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Procedures and Resources for Analyses Related to Public-Private Partnerships

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Abstract

The demands for delivering basic infrastructure services keep growing worldwide. However, funding from government and public agencies alone cannot cover the capital needed to operate and maintain existing infrastructures, much less to construct new ones. Public-Private Partnerships (PPPs), utilizing private capitals, are an innovative and cost-effective financing mechanism to solve this budgetary shortage problem. PPPs are becoming accepted by more and more public agencies all over the world as an alternative option to bridge the budget gap. However, this financial mechanism is relatively new and many institutions are still exploring the tool. In this research, basic procedures and useful resources for conducting various analyses related to PPP projects are synthesized and discussed based on a wide range of literature. Basic concepts, such as project finance, value for money, and financial viability, are first presented as an introduction to PPPs. Then the differences of PPP development between developed countries and developing countries are discussed. Since risk analysis is the key part in PPP project analyses, information on risk identification, quantification, allocation, and management is illustrated with examples. Furthermore, resources such as web-based tools and mathematical models applicable to dealing with PPP projects and quantifying risks associated with PPP procurements are provided. This research can help both public and private sectors better understand PPPs.

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1. INTRODUCTION

1.1 Background and motivation

With continuous growth of the world's economy, the demand for basic infrastructure services has increased drastically in recent years. The United States and China are the top two countries in 2012 GDP ranking with a total GDP of 15,680 billion dollars and 8,227 billion dollars respectively (Central Intelligent Agency 2012). As a result, more infrastructure services are required to meet the needs from the general public. However, due to restricted public budgets, the infrastructure services delivered by the public are constrained. There is an immediate need for government and public agencies to explore new funding sources.

Public Private Partnerships (PPPs), regarded as an innovative funding mechanism, have been applied to address this budgetary shortage problem. PPPs introduce private capital and expertise into the construction, operation, maintenance and replacement of the infrastructure (Yuwen 2012). The public authority and the private sector collaborate as partners in a project. A number of PPP projects have been implemented successfully in various regions (Reinhardt 2011; Asian Development Bank 2008; Robert 2011). As for the infrastructure in the U.S., it was estimated that 2.2 trillion dollars would be needed to improve the U.S. infrastructure from the current average score of "D" (Pantelias 2009; ASCE 2009). There are also continuously increasing expectations for mobility, travel demand and levels of service from the public (Brown 2007; Ortiz and Buxbaum 2008). Public funds alone are insufficient and cannot cover the expenditures. The situation is the same in most of the other countries where utilization of alternative sources of capital is called for, especially the financial strength from the private sector (Pagano and Perry 2008). Under these circumstances, PPPs are becoming an increasingly popular business model in providing flexible funding and reliving budget shortfalls.

Slowly but steadily, traditional ways of public infrastructure financing have given way to PPPs to attract private capital in delivering basic infrastructure services. In other words, PPPs, serving as a cost-effective approach, are changing the infrastructure provision (Pantelias 2009).

1.2 Research scope and objectives

Although PPPs have been embraced in many countries already, they are still a relatively new financing approach. Both public agencies and private entities are still exploring how to best apply this tool. This report aims at presenting a comprehensive summary of existing procedures and resources for conducting analyses related to the PPPs, including basic concepts, uses of PPPs in developed countries and developing countries, risk analysis for PPP projects, and analysis tools available for PPP problems. More specifically, the objectives of this research are:

1) To provide an overview of PPPs and illustrate the basic concepts about PPPs (concepts, features, classifications, etc.);
2) To present the history and development of PPPs in different parts of the world from the perspective of developed countries (the UK, the US and Australia) and developing countries (China, India and Africa);
3) To present risk analysis procedures for PPP projects, including methods for risk identification, risks associated with PPP procurements (financial risk and investment risk) and risk allocations;
4) To introduce tools and mathematical models that can be used to analyze PPP problems and quantify risks in PPPs.

1.3 Report outline

The report is arranged as follows:

Chapter 1 presents the introduction, including the background and motivation, research scope and objectives of the research.

Chapter 2 presents a comprehensive literature review of subjects related to PPPs, including the concept of Public Private Partnerships; features of PPPs; classification of PPPs; project finance; Finance flows; general introduction to risks in PPPs; value for money and financial viability of PPPs.

Chapter 3 presents the history and development of PPPs in other countries from the perspective of PPPs in developed countries and developing countries. The condition of PPPs in each of the countries reviewed is introduced and comparisons are made between the developed and developing countries.

Chapter 4 presents the risk analysis in PPP projects, including the risk identification, risks with PPP procurements and risk allocation. In addition to the introduction of four risk identification methods, risks associated with PPP procurements are also discussed along with methods for risk allocations.

Chapter 5 presents the tools and models available to analyze risks associated with PPP projects and assess the viability of PPP investments.

Chapter 6 summarizes the research work and provides recommendations for future research efforts.

2. LITERATURE REVIEW

2.1 Public Private Partnerships (PPPs)

Based on the findings from the literature review, various definitions have been used to define PPPs by different scholars and organizations at different periods. One of the most widely adopted is that PPPs are contractual agreements between a public agency (e.g., local government, state, or federal) and a private party (which can be one or more private sector entities) (Li and Akintoye 2003). Another widely accepted definition is provided by the U.S. Department of Transportation (U.S. DOT) (DOT 2004):

"A public-private partnership is a contractual agreement formed between public and private sector partners, allowing more participation by the private sector. The agreements usually involve a government agency contracting with a private company to renovate, construct, operate, maintain, and/or manage a facility or system. While the public sector usually retains ownership in the facility or system, the private party will be given additional decision rights in determining how the project or task will be completed."

According to the National Council for Public-Private Partnerships (NCPPP) (NCPPP 2007), through such a contract, the private sector agrees to play certain functions or conduct certain activities which are traditionally considered to be the public agency's responsibility. The public and private sectors share their skills and assets in delivering a desirable facility or service for the general public. In addition to the skills and assets, each party shares potential risks and rewards from the project as well (NCPPP 2007).

