping systems), creating potential "hold up" problems, especially at the contract renewal and negotiation stage because of the sunk investment, uncertain technologies and ever-changing economic environment (Parker and Hartley 2001). There is a wide awareness of the costly hazards of opportunism and of the difficulties of organizing exchange when the legal system is perceived to provide inadequate support for, and protection of, their interests (Lyons and Mehta 1997). Opportunistic behavior may come from either the public or the private sector. This is discussed in the following.

Cartels and Collusive Tendering

PPP projects are often developed through a project financing technique where the large amount of project development cost is financed upfront by the private sector and is expected to be recovered over a long concession period from revenues generated from the project. Often only a few large companies tender for these projects as most companies are small and not capable of undertaking them. There is a possibility of collusions in tendering or a tendency to form cartels for an unreasonably high level of benefits.

Adverse Public Concessionaire Selection

Public employees may have a strong resistance to competition from the private sector because, traditionally, they are not subject to this competition. They may purposely use unfair contract terms, inappropriately defined public sector comparator, operational or security excuses to prevent private sector involvement in projects that threaten their existing interests or cause loss of public jobs whereas they may pursue enthusiastically those projects that make them better-off. These opportunistic behaviors lead to "moral hazard" and "adverse selection" (Parker and Hartley 2001).

Specific Examples of Opportunistic Behavior

Opportunism takes various forms, for example: (1) a contractor may use design changes as an excuse for raising prices or seek cancellation payments; (2) a bidder may submit lower bids to win contracts first and then try to recover costs through claims; (3) a contracting party may interpret contract clauses in a way that favors its own interest; (4) a concessionaire may exploit its monopoly power after contract award to charge high prices; and (5) a concessionaire may economize on service quality where a "price cap" regulation is used or intentionally "overcapitalize" in a "rate of return" regulation.

One example of the hold-up problem was related to an public contract, where Railtrack plc, an private company that owns the rail infrastructure in Britain, threatened that it would only be able to complete Phase Two of the Channel Tunnel Rail Link if the government relaxed its regulation in the company's favour (Glaister 1999). In the intercity road concessions in Argentina, some concessionaires set up toll booths at very short distance between one another or near urban centers where captive traffic was created, increased the basic tolls by more than 50% in a short time based on indexation, and started to collect tolls before undertaking the required investments (Estache and Carbajo 1996).

FAVORABLE RELATIONAL CONTRACTING ENVIRONMENT

Relational Contracting

The traditional contract is usually "transactional," "one-off" and short-termed (Horrocks and Woo 2003) based on a "complete" formal/ written agreement that sets down rules governing contracting parties in business exchange and related transactions. This agreement is often legalistic and static, focuses on business transactions per se, and deals with transactions discretely (Cheung et al. 2001).

In contrast, RC recognizes the dynamic and evolving nature of business transactions (Eisenberg 2000) and the risks and uncertainties associated with such transactions, and introduces a degree of informality and flexibility into the contract. It also recognizes the important role played by the transactors (i.e., contracting parties) in conducting business transactions, and treats a contract as relationships between contacting parties according to prescriptive "norms and standards of proper conduct" and "principles of right action" instead of merely discrete transactions (Macneil 1974; 1980). In other words, RC subordinates legal requirements and related formal documents to informal agreements that are based on mutual trust, amicable relationships, ongoing cooperation/collaboration, and shared rights/obligations between contracting parties in business exchanges over a long period. Contracting parties themselves govern the business exchange between them within mutually acceptable social guidelines instead of relying only on a legal mechanism defined by a detailed written contract (Eisenberg 2001; Kumaraswamy et al. 2005). Business exchanges to be conducted in the "future" are determined based on a contracting party's "present" promise to offer it and its "past" reputation. For example, a "project charter" or "best effort" clause is often included when it is difficult to devise precise performance specifications and/or define clear obligations between contracting parties (Goetz and Scott 1981). RC enables mutual future planning and joint control of project risks by all contracting parties, particularly those that cannot be perceived or quantified before or during the concession award stage of a PPP project that is usually multidisciplinary with many transactions that are to be evolving over a long concession period. Appropriately managed, RC can result in minimized opportunism, better risk control, improved efficiency, and reduced production and transaction costs (Walker and Chau 1999).

Relational Public-Private Partnership Culture

Culture is a pattern of basic assumptions developed by a given group as it learns to cope with its problems of external adaptation and internal integration that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems (Schein 2004). Here, a relational PPP culture is defined as a project culture among all people that are involved in one way or another in the whole supply chain of a PPP project, which is mainly governed by RC arrangements based on mutual trust, shared ethical values and shared principles of fairness.

A good culture enhances motivation and personal satisfaction of contracting parties and consequently leads to high project performance, innovation, quality, value and customer satisfaction (Hoffman 2005). To create a healthy relational PPP culture, the public client should, first of all, avoid bureaucratic behavior which is a big obstacle to RC as a bureaucratic client itself is difficult to be transformed into an integrative culture. The client may need to take a "low power distance" or "loose control" approach, as is part of the Swedish construction culture (Brochner et al. 2002). Second, some existing laws/ regulations may restrict public clients in using RC with the private sector partners. The government needs to seek relevant changes in the legal framework and revamp existing regulations under its control to enable healthy RC strategies. Third, the public client, together with other contracting parties, needs to take strong initiatives to build an appropriate common mind set and team spirit in the decision-making of various issues of project development. Fourth, the multiple partners in a PPP project have diverse organizational and individualistic cultures, which need to be shaped toward a collective relational PPP culture. Fifth, traditional discrete project functions and adversarial relationships should be replaced by integrated functions and partnering/alliancing practices that transcend the organizational boundaries of individual project partners. Sixth, the project leader needs to play a key role as he/ she can effectively shape the communication, behavior, values and day-to-day performance of team members by focusing on four dimensions: directing/ organizing, visioning/ inventing, valuing/ honoring, and relating/ including (Hoffman 2005). For example, in the Stave Fall replacement project in Canada, the "champion" project manager brought this challenging project to completion on time and 21% under budget (Bourne and Higginbottom 2001).

Factors Facilitating Relational Contracting

The core of RC is to establish cooperative and collaborative working relationships between contracting parties to improve project performance and achieve win-win outcomes for all parties through their continuous motivation, commitment, mutual incentives and combined efforts (Sanders and Moore 1992; Bresnen and Marshall 2000; Holt et al. 2000).

Kumaraswamy et al. (2005) identifies 24 factors that facilitate RC and evaluates their relative importance through a questionnaire survey. According to the results of their survey, the top 15 factors are mutual trust, open communication, understanding of each other's objectives, equitable and clear allocation of foreseeable and quantifiable risks, attitude of the project participants, readiness to compromise on unclear issues, awareness of risks and rewards, effective coordination, collective responsibility, alignment of objectives, profession ethics, dispute resolution, frequent formal and informal meetings, "partnering" culture within the organization, and effective performance appraisal.

Selecting Project Partners

Successful RC requires that the multiple contracting parties in a PPP project possess certain degree of relational capabilities in addition to technical capabilities that are commonly evaluated in a traditional contracting method. Parties with higher relational capabilities are more receptive to RC arrangements, more capable of dealing with business issues according to RC principles, and consequently more suitable to the building of a relational PPP culture. Therefore, there is a need to identify appropriate relational criteria to evaluate the multiple contracting parties that form the concessionaire. Relational criteria may include industry reputation, previous performance in similar projects, risk and reward scheme, claims history, negotiation skills, partnering history and skills, motivation and commitment, open-book approach, teamworking spirit, workplace relations, and public relations in general. For example, some of these relational criteria were used in selecting the alliance team for the Australian National Museum design-build project (Walker et al. 2000).

Furthermore, Rahman and Kumaraswamy (2004a) have identified 9 technical factors and 13 relational factors and determined their relative importance for selecting different sources in construction projects, including consultant, contractor/subcontractor, supplier and possibly the client. In general, they recommend a combination of both technical and relational factors in selecting contracting parties with varying degrees of emphasis on these factors for different types of contracting parties. Consultants should have a mixture of both technical and relational capabilities, among which the top five factors are three technical factors (technical capability, timely project completion/delivery and similar previous work experience) and two relational factors (approach to joint problem solving and approach to joint decision making). Contractors must have very high capabilities on all of the 22 factors, among which the top five factors are four technical factors (timely project completion/delivery, quality of work/ materials, project management capability and pricing levels) and one relational factor (approach to joint problem solving). For subcontractors, more importance is placed on technical factors than on relational factors. For suppliers, three technical factors (quality, time and price) are the most important, with less importance placed on relational factors.