PPPs are also known as P3, Private Finance Initiatives (PFI), Private Participation in Infrastructure (PPI), Privately Financed Projects (PFP), and Private-Sector Participation (PSP). Regardless of which name is used, PPP programs have been recognized as a long-term and sustainable approach to financing and building social infrastructure, taking better advantage of taxpayer's money as well as enhancing public asset value. The objective of PPPs is to make full use of the resources of the private sector to deliver service or infrastructure more efficiently and effectively (Li and Akintoye 2003).

2.2 Features of PPPs

According to Peters (1998), there are five identified general features for PPPs:

First, from the definition of PPP, it is obvious that a PPP project always involves two or more parties, namely at least one public sector (local government, state, or federal) and another from the private sector. Besides the profit-oriented organizations and sectors, several scholars suggest that partnerships between the non-profit private sectors and local governments should also be regarded as PPP (Rocky and John 1998). Therefore, more parties are involved in the PPP projects.

Second, each participant is a principal in a PPP. For example, when signing the contract, instead of depending on other organizations or referring back to other sources of authority, each participant is able to bargain on its own behalf.

Third, the partnership in PPP projects is stable and long-term among the sectors. The relationship among them is enduring through the contracts. The average duration for

a concession contract is usually 30 to 40 years, which is not a simple and one-time transaction between the private sector and the public. The continuing consociation lasts from the parameters negotiated before signing the concession contract until the end of the contract (Middleton 2000).

Fourth, each participant in a PPP brings something or contributes to the partnership in some ways (Collin 1998). In order to complete the contract and build a genuine relationship, each sector will have to share or transfer some resources to the partnership. The resources can be material/obvious or immaterial/not obvious. The material/obvious resources include money, land, etc., while the immaterial/not obvious resources cover the authority of the project and other symbolic values (Bennett and Krebs 1991; Tiong 1992).

Finally, for PPPs, all the sectors in the project share the risks and the responsibilities for the outcomes (Collin 1998; HM Treasury 2000). This feature is different from the traditional relationship between a public agency and a private entity where the public agency takes full control of the policy decisions after accepting the advice from the private sector. In contrast, under PPP patterns, each participant shares joint investment, authority, responsibility, liability/risks and seeks mutual benefit as one entity (Grant 1996).

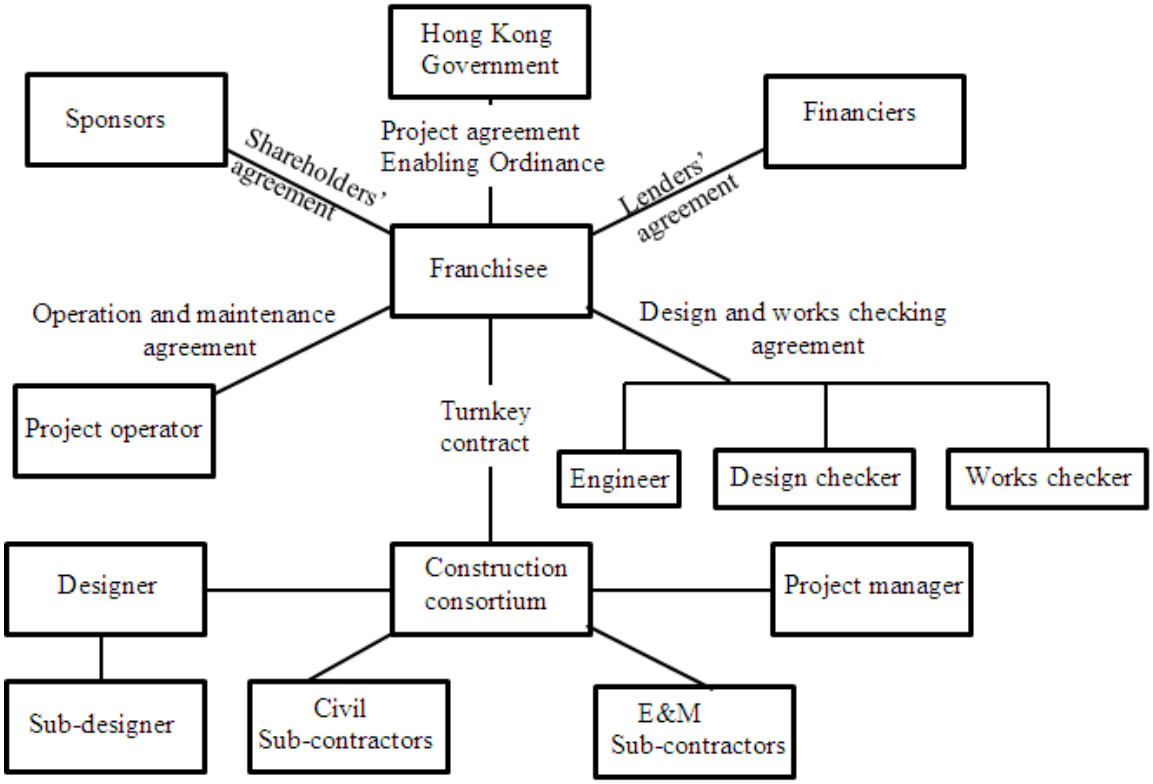
2.3 Classifications of PPPs

PPPs can be classified into different types according to different classification criteria used. Based on the ways that the raised debt is repaid, the PPPs are usually categorized as Private Finance Initiative (PFI) or Concession contracts. Both the PFI and Concession contracts are evolved from the Power Purchase Agreements (PPA) which were initially developed in the U.S. in the 1980s (Yescombe 2011). In a PFI contract, payments from the public agencies are introduced in order to pay back the debt; while in a Concession agreements, the debt is covered by the fees from the users (Pantelias 2009). According to the World Bank, the PPPs have a very broad definition that contains the privatization continuing interest, privatization regulated, concession, PFI, Operation and Maintenance contracts, and management/service contracts (World Bank 2007).

In addition, according to Yescombe (2007), the nature of the transfer of risks between the private sector and public authority can also be a criterion of classifying PPPs. Under such a classification, a PPP project is regarded as Availability-based or Usage-based. In an Availability-based project, rather than take the expected usage of the facility into consideration, the private sector assumes the risk of having the constructed facility available for use; while in a Usage-based project, the usage risk of the facility is transferred to the private partner and correspondingly, the private partner is responsible for these risks. Generally speaking, Availability-based PPP are under the structure of PFI model; the Usage-based PPP are executed on the basis of Concession agreements (Pantelias 2009).

Finally, based on the legal position of the private sector involved in the project, the PPPs can be classified into various categories (Li and Akintoye 2003; Yescombe 2011), such as Build-Own-Operate-Transfer (BOOT), Build-Operate-Transfer (BOT), Joint Ventures (JV) (Grimsey et al. 2004) and so on. This classification method defines clearly the point when the public authority should transfer the ownership of the facility to the private sector and the limits of the power, which reflects the nature of the contract. For

example, in a Build-Operate-Transfer project, the private party is responsible for financing, designing, constructing and operating the project within a certain period which has already been negotiated before signing the agreement (contract). Then the control of the ownership of the constructed facility is transferred to the public party free of liens and without any cost. Figure 1 presents a typical structure of BOT project in Hong Kong.



(Source: Kumaraswamy and Zhang 2001)

Figure 1. A general BOT project contractual arrangement structure in Hong Kong

2.4 Project finance

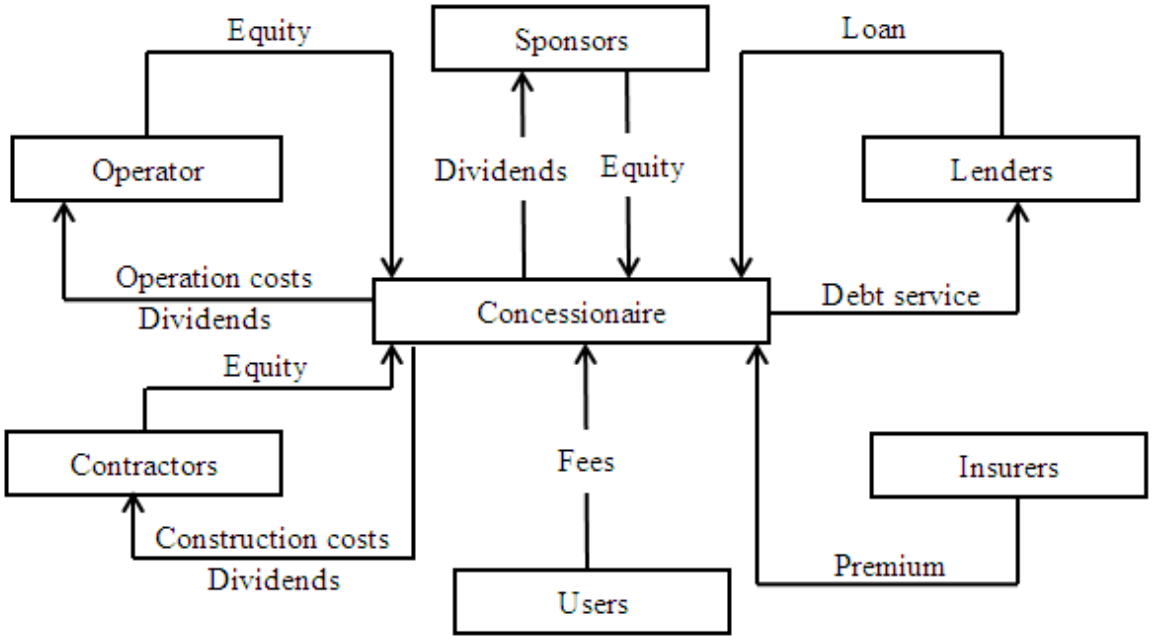
The terminology Project Finance (PF) is the situation in which the raised loan for the capital costs is paid back from the cash flow that is related to and achieved from the project (Asenova and Beck 2003). Instead of the traditional financing method where a project is financed by the public authority, the PPPs are funded based on the PF financing approach. Under a PF mode, most of the loans are raised subject to a non- (or limited) resource associated with the lender's resources being influenced only by the project's cash flows or/and the assets. One of the most principal characteristics is that the long-term project assets are financed with the corresponding long-term capital (Zakrzewski 1999; Carrick 2000).

According to Pantelias (2009), there is more than one single way to raise the necessary capital for a PPP project. In fact, the capital is raised through a combination of

different available financing options, such as commercial lending in the form of bank debt, bonds, mezzanine debt, leasing, and mortgage financing. Among these options, the senior bank debt is used most commonly while the other sources present an increasing trend as a form of PPP project financing (Sapte 1997; Ellis 1999; Pickering 1999). The proportion of the developers' or sponsors' equity is usually 10 percent to 15 percent (sometimes larger than 15 percent) of the total capital, which is required as a guarantee for them to implement the project successfully. Moreover, as the development of the financial markets recently, the equity invested in the PPP project is no longer only from the business companies involved (such as contractors), but also from a diversity of other sources that are pursuing low risk associated with long-term investment based on the revenues and operation profits from the project. The selection of financing method for a specific project is based on the project's particular requirements, the amount of the equities that is available, the risks in the partnership, and the perceived quality of the corporation (Asenova and Beck 2003).

2.5 Finance Flows

As mentioned previously, the necessary capital for a PPP project is raised on the basis of a combination of different financing options. More specifically, take the concession agreements in which the concessionaire is responsible to generate a viable, reliable and profitable financing plan to attract and ensure the essential funds to construct and operate the facility as an example, the funds are raised through the concessionaire's own capital associated with loans from senior banks, other large financial institutions and individual investors (Xenidis and Angelides 2005). It is a highly complicated process to structure the financing scheme of the project because during this period certain different contracts and agreements are signed. The contracts are usually comprised of an operation and supply contract, an off-take contract, and an insurance contract while the agreements include stakeholder agreements, insurance and loan insurance (Xenidis and Angelides 2005). These contracts and agreements are formed and signed to ensure two objectives: the investment profitability for all the stakeholders involved and the generation and operation of the basic financial flow. There are transactions and transformation of the money and authority between different parties when they sign the contracts or agreements, therefore, the financial flow of a project is generated. Figure 2 presents one typical BOT project financial flow among different sectors involved.



(Source: United Nations Industrial Development 1996)

Figure 2. One BOT PPP project financial flows

It can be seen from Figure 2 that there are many procedures involved in order to implement the project. As is known, there are risks in a certain process or procedure according to the characteristics of uncertainty. Therefore, how to identify and allocate these risks becomes the crucial important factor for a PPP project (Wang et al. 2004).