Mobilizing Partners

The many project partners in a PPP project may have different objectives, attitudes and perceptions on various issues. This diversity often leads to conflicts and undesirable project outcomes. There is a need to shape these divergent attitudes and perceptions toward a shared vision and common objective with strong motivation for successful project development and win-win outcomes for all partners. Although all project partners should take initiatives and be self-motivated, the public client need to play a leading role (Rahman and Kumaraswamy 2004b) in forming this shared vision and establishing a cooperative working environment. As a regulator, the public client has determinant power in decision-making over public works and services within its jurisdiction. As a major partner of the PPP project, the public client has effective control over project organization, contract structure/ contents, and the selection of private sector partners. It is expected that other partners will gradually retune themselves to think and behave "relationally" under the client's initiatives (Rahman and Kumaraswamy 2005).

Motivation and attitudes of the project partners are critical given the wide range of risks/ uncertainties and the multiple partners in a PPP project. Partners need to be continuously mobilized starting from as early a stage as possible through information sharing, frequent formal/ informal meetings and jointly organized socializing activities. This gives project partners opportunities to know, understand and learn from each other, to smoothen their relationships, and to build mutual trust and maintain team spirit so that a RC-based joint project planning and control is possible (Bayliss et al. 2004; Rahman and Kumaraswamy 2004b; Rahman and Kumaraswamy 2005). In addition, early inputs from all partners may significantly improve project economics, design, constructability and maintainability. For example, cost savings of 11–38% have been achieved in building construction in Hong Kong when contractors are brought into the project team at the very outset of the project development process (Ho 2000; Rahman and Kumaraswamy 2002).

Building Mutual Trust between Contracting Parties

Smyth (2003) defines trust as "a disposition and attitude concerning the willingness to rely upon the actions of or be vulnerable towards another party, under circumstances of contractual and social obligations, with the potential for collaboration."

RC prerequisites a shared project culture that transcends the organizational boundaries of the diverse contracting parties. This shared culture relies on the mutual trust of contracting parties to sustain relationships, enhance cooperation and collaboration, and to facilitate efficient business exchanges between contracting parties, which are vulnerable to opportunistic behavior in the face of unforeseen risks and emerging problems (Drexler and Larson 2000).

Lyons and Mehta (1997) distinguish two mechanisms that support trust: self-interested trust (SIT) and socially-oriented trust (SOT). SIT is the initial stage of developing trust between parties and is often based on a contracting party's reputation (past behavior). SIT is forward looking and expects rewards from cooperation. SIT will be the highest where contracting parties have shared goals whereas it may be minimal where there are unbalanced power relations between the parties. SIT often creates a short-term "win-win" situation and is maintained as long as it serves the interest of the parties concerned. However, this may be easily broken by opportunistic self-interest of one party and the sanction or retaliation behavior of another party against defection (Rahman and Kumaraswamy 2002; Smyth 2003).

In contrast to SIT, SOT is a deeper level of trust with a philanthropic character. As a "goodwill" trust, SOT is unconditional and not aiming at a short-term win-win result. Instead, SOT emphasizes the relationship value (Storbacka et al. 1994) and invests in it to build it up as an intangible asset for long-term benefits through continuous improvements in working relationships and social relations that create shared values, moral positions and friendships (Deakin et al. 1997). SOT will be maximized when there exists mutual understanding of expectations/ needs, mutual respect and consistent joint responsibility of contracting parties in risk management (Smyth 2003).

Companies usually are "accountancy driven," emphasizing more on "figures" than on "relationships" in their decision-making. Consequently, their pursuit of trust is limited to SIT with a short-term win-win objective (Smyth 2003). However, a sustainable long-term client-concessionaire relationship requires a switch from SIT to SOT and necessitates continuous support/cooperation of contracting parties in the supply chain or even some short-term sacrifice (Storbacka et al. 1994). As a valuable social capital, trust is hard earned and easily dissipated.

APPROPRIATE RELATIONAL CONCESSION PRINCIPLES

Value for Money

One of the major objectives of PPPs is to achieve better value for public money than that could be obtained in the traditional public procurement approach. Value for money is achieved through (1) innovation and improved efficiency and (2) improved contractual relationships, and is checked against a public sector comparator (PSC).

Innovation and Efficiency

Innovation and efficiency can be achieved through a combination of several mechanisms, including optimal risk allocation between contracting parties, whole-of-life management through integration of and synergy in multiple project development functions, innovation through a focus on outputs rather than on means to achieve them, improved asset utilization, better economies of scale, and innovation and efficiency through competition (Queensland Government 2002). A project having the following characteristics is more suitable to PPPs for improved value for money through the use of these mechanisms (Queensland Government 2002):

(1) The project size justifies the transaction costs;

(2) There is a defined measurable service delivery function;

(3) There is scope for optimal allocation of manageable risks to the private sector;

(4) There is scope for private sector innovation, value adding and/ or cost reductions;

(5) There is real value in transferring operation and maintenance functions to the private sector; and

(6) There is a market of private companies prepared to compete for the project.

Improved Contractual Relationships

The value for money objective is enhanced when works and services are carried out smoothly without contractual claims/ disputes. The actual final cost of a contract may happen to be startlingly different from the initial bid because of claims and disputes that may continue for years. Time extensions and resources spent on claims/ disputes often belie the initial bid price and bedevil the ultimate value (Kumaraswamy 1997).

Public Sector Comparator

PPPs need to be evaluated against traditional forms of public sector procurement. This is often done through a PSC. The United Kingdom Treasury Taskforce (1999) defines the PSC as a hypothetical, risk-adjusted costing by the public sector as a supplier, to an output specification produced as part of a procurement exercise. The PSC is expressed in net present value terms based on the required output specifications and taking into full account the risks which would be encountered by that style of procurement. The PSC is used (1) to determine if the project is affordable to government by evaluating full life cycle costing at an early stage; (2) as a means to test whether a PPP project is viable and demonstrates value for money; (3) as a management tool to communicate with partners on such key aspects as output specifications and risk allocation; and (4) as a means to encourage broader competition by creating greater confidence in the bidding process (Industry Canada 2003).

The net present value of the total cost of a proposed PPP project adjusted by risk factors should be lower than that of the PSC. The public client may define and release figures for the PSC as early in the procurement process as possible to promote competitive bidding and to save on private sector tendering costs where the PSC is likely to be below the private sector bids (Parker and Hartley 2001).

Calculations of cost saving are sensitive to the assumptions made. For example, the United Kingdom National Audit Office found that savings from the first big hospital development project were greatly over-estimated by the NHS Trust that awarded the project. The National Audit Office estimated the likely savings to be about only £5m instead of £17m as reported (Parker and Hartley 2001). Informed assumptions should be made based on actual project conditions, historical data and expert opinions.

Joint Project Planning and Control

PPPs involve multiple contracting parties, a wide range of business disciplines, and a broad scope of risks and uncertainties over a long concession period. This will definitely require a high level of cooperation and coordination of human interactions toward combined efforts of all contracting parties in successful project management rather than relying on a single party alone. It is useful and necessary to set up a joint project control team (JPCT) consisting of representatives from all partnering companies to plan and manage the project cooperatively and collaboratively. The objective of the JPCT is to achieve an optimal level of risk control for the overall project, not necessarily for one or some of the partnering companies. The JPCT identifies and allocates all potential risks among project partners, decides on the risks suitable for shared responsibilities, steers the risk each party has agreed to assume either alone or jointly, controls the risks of each party on equal terms with clearly defined levels of authority, and directs all partners to responsibly resource in the project in joint efforts to deal with foreseen and unforeseen risks when they occur (Hosking and Timaloa 1998).

Joint project control provides a way of concentrating contracting parties' energies on effectively managing the risks of the project and directing contracting parties to plan, bargain and negotiate on project-related issues on a common ground and win-win principle, to anticipate potential risks and conflicts through open communications, and to take coordinated and combined efforts to address emerging problems (Hosking and Timaloa 1998). This is confirmed by a survey conducted by Rahman and Kumaraswamy (2004b), which found that the construction industry in general prefer minimizing risk passing practices, reducing risk liabilities to individual contracting parties, and joint control of these reduced risk components through combined efforts of all parties.