2.6 General Introduction to Risks in PPPs

As illustrated in the previous paragraph, it is of great significance to identify and allocate the risks in a PPP project. The Royal Society gave a definition of the risk in 1991 that risk is the probability that a particular unexpected event occurs within a certain period of time (Royal Society 1991). This definition has been preferred over others since it incorporates three essential risk elements: the opportunity of occurrence, unpredictable and unexpected influence, and the duration of exposure (Edwards and Bowen 2003).

There are uncertainties through the whole procedure (make a decision, carry out the contract, operate and manage the facility.) of a PPP project and risks occur due to the characteristics of uncertainties. These risks, commonly known as “project risks”, can be the obstacle for all the parties, hindering the reaching of their financial goals. There are different origins of the risks which are related to different stages of the PPP project’s life cycle, resulting in different classifications (Pantelias 2009).

A very traditional classification of the risks is that it distinguishes them into external and internal depending on the sources of origin whether the risks came from inside the project or not (Songer et al. 1997). Another classification conducted by the United Nations Industrial Development Organization (UNIDO) is that the risks are grouped into General

(Country) risks and Specific risks. General risks are more related to the country's financial environment, law and political level while the specific risks concerns more about the risks generated from the project. In more detail, general risks can be subdivided into political risk, legal risk and commercial risks while specific risks consist of developmental risk, completion (construction) risk, operation risk and management risk (Thomas and Akintoye 2003; Jeon and Amekudzi 2006). Furthermore, risks can be categorized with project phases, including development risk, construction risk, operation risk and ongoing risks (Beidleman et al. 1990; Garnett 1992; Songer et al. 1997). Other classification methods are also available through a variety of literature and articles (Ashley et al. 1998; Edwards and Bowen 2003; El-Diraby and Gill 2006).

This section only introduces some generalized information (definition and classification) on the risks in PPP projects. More detailed discussions regarding risks (definition of different specified risks, financial and investment risk, allocation of the risks) are presented in the Chapter 4.

2.7 Value for Money (VfM) and Financial Viability of PPP Projects

According to the Business Dictionary, value for money (VfM) is a utility derived from each consumption (transaction) or amount of money spent in order to receive services and/or goods. VfM is based not only on the purchase price, but also on the effectiveness and efficiency (or the benefit/cost ratio) of the purchase (Business Dictionary 2013). The higher the benefit/cost ratio, the worthier the money is paid and the better value for money is. PPP projects are expected to offer all the stakeholders involved value for money. Consequently, whether the project can fulfill the certain financial targets (VfM) of different stakeholders becomes a measurement of the financial viability of a project (Pantelias 2009). As presented previously, there are various stakeholders with different financial targets and perspectives. Therefore, the meaning of project financial viability differs within the stakeholders. There are three parties whose benefits have to be balanced in order to successfully implement and operate the facility. These three parties are: public sector (authority), the lenders and the equity investors (Pantelias 2009).

From the perspective of the public authority, social welfare associated with VfM is the first priority. Therefore, the financial viability is usually equivalent to enhancing social welfare due to project fulfillment and obtaining the best VfM (Yescombe 2011). Whether a project deserves pursuing becomes the key issue for the public party decision makers. In order to justify the project and make a correct decision, the decision makers conduct cost-benefit analysis and/or analyze the economic revenue (together with externalities) before approving the project. Based on this point of view, the focus is synonymous with guaranteeing the affordability and best VfM, which is solved by conducting comparative research and analyses. A widely used method to deal with this problem is the application of the Public Sector Comparator (PSC) (Pantelias 2009). However, there are cases where there is no alternative public party to compare the PPP project to, leading to a situation where if a project is not operated as a PPP it will almost not to be procured at all. Consequently, the public party always desires to obtain the best VfM by ensuring that it is

reasonable and cost-effective to transfer the risks between different sectors involved in the project and by inspiring effective competition during the bidding stage (Pantelias 2009).

From the perspective of the lenders, the interest for a project relies on the total revenue and cost during the project's operation phase and is influenced by the repayment of the issued debt. In this point of view, the positive cash flows of profitability until the time all loans are paid off (the end of the operation stage) together with the accomplishment of certain Cover Ratio (CR) become the focus of the financial viability. CR is used to ensure the project is capable of repaying the issued debt when it comes due. Among various CRs in use, two of the most widely applied CRs are the Loan-Life Cover Ratio (LLCR) and the Annual Debt-Service Cover Ratio (ADSCR). The ADSCR is calculated annually to evaluate whether the project has the ability to repay the debt from its annual cash flow while the LLCR works as a measurement to assess the project company's capability to pay back the debt over the whole term (Yescombe 2011). The lenders regularly have a minimum acceptable CR based on the investment risk and it must be satisfied at all times in order to finally finance the project. The required LLCR is usually 10 percent higher than the ADSCR. As a matter of fact, since it measures the capability of clearing off the debt as it comes due, ADSCR is used as a more favorable alternative. Moreover, due to the fact that the lenders always have the first priority on the project's revenue, CRs can reflect the debt's actual influence (ratio of total debt to equity) on the project and to a greater extend, CRs are able to determine the fulfillment of the return on the investment for the equity investors (Pantelias 2009).

At last, from the perspective of the equity investor, the financial viability depends on the net profitability (especially after the issued debts have been paid off) of the PPP project. According to Pantelias (2009), the equity investors are the last priority in the PPP financing chain while they are the first ones that are likely to suffer from the potential losses. Equity investors measure their financial viability through various methods, such as Internal Rate of Return (IRR), Return On Investment (ROI), Return On Equity (ROE). These measurements can evaluate the efficiency of the investor's investment and assess the project's profitability by revealing the profit the project generates with the money invested. The equity investors usually have their particularly desired minimum profit of the investment before signing the agreement. For example, the investors aim to earn profits with a ROI of 15 to 20 percent in most cases (Menheere and Pollalis 1996). The equity investor will lose interest in the project and will not make any investment if the project cannot generate the minimum profit required by the investors.