Joint project control relies on "good faith" that is closely associated with notions of fairness, honesty and reasonableness. Two types of good faith duties could be implied between parties to a relational contract, that is, a general duty concerning the entire contract and a specific duty related to the exercise of specific terms of the contract (Horrocks and Woo 2003).

Joint project control has been practiced in many projects with remarkable results. For example, Bayliss (2002) presents a case study of the Tseung Kwan O Extension project where a pain/ gain share scheme was deployed. The Heathrow Express Railway project in the United Kingdom suffered an enormous setback midway through its construction. However, the joint project control and the consequent initiatives of all parties lead to 20% cost savings and project opening seven months earlier than scheduled (Lownds 1998; Rahman and Kumaraswamy 2004a).

Reasonable Allocation of Risks

PPP projects are governed by a concession agreement between the public and the private sectors, which define the rights and responsibilities/ liabilities of the concessionaire and the public client through general and specific contract conditions, for example, regarding the duration of the rights granted, terms of payment to the concessionaire from the client or directly from end users, conditions under which the client may terminate the concession, and any compensation to be paid by one party to the other in the event of unilateral termination of the concession (Guislain and Kerf 1995).

Contracts are often a kind of exercises in which the contracting parties try to obtain their own advantages by passing risks to other parties through aggressive and competitive negotiations and the consequent contract conditions. Risk passing may be not an ethical practice as it often causes undesirable effects instead of contributing to a successful project outcome (Hosking and Timaloa 1998). Each party tries to maximize its own benefits and protect itself against any responsibilities/liabilities by passing as many risks as possible to other parties instead of taking active actions to minimize risks even if it is best positioned to do so. Risk passing often leads to conflicts and disputes between contracting parties both in the contract formation stage and in the following contract implementation and renegotiation stage as contracting parties usually have inherently different perceptions of an "optimal" allocation of risks (Hartman et al. 1997; Rahman and Kumaraswamy 2004b). Incomplete information renders a definitive and exhaustive allocation of risks unrealistic. Even foreseeable risks may be difficult to quantify because their impacts may change as the project progresses, not to mention the unforeseeable risks.

No party can make "extra" profits in the long run by shifting risks to other parties (Scheublin 2001). Equitable contract conditions on both foreseeable and unforeseeable risks and the commitments from all partners to "fair dealing" without taking opportunistic behavior in the project implementation process after the contract award are critical to successful project delivery because they are the prerequisites of a RC-based joint project control mechanism. Furthermore, equitable contract conditions provide incentives for cooperation and collaboration of project partners in seeking innovative, efficient and timely solutions for win-win outcomes. As maintained by Hosking and Timaloa (1998), the overall benefits for all parties in adopting a risk sharing and collaborative JPCT will undoubtedly outweigh the possible gains to any single party in a traditional contracting method. Finally, although it is a general principle to assign the risks to those in the best position to control them, the "equity" idea still applies. A proper reward system should be developed to reflect the scope and deepness of the risks taken by each party.

An efficient and effective risk management system requires all contracting parties to (1) examine carefully the major transactions in the proposed project, potential risks involved in each transaction, risk mitigation measures and their required resources, (2) develop an appropriate risk sharing and reward mechanism, (3) resource optimally in terms of money and personnel both within each party and in the overall partnering network, and (4) take an "open book approach" with strong motivation and commitments to super project performance.

Balanced Competitive and Relational Contracting Arrangements

One the one hand, a competitive source selection process usually encourages innovative, efficient and cost-effective solutions by maintaining a pressure on competitors of being taken over or getting bankrupt if unable to provide competitive services and make profits. Permitting entry of new competitors in a PPP project ensures that direct competition will take place wherever possible and forces the incumbent concessionaire to maintain good performance (Guislain and Kerf 1995). A well-defined concession facilitates the regulation of natural monopolies for improved efficiencies (World Bank and Inter-American Development Bank 1998). However, the advantages of competition, nonetheless, come at a cost. In addition to the transaction costs to industrial players involved in the competition process, the incumbent concessionaire may be less willing to make capital investments or may skimp on maintenance in the late years of the concession, anticipating that it may not benefit from such activities if losing the concession in competition. This may increase total life cycle cost of the project. Furthermore, overcompetition can lead to inefficiency, for example, in the nineteenth century, competing companies laid parallel water pipes in the United Kingdom and parallel railway lines in Germany (World Bank and Inter-American Development Bank 1998). On the other hand, although healthy relationships and RC strategies can reduce opportunism and transaction costs (Macneil 1978; Williamson 1993a), uncomfortably close relationships may be abused, for example, in a collusive and corruptive scheme. Therefore, there are tensions between competition and trust-based RC (Parker and Hartley 2001). A right balance between competitive contracting and RC should be maintained in view of the need of open competition to comply with laws/ regulations and prevent collusion/ corruption and the need of RC to overcome opportunism and reduce transaction costs. This is possibly why in Japan there is a move away from long-term RC-based collaborative relationships toward more competitive contracting (Hughes and Maeda 2002).

Complete Versus Incomplete Contract

In principle, PPPs require clarity in technical specifications and output requirements, and clear division of the rights and responsibilities between project participants. General and/ or industry-specific PPP guidelines, standardized tender documents and model contracts have been established in different countries to facilitate infrastructure development, reduce costs and increase efficiency. Standardization facilitates infrastructure development through complete contracts, which are more suitable to large projects that are amenable to full specification ex ante, with relatively predictable and measurable outcomes and clear lines of authority and responsibility (Mumford 1998).

However, it is often impossible to write a detailed complete contract to cover all contingencies associated with a PPP project and it is very costly even if this is possible partly because of the need of lawyers and other external consultants. In addition, a long-term complete contract may be not desirable even if possible as it may cause moral hazards such as a monopoly or "hold up" problem (Parker and Hartley 2001). The risks borne by the concessionaire over a lengthy concession period may result in excessive profits to the private sector at the expense of public interests (Abdul-Aziz 2001), or huge losses and even bankruptcy of the concessionaire for which the government has to bail-out (Ogunlana 1997). The United Kingdom National Audit Office also criticised the high profits some private companies made on certain deals (National Audit Office 1997a; 1997b).

An incomplete contract based on RC strategies and perceived trust/reputation and expected cooperation/collaboration in the future provide a useful means to overcome the problems mentioned above. A reputation for "fair dealing" is a business asset and can substitute for detailed contractual controls (Klein 1997; Parker and Hartley 2001). But, reputation and trust alone do not always guarantee successful outcomes from PPPs as there is a potential risk of misplaced trust (Smyth 2003). Furthermore, legal enforcement of an incomplete contract is difficult if disputes occur and these cannot be resolved internally within contracting parties. This is illustrated in a recent court case regarding the termination of a concession agreement between Privy Council and Dymocks. The High Court was prepared to imply an overall duty of good faith between the client and the concessionaire regarding information disclosure according to the "law of implied good faith" that "the parties to a contract must act in good faith in making and carrying out the contract." However, the Court of Appeal rejected this approach, saying that such a general implication would create too much uncertainty (Horrocks and Woo 2003).

Hence, there is a need to determine the right level of completeness of a contract, in which supportive RC principles provide (1) a means to address the inadequacy of contract language alone to clearly define risk apportionment between contracting parties who may interpret contract terms differently (Hartman et al. 1997; Rahman and Kumaraswamy 2004b) and (2) the necessary flexibility and cooperative working environment for optimal joint risk management of all contracting parties through timely proactive measures, and in which a formal (classical or neoclassical) written agreement underpins the RC strategies as a form of legal security against deviant behavior (Parker and Hartley 2001; Kumaraswamy et al. 2005).

EFFECTIVE RELATIONAL CONCESSION MEASURES

Performance-Based Contracting

Rationale of Performance-Based Contracting

Performance-based contracting (PBC) (OFPP et al. 1998) includes two aspects: performance-based budget and performance-based payment. PBC represents a change to emphasis on "end results" from traditional contracting practices that emphasize the process (e.g., predefined investment schedules) or means (e.g., detailed technical specifications) to achieve such perceived end results (e.g., the service coverage ratio of rural communities in a water distribution project). PBC requires that effective and efficient project development functions be designed and structured around the mission objective of the public client in order to maximize the end outcomes. Hence, the public client should focus on end outcomes, performance specifications/measures, compensation, incentive/disincentive mechanisms, and measuring techniques in making procurement decisions and the private concessionaire should focus on statement of work, innovative and cost-effective solutions, value engineering, constructability and maintainability, schedule/ cost plan, performance guarantee arrangements in making bidding decisions. Therefore, PBC opens a project to all potential solutions and thus provides flexibility for the concessionaire to generate an innovative and cost-effective proposal that maximizes efficiency.