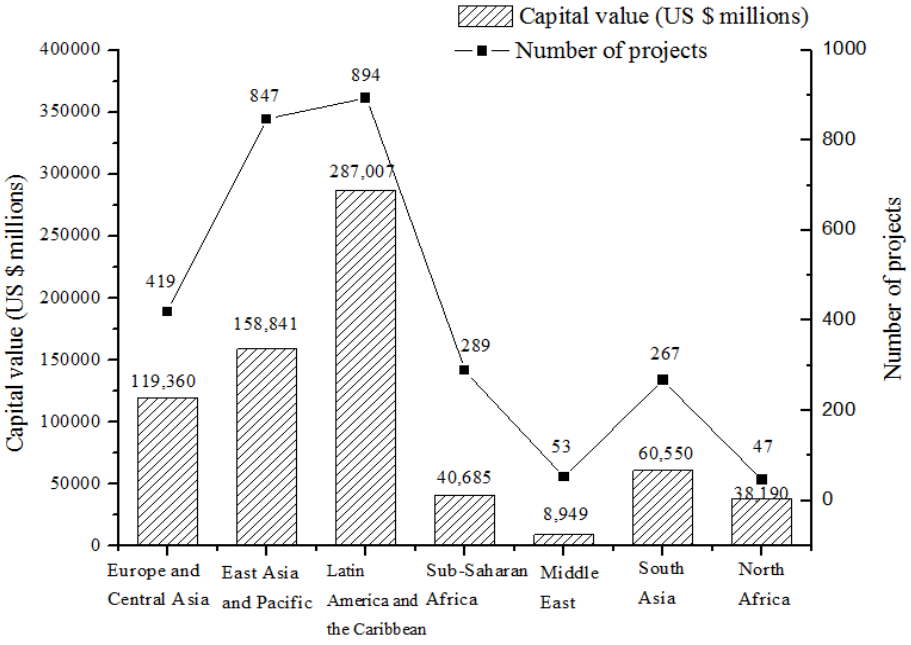
2.8 Summary

In this chapter, findings from the literature review on the basic concepts of the Public Private Partnerships (PPPs) are presented. First, the definition of the PPPs is illustrated, followed by the five main features and classifications of PPPs. Then, the project finance associated with the finance flow is introduced. Based on these basic definitions and concepts, generalized information on risks in PPPs is presented with an emphasis on various classification standards and the corresponding risks. Finally, the chapter ends with the concept of Value for Money (VfM) and the financial viability of the PPP project. The

financial viability is discussed from the perspective of the main three parties (public authority, the lenders and the equity investor) involved in the project respectively.

3. PPPS IN DEVELOPED COUNTRIES AND DEVELOPING COUNTRIES

Public Private Partnerships (PPPs) have been more and more widely used all over the world during the last several decades, serving as an innovative financing mechanism for the public sector (Rall et al. 2010). This has changed the infrastructure construction provision slowly but steadily. However, due to the different modernization degrees of the countries, the severity of the challenges faced and the government flexibility to accommodate PPP's, leading to a situation in which the development of the PPP is faster in some parts of the world while slower in others. The way different countries perform a PPP project also varies. Based on the World Bank PPI Project Database, Figure 3 illustrates a statistical graph of the number and value of private participation in infrastructure by region from 1996 to 2006.



(Source: World Bank PPI Project Database)

Figure 3. Number and value of private participation in infrastructure projects, 1996-2006

As can be seen from Figure 3, both the number of projects and the total capital are very different among different regions. The largest number of projects is 894 with a total capital of 287,007 million dollars in Latin America and the Caribbean regions while the smallest number of projects is only 53 with a total capital value of 8,949 million dollars in the Middle East region. This is because each country in the region has its own characteristics in the development of economy, policies on the PPP project, the legal framework, ways to attractive financing and public acceptance of PPPs, or even sometimes the religion can also be a factor. This chapter presents the PPP in both developed countries

(regions) and developing countries (regions), providing an in-sight angle to have a better understanding of the PPP globally.

3.1 PPPs in developed countries (areas)

3.1.1 PPPs IN THE UNITED KINGDOM (UK)

PPP in the UK covers a wide range of both partnership arrangements and business structures, from the PFI contract to concession agreements and joint ventures, and even trades of equity stakes in public-owned businesses (Li and Akintoye 2003). The terminology Public Private Partnerships (PPPs) was initially referred to as the Private Finance Initiative (PFI). The first appearance of PFI in the UK was in 1992, when the government of John Major in the UK introduced it to the public. The original goal of PFI was to reduce the public authority borrowing requirement (Connolly and Wall 2011). It focused on the participation of private parties (individuals or companies) in infrastructure projects which were originally sponsored by public authorities (e.g., the government departments) (Beck and Hunter 2003). At first, the UK government expected that by the budget year 1996/1997, nearly a quarter of the Government's capital investment, which was a total amount of 10 billion pounds, should be financed through PFI. However, the results were disappointing as only 500 million pounds were financed from the PFI projects by the budget year 1993/1994 (Harding et al. 2000).

The government analyzed the reasons why there were so few private sectors involvements in PFI and found that the lack of legal framework for the procedure and shortness in expertise were the key reasons. The private sector felt that risks were too large to invest in PFI projects. As a response, Local Authority (LA) associations set up the Public-private Partnership Program Limited in 1996 to support and encourage partnership arrangements (Beck and Hunter 2003). Although a lot of work had been done, the effects were still not significant. Only one LA signed a PFI contract by the time of the 1997 election (Harding et al. 2000). When the new government came into power in 1997, a number of initiatives were adopted to expedite LA participation in PFI. In December 1997, the Local Government (Contracts) Act, which was enacted by the New Labor administration, came into force to eliminate obstacles to local private sector participation in PFI. The Local Government (Contracts) Act expanded the LAs' authority by clarifying the powers and the functions of LAs to participate in long-term service contracts with the private party. Furthermore, the Act stipulated the compensation of the private partners in the cases where the contract was set aside. Despite the expansion of the LAs' authority with respect to PFI, the government still kept significant control over the LA-PFI activities (Beck and Hunter 2003). Moreover, a number of public departments promoted these initiatives. As a result, 30 pioneer projects were announced in 1997, including all kinds of urban services ranging from social services, to schools and libraries (Harding et al. 2000). It was also reported that by mid October 1998, there were 79 local authorities involved in 184 projects. Among all the LA-PFI projects, education-related projects were most prevalent (29 percent), followed by transportation projects (15 percent), administrative/public buildings (15 percent), housing (11 percent) and IT (9 percent)

(Akintoye et al. 1999). In April 1998, the New Deal for Schools (NDS) facilitated over 220 schools with a total capital value of 200 million pounds (DfEE 1999). As a consequence, by the end of 1998, over 70 schools had already been scheduled to be restored or rehabilitated under a PFI contract (Li and Akintoye 2003).