Performance-Based Budget

Performance-based budget focuses on the outcomes required instead of resources needed by linking public funding to project performance and linking performance in the current contract to the award of future contracts. This ensures that public works programs generating desirable outcomes will continue to receive funding while those unable to achieve satisfactory results may lose funding for future years (Executive Office of the President and Office of Management and Budget 2002).

Performance-Based Payment

Performance-based payment links public payment to the concessionaire's actual performance. For example, in the Argentine road concessions, the serviceability index (ranging from 1 to 10) was used to measure performance. The concessionaire was required to raise the index to about 6.4 during the first three years, improve it to 8 in the following seven-year period, and maintain it above 7.5 during the last two years of the concession (Estache and Carbajo 1996). In highway concessions in the United Kingdom, payments are linked to performance measures such as the availability of carriageways and footways, road accidents, operational standards, bus journey time reliability, junction delays, and queue lengths (United Kingdom Highways Agency 1997).

Usually, an appropriate incentive/disincentive mechanism is incorporated into the performance-based payment system to provide bonuses for services that meet or exceed predetermined quality levels and penalize substandard performance. For example, in the Lal Pir BOT power plant in Pakistan, to encourage timely project completion, the tariff will be increased by 0.25¢/kWh if the plant is finished on schedule. In the United Kingdom, a penalty point system is used to deal with poor performance in highway development.

Key Issues in Performance-Based Contracting

Some key issues need special attention in PBC. First, the expected outcomes should be differentiated from the process or means to achieve them. Public clients often require the concessionaire to take specific procedures or use particular means in a proposed project. This stifles creative initiatives from the private sector. Second, appropriate performance measures or their indicators need to be established. Commonly used performance measures include project completion time, output quality/quantity, efficiency, life cycle costs, and safety, health, and environmental standards. Third, the relative significances of performance measures/ indicators need to be assessed in terms of their contributions to the public client's mission objective. This facilitates the evaluation of how a particular works program's performance or a project's performance in a certain period contributes to this mission objective. Fourth, undue severe penalties may impair the relationship between the public client and the concessionaire, which is critical to successful project development. Penalizing measures should reflect the negative impacts (preferably in economic terms) on the public sector incurred by substandard performances of different degrees of severity.

Equitable Concession Period Determination Strategies

Concession Period

The length of concession is a key factor that defines a concession project, as it to some extent demarcates the rights and responsibilities between public and private sectors in the project's life cycle and it also is critical to the project's sustainable development (Zhang and AbouRizk 2006). The length of concession is usually determined based on "normal" or "expected" conditions, which are subject to various changes that may cause extension to the original concession or its early termination.

The concession period should be short to permit frequent competition without jeopardizing the incumbent concessionaire' return on socially desirable investment if no substantial sunk investments are involved (Kwoka 1996). However, a long concession period is desirable if a project involves large initial sunk costs in construction, related construction/operation equipment, and other project-specific assets. In general, the concession period should not be longer than the designed life of the project.

Whether a fixed term or flexible concession period is adopted, it should satisfy conditions specified in the concession agreement and required by relevant laws, for example, the allocation of risks specified in the concession agreement, and the maximum allowable length of concession limited by the law or regulations if any.

The following strategies may be deployed to determine the length of concession in light of specific project conditions.

Factors Affecting Length of Concession

The length of concession depends on a number of factors, such as project type, scope, asset specificity, construction complexity, project lifespan, project development costs, combination of financing instruments, opening asset value, depreciation, operation and maintenance costs, market demand (price and quantity) of the services provided by the project, interest rate, inflation rate, foreign exchange rate (if foreign currency is involved), and governmental regulation practices.

Concession Period Integrating Construction and Operation

In some projects, the concession does not include the construction phase, i.e., concession begins at the completion of the construction. However, it is a common practice to include the construction phase as part of the concession period to encourage early project completion and early opening of services to the public (Ye and Tiong 2003). Furthermore, the concessionaire is often required to design and build the project facilities by a specified date. It has to pay liquidated damages if the works are not completed on time. There may also be a "backstop" date (e.g. one year from the target completion date) on which the client is entitled to terminate the concession agreement if completion has still not been achieved (Guislain and Kerf 1995).

Short Concession with High Service Price

This approach allows the concessionaire to recover development costs in a short time while still maintains the efficiency from frequent competitions. However, this mechanism may not always be feasible unless the government pays the concessionaire. Otherwise, unaffordable prices may reduce market demand to a degree that the initial project development costs might not be recovered at any price level over the short concession period (Guislain and Kerf 1995). Extremely high prices may also cause strong public oppositions and consequent social and political problems. For example, in Mexico, the loans to the BOT projects were characterized by high floating interest rates due to a lack of mature domestic financial market. The government adopted the shortest concession period length as a key award criterion to address the difficulty in obtaining long-term fixed-rate financing. This encouraged the concessionaires to charge the maximum allowable toll with the aim of reducing the payback time. The combination of high floating interest rate and short maturity period resulted in prohibitively high tariffs (Vazquez and Allen 2004).

The use of shadow tolls would be suitable for projects where there is a perception of final users being resistant to paying tolls. Shadow tolls are "per vehicle" amounts paid to the concessionaire by a sponsoring governmental entity rather than the final users (United Kingdom Highways Agency 1997). This approach offers the government the advantages of a conventional concession contract plus the flexibility of transferring traffic risk to the concessionaire. Tolling final users may create opposition for some projects. For a service that are traditionally free to the public, or that there is an alternative option that is free, the users may not use the tolled facilities. This would result in the project's being financially non-viable and "congestion" to free facilities.

Staged Lifespan Concession and Price System

A staged concession system with variable prices may be explored in the designed life span of a project. For example, the construction costs of a project that has a life of 2.5X years before major repairs are needed may be recovered in an X-year concession. The competition in the second X-year concession would cause prices to fall to the level need to operate and maintain the project. In the third X-year concession, the prices are set to a level enough to cover the operation and rehabilitation costs. This approach has some weaknesses. In addition to the "feasibility" and "opposition" problems in the first and third concessions resulted from high prices due to huge construction or rehabilitation costs as discussed in the "short concession with high service price" mechanism, the periodic significant changes of prices result in an unstable toll regime that may be not socially desirable.

Bidding-Driven Concession Period

It is a common international practice that the concession period is fixed by the public client before advertising the request for proposals. However, there is another option, i.e., listing the concession period as one of the factors to be bidden by the private sector. This approach was taken in the Talca-Chillan stretch of route 5 in Chile (Engel et al. 1996).

Condition-Dependent (Flexible) Concession Period

The length of the concession may be determined by the actual occurrence of endogenous factors according to a predefined logic. For example, it is determined over time by reference to the date of recovery by the lenders of their principal and interest, to the date by which equity holders have achieved a certain level of return, or to the date by which the project has achieved a certain level of production/usage (Clement-Davies 2001). One case to the point is the concession of the Queen Elizabeth II Bridge in Dartford, the United Kingdom, which will end when the concessionaire's cumulative revenue has reached the level of outstanding debt or after 20 years, whichever comes first (Her Majesty Treasury 1995). The flexible and condition-dependent concession leaves more space for dealing with risks and uncertainties.

Concession Extension and Termination

Various project variables may happen to be quite different from those assumed before or at the time of the award of the concession, unexpected situations may appear, and the public client' objectives in the concession may change. These problems necessitate the modifications and changes of the original concession agreement to reflect the changed conditions. For example, the Argentine Government suspended the intercity road concessions and renegotiated with concessionaires only five months after the concessions had been in operation, leading to a major overhaul in the design of the concession: (1) the number of toll booths was reduced and their locations adjusted, (2) tolls were reduced by more than 50 percent, and (3) the government withdrew the "canon" requirement and granted a total annual subsidy of US$57 million to compensate the concessionaires (Estache and Carbajo 1996).

Concession Extension

Concession may be extended in order to compensate the concessionaire for the impact of risks that are beyond the control of the concessionaire or not assigned for the concessionaire to bear. For example, in the more than US$13 billion program of concession toll roads under the Puebla Panama Plan in Mexico, a clause for concession extension was provided for (1) traffic levels falling below government forecasts, (2) cost overruns resulting from government imposed delays or design modifications, and (3) cost overruns in excess of 15 percent of the original project budget (Vazquez and Allen 2004).