In addition to education, PPPs have also been widely applied in the UK's National Health Service (NHS). The Major PPP pattern in the NHS is typically Design-Build-Finance-Operate style, where the facilities are owned by the private sector during a concession period of 25-40 years and the NHS makes annual payments to the private sector for the facility usage. Unlike other government infrastructure services, each PFI hospital (hospital under a PFI contract) has its own limited budget to pay off the fees, which makes the project reliable and trusty to the private sector (Grimsey and Graham 1997). It clearly defines in the contract that the responsibilities of the private sector are: designing the facilities based on the requirements of the NHS; building the facilities within a fixed time and cost; raising the capital cost; and operating the facility along with providing maintenance and other support services (NHS 1999). Since the private sector undertakes the risks that are borne by the public authority, the NHS rules (1999) also require that the public authority must supply adequate value for money expected by the private sector.

Today, there has been significant development of the PPP and it is now composed of several models. The UK government authorizes eight different types of PPP models to the public as shown in Table 3.1 (HM Treasury 2000). In practice, there are no absolute boundaries of each model and sometimes there is overlap of the models, with a certain PPP project belonging to more than one category. Among these models, the aforementioned private finance initiative (PFI) is the best known approach to attracting the private sector to make project investments.

Table 3.1 Eight PPP models in the UK

Model	Definition
Asset sales	The sale of surplus public party assets
Joint ventures	The partnerships in order to achieve long-term development in value for both sectors, the public and private parties pool their assets and finance in a joint management way
Partnership companies	Introducing private party ownership into public-owned business, while at the same time keeping the public interest and policy objectives with the help of rules, regulation, legislation or retention by the government of a special share
Partnership investments	The partnerships where the public authority makes a contribution to the financing of the investment projects by private sectors, to ensure that the public authority can share the profits generated by the investments
Policy partnerships	Arrangements in which the private parties or individuals take part in the development and implementation of policy
Private finance initiative	The public authority signs long-term contracts with the private sector to purchase quality services, with defined conditions, including the risks, maintaining or constructing the necessary facility; the term also contains financially free-standing projects in which the private sector designs, finances, constructs and operates an asset
Sales of business	The flotation or trade sale of shares in state-owned business, with the sale of a minority or majority stake
Wider markets	Introducing the skills, technology, finance and advantage of the private party to help the public authority make better use of their assets both physically and intellectually

Source: HM Treasury, 2000.

PPP is now serving as a key component in providing modern and high quality infrastructure services in the UK and helps to make the UK more competitive around the world (HM Treasury 2000).

3.1.2 PPPS IN THE UNITED STATES (US)

In recent years, the U.S. is at the front row to apply PPPs to address the problem caused by the increasing demand for infrastructure services and the insufficient available budget from the public authorities. PPPs are now widely used at different levels of U.S. governments, such as local government, state, and the federal, which have highly improved the quality and cost-effectiveness of government services (Smith 2003).

Beginning in the 1970s, most of the PPP experience is composed of two major categories: one is government services contracts; the other is infrastructure partnerships, where the private party is responsible for designing, financing, constructing, operating and maintaining (in some cases) the infrastructure based on the requirements from the public

authority (Smith 2003). The success of the partnership highly depends on the detailed contract or transactions selected.

According to Kanter (1999), there are some leading companies participating in the social sector in the US, including projects in public schools, city rehabilitation and public welfare programs. For example, Bell Atlantic offered computer networks to the schools in Union City; the Bank of Boston launched the Community Bank program (Kanter 1999). Another application of PPP arrangements is public buildings. In 1999, the Modesto reconstruction project was completed which included a plaza, a garage and a county administrative building (Li and Akintoye 2003). Martin (1996) reported that there were thousands of housing units developed as PPP projects in Dade County, Florida, generating a system where public-owned housing properties were separately managed by the private sector, while keeping the social responsibilities of the public authority (Martin 1996).

In terms of transportation infrastructure, PPPs have been implemented successfully in the U.S. (Chan et al. 2010). There have been large numbers of successful transportation infrastructure PPP projects since the beginning of the application of PPPs, such as the Illinois Central Railroad, the Interstate Highway System, the New York City Subway, and the SR 91 express lanes in California (Garvin 2007). Among all the PPP projects, two of them draw more attention due to the length of the lease agreements with the foreign private sector company. One of them is the Chicago Skyway which has a 99-year lease; the other one is the Indiana Tollway with a lease agreement of 75 years (Papajohn et al. 2011). Since PPP is still regarded as a relatively new concept in U.S. transportation infrastructure projects, the application of PPPs varies from state to state. In 2011, a survey was conducted to identify the current practice of transportation PPPs in the U.S. Based on the feedback from the state transportation planning engineers, Table 3.2 shows different states' experience with PPPs in the U.S. (Papajohn et al. 2011).

Table 3.2 Different States' experience with Transportation PPPs in the US

State-of-experience	States
Experienced	California, Connecticut, Florida, Minnesota, South Carolina, Texas, Virginia
Currently practicing	Colorado, Nevada, Washington
Plans to implement	Arizona, Illinois, Kansas, Kentucky, Louisiana, Michigan, Missouri, Mississippi, North Carolina, New York, Pennsylvania, Tennessee, Vermont, West Virginia
Does not plan to implement	Montana, North Dakota, Oregon, South Dakota, Utah, Wisconsin, Wyoming

Source: (Papajohn et al. 2011)

From Table 3.2, it can be observed that seven states have transportation PPPs; three states are currently practicing transportation PPPs; 14 states plans to implement the new approach; while seven states do not plan to implement. Other states are deemed as not applicable in this case because no feedback is received from the state transportation engineers. Among the 14 states that plan to implement PPPs, five of them have already had

PPP legislation, eight of them do not have PPP legislation yet and one state has a bill in process. Moreover, PPPs have successfully helped 90 percent (9 out of 10, except Washington) of the states to achieve their objectives. In these states, the application of PPPs in transportation projects allows them to remain under the limited budget and within the time schedule. Also, nearly half of the states (47 percent) plan to implement PPPs in the future, showing the high acceptance of PPPs. The main reason cited by those states that not plan to implement PPPs is that traffic volume is relatively low (Papajohn et al. 2011). This survey was conducted in 2011 and there might be some changes for today. However, it is no doubt that transportation PPPs benefit the states and more and more states are accepting PPPs as a new approach.