Unscheduled (Early) Termination

Termination has quite different impacts on a concessionaire in a project that has low degree of asset specificity from that in a project with high degree of asset specificity (Kwoka 1996). In the former, the concessionaire can easily sell the assets at their market value, or to utilize them in other similar projects or for other purposes. For example, an airline concessionaire can easily sell the airplanes or use them for other routes. In the latter, it is very difficult for the concessionaire to sell at a reasonable price or to find an alternative use for the largely sunk assets, for example, roads, bridges, and tunnels.

Financial Engineering

Incorporating Existing Facilities into the Concession

Some existing revenue-generating facilities may be incorporated into a concession, where one of two approaches may be taken. One approach is to transfer existing facilities to the concessionaire free of charge. This reduces the size of investment required from the private sector because of the revenues generated from the existing facilities. The other approach is a public-private joint venture concession company, in which the government uses the existing facilities as investment. Incorporating existing facilities has some advantages. First, it improves the project's financial status and consequently increases the private sector's interest in the project. Second, it increases the concessionaire's debt-borrowing capacity and reduces the cost of capital. Third, it allows integrated and coordinated infrastructure management to improve economies of scale. Fourth, it reduces conflicts of different operating policies between different projects serving same or similar purposes, for example, a tolled road and a free road.

Combined Financial Instruments

It is difficult to raise long-term capital within a country that lacks mature capital markets. However, the government can help the concessionaire to raise multilateral/ bilateral agency loans, or to issue bonds guaranteed by toll revenues. Various financial instruments may be combined to generate the required capital. The following strategy was proposed in highway infrastructure development in Mexico (Vazquez and Allen 2004): First, to use multilateral/ bilateral agency loans as front equity to trigger construction loans from domestic commercial banks. Then, to refinance the project through the issuance of medium-term "infrastructure bonds" on the domestic market once the project is completed. Finally, to refinance the project on international markets once the project has been in operation for a few years to release domestic financial resources for other projects.

Escrow

Escrow is a legal arrangement whereby money or a non-money property is delivered to a third party (called an escrow agent) to be held in trust pending a contingency or the fulfillment of a condition or conditions in a contract. Upon that event occurring, the escrow agent will deliver the thing to the proper recipient; otherwise the escrow agent is bound by its fiduciary duty to maintain the escrow account (AnswerNation 2004).

Banks usually take conservative lending policies. They are more confident in public clients in traditional infrastructure projects than in the private sector concessionaire in PPP projects that exercises a project financing technique. This makes it difficult for the concessionaire to obtain long-term capital for a PPP project. However, commercial banks may be willing to offer a long-term debt through an escrow agent. This practice is adopted in Mexico (Vazquez and Allen 2004). The concessionaire equity, loans from financial institutions and the government up front equity are put into an escrow account. The escrow agent takes over the administration and management of revenues from the PPP projects, distribute money for project construction/ rehabilitation/operation/maintenance, debt service and ultimately to the concessionaire.

Economic Regulation

Different economic regulation mechanisms have been in use (Burns and Estache 1999). There is a need to analyze their characteristics and impacts on the performance of the concessionaire and to assess the level of efforts needed in the implementation of each mechanism in order to choose an appropriate economic regulation mechanism, taking into consideration the particulars of the project, for example, its type, scope, and the environment in which the project operates. Effective economic regulation requires adequate information on the performance of the concessionaire and the overall performance of the industry with a reference to local, national and international practices. This obviously takes time, effort and money and the monitoring and enforcement capabilities are often limited (Ergas and Small 2001). Therefore, key areas that necessitate more time and efforts than others should be identified. For example, a rate of return regulation may encourage the concessionaire to maintain service quality whereas it may also dampen down the concessionaire's incentives to reduce costs (Averch and Johnson 1962). Hence, in a rate of return regulation, more efforts are needed in monitoring the usefulness of the capital investments and the efficiency of operation and maintenance than in the monitoring of service quality.

Service Price Setting and Adjustment Mechanism

The main purpose of a price setting and adjustment mechanism is to ensure a fair deal. This mechanism allows the concessionaire to keep reasonable efficiency gains while siphons excessive gains into the public sector, for example, by reducing the tolls/ tariffs or cross-subsidizing less profitable projects (Estache and Carbajo 1996). The price is mainly dependent on the required revenues to cover costs and the required return on the concessionaire's capital. The following procedures may be taken to set/adjust prices:

(1) Determining the reasonable rate of return on the concessionaire's capital. The capital structure and the risks assumed by the concessionaire are the base on

which the rate of return is determined. The reasonable rate of return may be determined as a weighted average of the cost of debt and the cost of equity of the particular project, taking into consideration of current and future market conditions and the risk factors of the specific industry such as its beta value.

(2) Determining the basic price that enables the concessionaire to earn this predetermined level of return based on the cost structure (composition of the total costs and the relative amount of each component, such as project development cost, operation and maintenance costs, interest, and taxes), and the quantity of demand for the services of the project in each period of the concession.

(3) Indexing key cost components of the project by the factors that best indicate their changes such as exchange rate, interest rate and inflation rate.

(4) Periodic review and revision of the price system based on audited actual costs and revenues and their forecasted future trends.

(5) Specific price adjustment to reflect unforeseen events that significantly affect the cost and revenue structure of the project.

Social Objectives

Concessions are also used to achieve redistributive goals for social purposes. The public client may provide subsides to users of privatized projects/services where such projects/services generate positive externalities whereas users or part of them cannot afford the cost-covering tariffs. If the concessionaire is asked to subsidize, it may lack incentives to extend services to the poor users. Subsidies should be precisely targeted to the neediest customers to minimize distortions in resource use and maintain incentives for productive efficiency (World Bank and Inter-American Development Bank 1998). Another practice is "cross-subsidy," where different prices are charged for different types of users even if the service costs are the same, and vice versa. The exclusive rights of the concession prevent potential competitors from undercutting the prices paid by the over-charged users and thereby depriving the concessionaire of the revenue needed to subsidize other users (World Bank and Inter-American Development Bank 1998).

Subsidy practices are often nontransparent and they distort consumption patterns. A variable tariff system that reflects cost differences in services to different users will promote allocative efficiency and economic use of resources, and eliminate/ reduce the need to superimpose specific investment or coverage obligations in a uniform tariff system where the tariff cannot cover the service cost (for example, in water supply to a rural area), since the price regime itself gives the concessionaire adequate incentives to invest (World Bank and Inter-American Development Bank 1998).

Two approaches may be taken to improve in this regard. One is to finance carefully targeted subsidies through special funds financed from explicit levies on all consumers by collecting the levy from service providers in proportion to their market share (Irwin 1997). Another is to make subsidies an integral part of the welfare system rather than the responsibility of infrastructure providers. This approach minimizes distortions and allows competition. In addition, to maintain incentives for the provider to be efficient, budget payments can be made only for each unit of service actually provided. For example, Chile adopted a comprehensive subsidy scheme for low-income households involved in concession projects. Every two years the Ministry of Planning conducts a detailed national survey to determine household poverty, the number of households requiring subsidies and monetary volume of subsidies required by the municipalities. The Ministry of Finance then reviews this assessment and requests the necessary budget from Congress. Finally, the municipalities implement the subsidy scheme. In the case of water, the subsidy covers 25-85 percent of the charges for the first 20 cubic meters of consumption. The municipalities pay it directly to the service provider on the basis of services actually provided (Rivera 1996).

Ex Ante versus Ex Post Evaluation

The capital expenditure and operation cost may be evaluated either ex ante based on estimates or ex post based on actual costs. The use of ex ante or ex post data to evaluate costs has strong implications on the incentive of the concessionaire to invest and improve efficiency. In ex ante evaluation, the concessionaire keeps the efficiency savings or assumes the cost overruns, depending on whether the difference between the estimated and actual expenditure is positive or negative. The concessionaire has more incentive to minimize the actual development and operation costs. However, the concessionaire also tends to quote high cost estimates. In ex post evaluation, the concessionaire may have little incentive to reduce costs, which may lead to unnecessary investments. Whether to use an ex ante or an ex post evaluation depends on several factors, including (1) significance of the investment program; (2) expected efficiency savings; (3) regulator's ability to establish the efficient level of investment; and (4) the incentives applied to operating expenditure and investment (Burns and Estache 1999).

Change Management through Win-Win Negotiations

The complexity, wide range of risks and uncertainties of a PPP project may cause various changes in the long concession period. Either the public sector or the private sector may require changes to the original concession agreement, for example, related to project scope, technical specifications, service levels, and pricing and payment methods. These changes could become sources of disputes if not managed properly. Negotiations are a non-adversarial and usually cost-effective way to deal with changes. The impacts of a required change (whether expected or unexpected) on each contracting party should be assessed in terms of its time and cost consequences, based on which corresponding cost and plan/ schedule adjustments and compensations are made. A "fair dealing" principle and the readiness of contracting parties to compromise are critical to maintain amicable working environments, minimize conflicts and enhance project performance. One issue needs attention is that changes to a concession that is being implemented should not reduce the rate of return on the investment of the concessionaire when such changes are beyond the concessionaire' control. Otherwise, it could seriously impair the concessionaire's incentive to invest and consequently delay the project development process. For example, private investments in the intercity road concessions in Argentina were far behind schedule because renegotiations reduced the concessionaires' potential returns (Estache and Jose Carbajo 1996).

Non-Confrontational Dispute Resolution Based on Trust and Cooperation

The many contracting parties may have different objectives/ interests in a PPP project, different views of the multidisciplinary transactions, different perceptions of risks and their underlying assumptions, and different positions on the scope and degree of risks they are willing to undertake. This, coupled with the unforeseen/ unforeseeable risks and uncertainties over the long concession period, often leads to conflicts and disputes between contracting parties.

Dispute resolution though a formal arbitration or litigation process is usually costly and time-consuming. In addition, resorting to a formal legal process by any contracting party can easily damage the hard-earn trust and cause an adversarial relationship with other parties involved and it is very difficult to reestablish trust once damaged. Lack of trust and an adversarial relationship have serious negative effects on the cooperation of contracting parties in on-going and future transactions of the project. Furthermore, being known involved in issues that were settled by arbitration or in court, whether won or lose, impairs a party's reputation, which is a valuable intangible asset.

An informal and non-confrontational dispute resolution system based on trust and cooperation would be conductive to a RC framework and maintain continuous relationships of contracting parties toward smooth project development and win-win outcomes. This system has the following characteristics: (1) all contracting parties commit to the idea that any potential conflicts/ disputes should be resolved internally through negotiations and other non-adversarial means without resorting to arbitration and litigation; (2) there is a conflict/ dispute prevention mechanism where contracting parties take an open book approach, communicate openly and keeps free flow of information to anticipate and take joint actions to prevent and mitigate potential problems/ conflicts; (3) there is a dispute resolution escalation mechanism where problems and conflicts are settled with collective responsibility and combined efforts at the lowest possible level of the PPP project network before escalating to a higher level; and (4) the residual problems/ conflicts are resolved by restorational methods and a risk sharing and rewarding scheme based on a "fair dealing" principle rather than through claims that are often adversarial.

The informal and non-confrontational dispute resolution system has been increasingly used. For example, in some alliancing contracts in Australia, participants agree not to use arbitration/ litigation, and to regard the alliance board as the last resort to resolve disputes (Rahman and Kumaraswamy 2004a). There are also some projects that use an ombudsman, who investigates the conflicts, recommends measures to address current problems, and provides insights on future improvements.

CONCLUSIONS

Successful infrastructure development through PPPs depends on a multitude of factors, among which the relationship between contracting parties has a significant impact on the potential value to be achieved in view of the multidisciplinary and multiparty transactions and the wide range of risks and uncertainties over the long concession period. There is a need to address both the nature of the transactions and the characteristics of the transactors (i.e., contracting parties) in the design of a workable concession, in which PPPs should be viewed as partly an informal contracting strategy to improve the project culture and contractual relations based on trust for minimized opportunism and transaction costs and partly a formal contracting means to define and govern transactions with certain degree of legal security toward the general objective of efficient and effective delivery of public works and services.

This research develops a relational concession framework, which focuses on four aspects in relational concession arrangements toward efficient delivery of public works and services: (1) enhancing economics of public procurement, (2) creating favorable relational concession environment, (3) establishing appropriate relational concession principles, and (4) taking effective relational concession measures.

RC techniques provide a useful way to enhance trust and strengthen contractual relationships in the whole project supply chain and consequently reduce transactional frictions/ conflicts and make “flexible” and “incomplete” contract provisions for effective management of risks and uncertainties. RC strategies are more useful for PPP projects with long concession period, indefinite scope of work activities and less predictable outcomes. However, there are still reservations on the value and viability of RC schemes. Guidelines are needed to direct RC arrangements toward a healthy way.

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CHAPTER 6: CONCLUSIONS

SUMMARY CONCLUSIONS

PPPs have been in practice worldwide in the past two decades where private sector participation is encouraged in the provision of public works and services with an aim to improve efficiency, increase the infrastructure development speed, and expand the scope of services beyond what the government on its own could achieve due to limited budget and inadequate technical/ managerial skills. PPPs bring competition to public monopoly by substituting competition for the market for competition in the market for a monopolistic infrastructure sector where ordinary competition may be not workable or even inefficient and wasteful. PPPs overcome many obstacles to private finance initiatives and thus enable the public sector to utilize private funds, technology, knowledge and expertise to a wider scope and at a higher level. Furthermore, as a network linking public and private sectors, PPPs reverse the fragmentation of functions and divergent/ confrontational agendas of contracting parties associated with traditional public procurement routes by integrating multiple project development functions on a single private source, the concessionaire, and consequently improve the economies of scale and provide incentives to reduce life cycle costs through innovations in different stages of the integrated project procurement process.

However, PPPs do not automatically generate or guarantee better outcomes than traditional contracting methods. PPP projects are usually much more complicated because of the multidisciplinary transactions, multiparty participation, sophisticated project financing techniques, and wide range of risks and uncertainties over a long concession period. In addition, potential high transaction costs exist in various stages of the project development process because of incomplete information, asset specificity and the resulting scope for opportunistic behavior, the complicated contractual arrangements with different agreements between multiple project participants, lack of adequate skills and expertise for such complicated arrangements in both the public and private sector who have to rely somewhat of external financial/ legal/ technical consulting services, and political influence that often leads to over-protracted and wasteful project bidding and aborted projects.

Mixed results have been experienced in international PPP practices, coupled by substantial controversy, criticism and conflicts over PPPs. The division in opinions over PPPs is as wide as the world itself. The worldwide interest in PPPs, problems encountered in many countries and the substantial controversy over PPPs promoted the launch of this research, with the objective to learn lessons and draw experience from international practices in order to development an methodology for innovative and efficient delivery of infrastructure and services to overcome current difficulties and improve future practices.

In this research, the following outcomes are achieved:

1. The development of an integrated general framework for effective and efficient delivery of public infrastructure and services through systematic approaches to PPPs.
2. The identification of critical issues in the developed general framework in which little research has been done and there is an urgent need in the industry

for such issues to be solved for improved practices. These critical issues are (1) financial evaluation, (2) determination of concession period, (3) concessionaire capital structure optimization, and (4) improvement of contractual arrangements to minimize risks.

3. The development of an innovative financial evaluation methodology that reflects the characteristics of project financing, incorporates simulation and financial analysis techniques, and aims at win-win results for both public and private sectors.
4. The development of a mathematical model that determines the appropriate length of the concession period that demarcates the rights and responsibilities between public and private sectors in a project's life cycle.
5. The development of a mathematical model that optimizes the concessionaire's capital structure when it is subject to various risks and financial viability requirements.
6. The development of a relational concession framework for the establishment of a cooperative and collaborative working environment to minimize opportunism and transaction costs associated with the wide scope of risks/ uncertainties and incomplete information in the long-term concession.

These research outputs make significant contributions to the knowledge body of public works and services provision, and provide specific means to overcome the various problems currently encountered in international PPP practices and to improve future practices toward innovative, effective and efficient public works and service delivery.

SYSTEMATIC FRAMEWORK FOR INFRASTRUCTURE DELIVERY

This research develops an integrated four-stage systematic framework for innovative and efficient infrastructure development through PPPs in general based on public procurement principles and win-win solutions for parties involved, on the realization that although there are many aspects that are project-, sector-, and/ or country-specific, the concept, process and key principles in infrastructure and service delivery through PPPs are essentially identical. This framework takes into account the requirements of public services, realignment of responsibilities and rewards among multiple project participants in PPPs, the monopolistic rights of the concessionaire, and the wide range of risks and uncertainties in the long-term concession period.