According to the Federal Highway Administration (FHWA), the most 3 common types of PPPs used in the U.S. are Design-Build-Finance-Operate projects, Long-term lease projects and the predevelopment arrangements. The state engineers from all experience levels point out the reason of adopting PPP. Financing becomes the major reason followed by cost and time savings and work force savings (Papajohn et al. 2011).

In addition, there are some laws and regulations that support the application of PPPs in the U.S. In 1991, special legislation was enacted by the Commonwealth of Massachusetts to allow Plymouth County to sign long-term contracts for correctional facilities to house public inmates. This legislation exempted project-related cost from state bidding (Bloomfield et al. 1998). In 1998, Senator Bob Graham introduced the Public Schools Partnership (PSP) Act to amend the federal tax code to authorize the utility of tax-exempt private bonds to construct the school facilities which are privately owned, and then the private sector could lease the facilities back to the public authority. This PSP Act worked as the basis of a legislative plan that promotes the application of PPP's, which can build public facilities more rapidly and more cost-effectively (Utt 1999). In 1985, the National Council for Public-Private Partnership was founded to offer a forum for ideas and innovators in the PPP area. The U.S. Department of Transportation (U.S. DOT) also took actions to push U.S transportation toward a PPP model, including investing in tolling research, providing tax-exempt bonds for PPPs, easing government restrictions against PPP's (Layton and Hsu 2008). The FHWA identified 28 key elements to help states enact PPP legislation, involving the use of Transportation Infrastructure Finance and Innovation Act (TIFIA) loans, issue of bonds or notes, and the preservation of tolls after the debt is paid (U.S.DOT 2007). Based on these promotions, Arizona passed H.B. 2396 to permit a legal framework for application of PPPs (Holstege 2009; Horner 2009). In 2009, California licensed Caltrans and regional transportation agencies to participate in PPP contracts without the need for extra state legislative approval (Milbank 2009). According to Fisherman (2009), over 80 percent of the US states have legislation allowing PPP contracts (Fishman 2009). The legislation assists to attract funding from private equity and facilitate development of transportation PPP's

Furthermore, compared with other countries, the U.S. is leading in the managed competition. In order to achieve the most cost-effective service, the U.S. government organized the managed competition in which the private parties compete with public sector. This business management tool associated with its implementation and legislation guides, which was originally issued by the Office of Management and Budget (OMB) Circular A-

76 in 1966, has served the US for 47 years, making significant contributions to PPP development. The basic process of managed competition is shown in Figure 4 (U.S. General Accounting Office 2000).

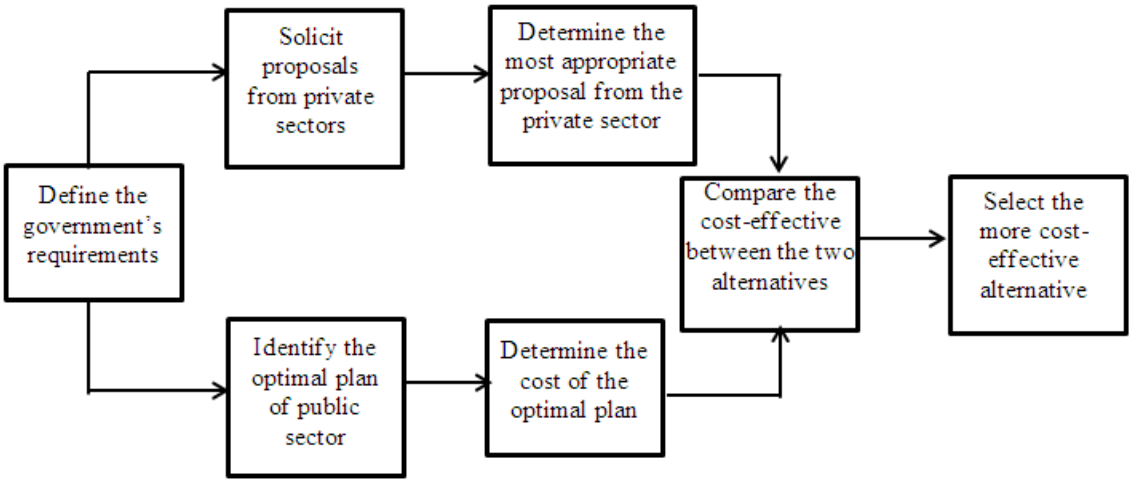


Figure 4. The basic process of managed competition in the US

3.1.3 PPPs IN AUSTRALIA

Australia also performs an excellent role in applying PPPs. PPPs have been mainly applied in the infrastructure sectors to help supplement public cost and expertise in Australia (Dahdal 2010). The application of PPP's in Australia can be divided into two stages: pre-2000 and post-2000. The year 2000 is marked as a milestone year in Australia PPP development when the Victorian Department of Treasury and Finance established the Partnership Victoria. This is a significant reform in PPP development and implementation in Australia. On one hand, the terminology "public-private partnership" was first officially adopted to cover a range of hybrid PPP models which had previously been used. Before 2000, the most common PPP models in Australia were the build-own-operate-transfer model and the build-own-operate model, but they were separately identified. On the other hand, the Victorian Government started to develop a series of comprehensive PPP mechanisms based on the Private Finance Initiative (PFI) model from the UK. The mechanism established procedures to control the PPP pre-contractual decision making stage which resulted in the signing of the contract and monitoring in the construction and operation stages (English 2006). Policies on PPPs in other Australia states followed the Victorian policies. As a result, in 2005, all the State Governments and the federal authority officially came into agreement to harmonize their approach toward PPP implementation and development (Hughes et al. 2005).