The first stage, design of concession, plans the project and allocates risks for enhanced efficiency. This stage also forms the foundation on which other stages are implemented. In this stage, emphasis need to be placed on the following issues: (1) whether a project is necessary to be concessioned, (2) separation of monopolistic sectors from competitive ones, (3) establishing adaptable project development objectives, (4) reasonable risk allocation and suitable government support, (5) evaluation of partnership models, (6) comparison with traditional procurement approaches, (7) integrated project plan, (8) technical innovations, (9) affordability, (10) performance-based contracting, and (11) balance of certainty and flexibility.

The second stage, concessionaire selection, plays an important role in achieving innovation, efficiency and cost effectiveness through direct competition. This stage necessitates a sound best value source selection methodology, a competitive source selection process, transparent and valid evaluation criteria, and suitable evaluation methods.

The third stage, economic regulation, allows the government to address changing conditions and to regulate the concession for efficient operation with due discretion. The public client needs to establish clear economic regulation objectives, choose suitable regulation mechanisms (rate of return, price cap or intermediate scheme), define participation and incentive compatibility constraints, and overcome regulatory weaknesses.

The fourth stage, reconcession and rebidding, has effects similar to the second stage. Periodic rebidding keeps incumbent concessionaire under pressure to improve performance during the term of the current concession in order to raise its chances of keeping the following concession and to offer competitive services in the following concession if selected. Attention should be paid to the following issues: (1) scheduled/ unscheduled reconcession, (2) periodic rebidding of concession, (3) valuation of incumbent's unamortized capital, (4) concession rebidding interval, and (5) biased rebidding.

A sanction test is made for this proposed four-stage systematic framework by discussing with several PPP researchers and practitioners, who, in general, think this framework valid and useful.

FINANCIAL EVALUATION

The financial evaluation of a privatized infrastructure project is complex and challenging because of the complexity of the non-recourse financing technique and a variety of risks and uncertainties related to project finance that make the forecasting of cashflows very difficult. The radical reallocation of risks among project participants makes the concessionaire undertake much more and deeper risks than a mere contractor. Construction and economic risks are the two major risks to the concessionaire. Successful development of a privatized project necessitates the effective management of these risks and the use of improved financial engineering techniques.

Traditionally, feasibility study is conducted from the developer's point of view. The loan is based on the developer company's credit, general funds and assets. Feasibility analysis is carried out by examining a few key financial viability indicators such as the payback period, NPV and IRR. However, a PPP project is much more complicated than a traditional project because of its project financing technique, multidisciplinary transactions, multiple participants with different responsibilities and interests, and long-term contract period with many risks and uncertainties. This research recommends that the following aspects be further examined in a PPP project: equity level, types of equity participation, equity at project risk, ratio of equity at project risk, self-financing ability, and project bankruptcy probability during construction. It also recommends that the value of government loan guarantee be taken into account. On the one hand, the governmental loan guarantee enhances private sector developers' money-borrowing capability, reduces the cost of their borrowed money, and minimizes the project completion risk. Therefore, a project that is financially unviable when there is no governmental guarantee may become financially viable when there is a government loan guarantee. On the other hand, the governmental loan guarantee may cause possible problems. When loans are guaranteed, project lenders and equity holders may not examine the project rigorously. The lack of due diligence may result in the selection and development of a project that is not financially feasible. Risks and liabilities related to this will eventually undertaken by the public sector.

CAPITAL STRUCTURE OPTIMIZATION

In capital structure optimization, this research provides an improved definition to reflect the different perspectives of different project participants, the types, and effects of capital participation by defining it in four dimensions: (1) types of financial instruments, (2) the relative amounts of different financial instruments, (3) the sources of the financial instruments and (4) the corresponding contractual conditions on these financial instruments.

The capital structure affects the allocation of responsibilities and risks among project participants, the total life cycle project cost, and consequently the financial viability of the project. In addition, the capital structure also affects the motivations and commitments of different project participants to the success of the project.

The proposed model optimizes the concessionaire's capital structure when it is subject to construction and economic risks and financial viability requirements.

The financial evaluation and capital structure models developed in this research reflect the characteristics of project financing, incorporate simulation and financial analysis techniques, and aim at win-win results for both public and private sectors. They optimize the capital structure and evaluate the project's financial viability when it is under construction risk, bankruptcy risk and various economic risks and is subject to other constraints as imposed by different project participants. These models also evaluate impacts of governmental guarantees/supports, and address the issue of the equity holders' commitments to project success by initiating the concept of equity at project risks.

The integrated financial evaluation and capital structure optimization framework takes three steps: Step 1 – simulation of construction risks; Step 2 – simulation of economic risks; and Step 3 – financial analysis and capital structure optimization. The integrated framework and corresponding mathematical models facilitate both public and private sectors in evaluating a privatized project's financial viability and collectively determining an optimal capital structure that safeguards their respective interests.

DETERMINATION OF CONCESSION PERIOD

The length of concession is an important issue in infrastructure development as the concession period divides the rights and responsibilities between the public and private sectors in the life cycle of the project. The essence of the methodology proposed in this research is that the concession should integrate construction and operation to encourage innovations, efficiency, cost savings and early project completion. The project completion time should allow a competent contractor to complete the project on schedule and the operation period should be long enough to enable the concessionaire to achieve a "reasonable" return, but not too long such that the concessionaire's return is "excessive" and the public sector's interests are sacrificed.

In practice, a long-term fixed concession is in common use. However, a variable concession period may be more suitable where the project scope has not been clearly defined, the project company is financially high-leveraged, construction activities of the project are very complex with high risks, and the cash flows in future operation are very difficult to predict.

The concession period depends on a number of factors, such as the type of the project, the size and complexity of construction activities, operational life of the project facility, the capital structure of the concessionaire company, and the market situation and revenue stream in the future operation. There are many uncertainties and risks in construction and future operation, which have significant impacts on the length of the concession period. Therefore, it is necessary to quantify these risks and model the project development as a stochastic process that behaves according to certain laws of probability. Risk analysis and modeling and consequent re-engineering of the project development process can lead to informed decisions in the procurement of pubic works and services. Simulation is a useful tool to measure uncertainties and reason with construction and economic risks.

The proposed methodology, mathematical model and simulation-based approach would facilitate the public sector in determining a suitable concession period for a particular infrastructure project, and the private sector in determining whether to bid for a concession solicited by a public client. It would also facilitate the private sector to develop unsolicited concession proposals for potential infrastructure projects and the public sector to evaluate such unsolicited proposals.

RELATIONAL CONCESSION

Public infrastructure had been traditionally developed through the mainly price-based design-bid-build route and relied on rigid "complete" contracts. The design-bid-build approach has some inherent problems: (1) fragmented transactions often lead to confrontational working relationships between contracting parties; (2) disintegrated project functions do not encourage economies of scale; (3) contracting parties may behave opportunistically to take their information advantage. These problems often result in lengthy and costly disputes, time and cost overruns and poor quality.

Successful infrastructure development through PPPs depends on a multitude of factors, among which the relationship between contracting parties has a significant impact on the potential value to be achieved, in view of the multidisciplinary and multiparty transactions and the wide range of risks and uncertainties over the long concession period. The construction industry has been adversarial, and project partnering is largely tactical and short-term largely based on self-interested trust. High transaction costs have a negative impact on the client's best value objectives. There is a need to address both the nature of the transactions and the characteristics of the contracting parties that conduct these transactions in the design of a workable concession, in which PPPs should be viewed as partly an informal contracting strategy to improve the project culture and contractual relations based on trust for minimized opportunism and transaction costs, and partly a formal contracting means to define and govern transactions with certain degree of legal security toward the general objective of efficient and effective delivery of public works and services.

This research develops a relational concession framework in which relational contracting strategies are incorporated to deal with the problems mentioned in the above. This framework focuses on four aspects in relational concession arrangements toward efficient delivery of public works and services: First, to enhance economics of public procurement by examining (1) types of contracts, (2) in-house provision or outsourcing, (3) transaction cost economics, (4) efficiency in public works and services, and (5) potential opportunistic behavior in PPPs. Second, to create a favorable relational concession environment by (1) building a relational PPP culture, (2) understanding relational contracting, (3) identifying factors that facilitate relational contracting, (4) selecting suitable project partners, (5) mobilizing project partners and (6) establishing mutual trust between contracting parties. Third, to apply appropriate relational concession principles, which include (1) value for money, (2) joint project planning and control, (3) reasonable allocation of risks, (4) balanced competitive and relational contracting arrangements, and (5) right level of contract completeness. Fourth, to take effective relational concession measures, which include (1) performance-based contracting, (2) equitable concession period determination strategies, (3) concession extension and termination, (4) financial engineering, (5) economic regulation, (6) service price setting and adjustment mechanism, (7) social objectives, (8) *ex ante* versus *ex post* evaluation, (9) change management through win-win negotiations, and (10) non-confrontational dispute resolution based on trust and cooperation.

Relational concession techniques provide a useful way to enhance trust and strengthen contractual relationships in the whole project supply chain and consequently reduce transactional frictions/ conflicts and make "flexible" and "incomplete" contract provisions for effective management of risks and uncertainties. Relational contracting strategies are more useful for PPP projects with long concession period, indefinite scope of work activities and less predictable outcomes. However, there are still reservations on the value and viability of RC schemes. Guidelines are needed to direct relational contracting arrangements toward a healthy way.

A sanction test is made for this proposed relational concession framework by discussing with several PPP researchers and practitioners, who, in general, think this framework valid and useful.

RECOMMENDATIONS FOR FUTURE RESEARCH

The four-stage framework for infrastructure delivery proposed in Chapter 2 provides a systematic approach to infrastructure development through PPPs in general. In the application of this general framework for future projects, it needs to be adapted to project-, sector- and/or country-specific conditions. Consequently, it is useful for a future research to study different types of infrastructure projects, compare their similarities and differences, and make specific modifications/changes to this general framework in light of the particularities of different types of projects in order to facilitate the application of this general framework in different industrial sectors and in specific countries or regions. Furthermore, it is also necessary to conduct detailed studies of the major issues discussed in each of the four stages of the general framework, for example, in the areas of partnership evaluation, performance-based contracting, best value source selection, valuation of unamortized assets, concession rebidding interval, economic regulation, and price setting and adjustment mechanism.

In the financial engineering methodologies and techniques proposed in Chapter 3 and Chapter 4, including financial viability evaluation, concession period determination and capital structure optimization, the major challenges are the effective measurement of construction and economic risks in a quantitative way and the input data modeling to generate the statistical distributions of this wide range of random risk variables. Consequently, it is useful to collect historical data for different types of projects and conduct statistical analyses to generate such distributions. In addition, it is useful to develop special purpose simulation templates for these financial engineering techniques to facilitate their applications.

The relational concession framework proposed in Chapter 5 provides guidelines for effective concession arrangements to minimize transaction costs and opportunism and to improve project development efficiency. It is useful to conduct deeper studies on the major issues discussed in each part of the proposed relational concession framework, for example, the historical transaction costs in different types of contracts (particularly, PPP projects), allocative efficiency in PPP projects, opportunism, relational source selection criteria and methodology, competitive and relational contracting arrangements, suitable degree of concession completeness, ex ante and ex post evaluation, and non-confrontational dispute resolution mechanisms.

Appendix I: List of Acronyms

BBO: buy, build and operate

BLT: build, lease and transfer

BOO: build, own and operate

BOOM: build, own, operate and maintain

BOOT: Build, own, operate and transfer

BOT: build, operate and transfer

BTO: build, transfer and operate

BVSS: best value source selection

CDF: cumulative distribution function

CPM: critical path method

DBB: design, bid and build

DBFO: design, build, finance and operate

DBOM: design, build, operate and maintain

DOT: develop, operate and transfer

DSCR: debt service coverage ratio

EPR: equity at project risks

IRRE: internal rate of return to equity

JPCT: joint project control team

LDO: lease, develop and operate

LLCR: loan life coverage ratio

MOT: modernize, operate and transfer

NCI: net cash inflow

NPV: net present value

OM: operation and maintenance

PBC: performance-based contracting

PBIT: profit before interest and tax

PDF: probability density function

PERT: program evaluation and review technique

PFI: private finance initiative

PPP: public-private partnership

PSC: public sector comparator

RC: relational contract(ing)

REPR: ratio of equity at project risks

ROO: rehabilitate, own and operate

ROT: rehabilitate, operate and transfer

SFA: self-financing ability

SIT: self-interested trust

SOT: socially-oriented trust

TOT: transfer, own and transfer

WBS: work breakdown structure

Appendix II: Examples of PPP Projects Studied

Power Plants

1. Hydroelectrica Alicura (Hydro-Electric Project), Argentina
2. Elcogas (Integrated Gasification Combined Cycle Power Plant), Spain
3. Humber Power (Gas-Fired Combined Cycle Power Project), UK
4. PT Paiton Energy (Coal-Fired Power Plant), Indonesia
5. Termobarranquilla (Combined-Cycle, Gas-Fired Power Plant), Columbia

Pipelines

6. Centragas (Natural Gas Pipeline), Columbia
7. Transgas de Occidente (Natural Gas Pipeline), Columbia
8. Kern River Funding Co (Interstate Natural Gas Pipeline), USA
9. YPF Sociedad Anonyma (Oil Pipeline), Argentina

Refinery

10. Deer Park Refining Limited Partnership (Fuel Refinery), USA

Gold Mine

11. Andacollo Gold, Chile

Telecommunications Projects

12. Fiberoptic Link Around the Globe, a Multinational Fiberoptic Cable Network
13. Telecom Development (Cellular Telephone System Gateway Switches and Integrated Overlay Network), Russia

Transportation Projects

14. Greater Vancouver Transportation Authority Golden Ears Bridge, Canada

15. Kicking Horse Canyon Project, Canada

16. Canada Line, Canada

17. William R. Bennett Bridge, Canada

18. Trans-Canada Highway (New Brunswick), Canada

19. Sierra Yoyo Desan Road, Canada

20. Sea-to-Sky Highway Improvement Project, Canada

21. South East Edmonton Ring Road (Anthony Henday Drive), Canada

22. Northeast Calgary Ring Road, Canada

23. Ottawa Light Rail Transit Project, Canada

24. Mexico-Cuernavaca Toll Road, Mexico

25. North-South Expressway, Malaysia

26. M1-M15 Motorway, Hungary

27. M5 Tolled Motorway, Hungary

28. Beiras Litoral and Alta Shadow Toll Road, Portugal

29. International Airport Hamburg AG, Germany

30. Local Airport Kassel-Calden, Germany

31. International Airport Warsaw, Poland

32. Wijkertunnel Randstad, The Netherlands

33. Perpignan – Figueras Rail Concession, France and Spain

34. Channel Tunnel Rail Link, UK

35. I-PASS Public-Private Partnerships for Illinois Tollway, USA

36. Port of Galveston Cruise Terminal Development, USA

37. Chicago Regional Environmental and Transportation Efficiency Project, USA

38. Pocahontas Parkway, USA

39. International Air Terminal 4 at John F. Kennedy Airport, USA

40. U.S. Navy Public Works Center, San Diego, USA

41. Massachusetts Route 3 North Project, USA

42. Grand Central Terminal, New York, USA

43. Union Station, Washington, D. C., USA

Water and Waste Water Treatment

44. Britannia Mine Water Treatment Plant, Canada

45. Whistler Wasterwater Treatment Plant, Canada

46. Scottish Water Solutions, UK

47. Scottish PPP Water Projects, UK

48. BerlinWasser, Germany

49. Constanta Water and Wastewater Project, Romania

50. Karvina Sewerage, Czech Republic

51. Trencin Water System, Slovak Republic

52. Edwardsville Water and Wastewater Treatment Facilities, USA

53. South Zone Water Utility System, USA

54. El Paso County Water Treatment Services, USA

Health Care

55. Abbotsford Hospital, Canada

56. Royal Ottawa Hospital, Canada

57. Academic Ambulatory Care Center (Vancouver), Canada

58. Brampton Civic Hospital, Canada

59. Montreal University Hospital Center, Canada

60. McGill University Health Center, Canada

61. North Bay Regional Health Center, Canada

62. Bluewater Health (Sarnia Hospital), Canada

Solid Waste Management

63. ASA and Rethmann, Hungary

64. RWE Entsorgung, Bulgaria

65. Nessebar "Golden Bug" Landfill, Bulgaria

66. Kirklees Metropolitan Solid Waste Project, UK

67. Prescom in Targoviste, Romania

68. Jegunovce Concession, Macedonia