PPPs have been widely applied in Australia to deliver projects in transportation, schools, sporting facilities, utilities, and other infrastructure (English 2006). In 2000, The Victorian Government applied a privately operated model to finance a range of projects that were traditionally financed by the public, such as hospitals and corrective services (Dahdal 2010). By the year 2006, there were a number of 127 PPP projects with a total cost

of 35.6 billion dollars that had been initiated in Australia. According to English (2006), the Victoria state was leading in Australia in both PPP projects and the total capital cost, followed by New South Wales. There were 49 PPP projects (38.6 percent of the total) with 14 billion dollars (39.4 percent of the total financing) located in Victoria; while 30 PPP projects (23.6 percent of the total) with 10.6 billion dollars (29.7 percent of the total financing) situated in New South Wales (English 2006). The annual capital cost on PPPs in New South Wales took up 11 percent of all the capital cost and was expected to remain between 10 percent to 15 percent (Phibbs 2008). Table 3.3 presents the distribution of PPP project numbers and capital cost percentage in infrastructure services in Australia.

Table 3.3 Distribution of PPP projects numbers and capital cost percentage in different infrastructure services in Australia (English 2006)

Infrastructure Service	Number of PPP projects	Percentage of total capital cost (percent)
Water Projects	22	17
Correctional Projects	13	4.4
Health Projects	12	7.5
Transportation Projects	12	33

From Table 3.3, it can be observed that water projects are the largest number (22), followed by correction projects (13), health projects (12) and transportation projects (12). In terms of total capital cost the order is transportation projects (33 percent), water projects (17 percent), health projects (7.5 percent) and correctional projects (4.4 percent). Despite comprising only 12 (one-tenth) of the total number of projects, transportation related projects are dominant among Australian PPP's because they account for 33 percent (one-third) of all the capital costs on PPP projects.

During the last 10 to 15 years, the development of PPPs is Australia has been significant. PPP is serving as both a financing approach and a cost-effective alternative model for the public authorities with a number of successful applications, making it one of the leading countries in PPP utilization all over the world.

3.2 PPPs in developing countries (areas)

3.2.1 PPPs IN CHINA

Since the mid-1990s, with China's flourishing economy, the demands for public services and infrastructures have been drastically increasing, leading to a situation where the public service offered by the government is insufficient. At the same time, the Public-Private Partnerships (PPPs) have been adopted in many industrialized and developed countries. The Chinese government noticed the significance of PPPs in delivering public

services and introduced this feasible framework to China in recent years (Liu and Yamamoto 2009).

Due to the development of the economy, people's demand for public infrastructure in China keeps increasing. However, public infrastructure in China is offered by the government who takes full responsibility to finance, construct, operate and maintain the infrastructure facilities. Because of the increasing demands and speedy urbanization, the government does not have enough human resources and funding to satisfy the needs, even including the traditional method of borrowing money from banks. A new cost-effective and feasible approach is needed to solve this problem.

In 1999, a training course was held to discuss international cooperation with Local Agendas 21 (an administrative government organization) in China. During the course, the Administrative Center for China's Agenda 21 (ACCA21) first introduced the concept of PPP model to the 16 Chinese regional representatives (Liu and Yamamoto 2009). This was the first time that the term PPP was introduced to China and in June 1999, another tripartite meeting was held in Beijing to address the conceptual framework of PPP. The Ministry of Science and Technology (MST) of China together with the State Development Planning Commission (SDPC) expressed their opinions to support PPPs in China. As a result, Beijing agreed to apply the PPP model to its on-going Capital 21 Program. From then on, more and more public departments in China realized the importance of PPPs. The Ministry of Education (MOE) and the Ministry of Finance (MOF) cooperated with some international organizations to implement PPP schedule in China's public services (Liu and Yamamoto 2009). In 2003, China Center of Public-Private Partnerships (CCPPPs) was founded in Beijing, which later published reports about the influence of PPP models on public infrastructure reforms. In 2005, the China Public-Private Partnership Forum was held in Beijing. A number of experts from developed countries, such as the U.S. and Australia, as well as international institutions like the World Bank gathered together to share their experience with PPPs and how to apply the PPP model to China's infrastructure service. Slowly but steadily, PPPs are becoming more and more active in delivering public services in China.

The most common PPP model used in China is the BOT model. There are PPP projects in environmental infrastructure, road-building, power plant construction and water treatment (Wang et al. 2000; Qiao et al. 2001; Sachs et al. 2007). In addition, PPP played an important role in constructing the Olympic sport sites when Beijing held the Olympic Games in 2008. Among all the PPP projects, the most typical one is the Laibin B Power Plant built in Guangxi Province. This project was financed through an international bidding process and became a successful PPP example in China (Sachs et al. 2007).

In the transportation infrastructure area, from 2002 to 2004, 20.2 billion dollars (163.3 billion RMB) were invested in Beijing. Due to the Olympic Games held in 2008, there were a large number of construction projects to be implemented, including the Olympic-reserved venues. As a result, an additional 39.51 billion dollars (320 billion RMB) were invested by the year 2008. However, at the same time, the Beijing government had only 9.19 billion dollars (74.4 billion RMB) available to invest. The funding was far from what was needed. The government was in search of funding and PPP solved this problem appropriately. The Chinese private sector together with foreign companies were

involved in the projects to deliver public service in China. For example, in Beijing's No. 4 Subway project, the estimated cost was 1.82 billion dollars (15.1 billion RMB). The Hong Kong Mass Transit Railway (HKMTR) invested 741 million dollars (6 billion RMB). The other investor, the Beijing Capital Group also offered to conduct this project. Finally, Hong Kong MTR, BCG and Beijing Government signed the Beijing No. 4 Subway Concession Agreement, which required that the concessionaire was responsible for construction, operation and management. On the other hand, the concessionaire would be paid through ticket sale revenue. By the end of the concession agreement, all the facilities would be returned to the No.4 Line Company which is a public authority (Chai 2005). In 2009, Beijing No. 4 Subway was open to the public. It turned out to be a successful PPP project and has been serving the public since then.

Today, China's economy is still developing at a very rapid pace. The needs for public infrastructure service keep increasing. As an innovative approach to facilitating, the benefit of PPP is obvious. More and more public authorities realize the significance and feasibility of PPP in public infrastructure projects. Although the concept of PPP is new to China and the understanding of PPP schemes remains limited in both government circles and the academic area, the future for PPP in China is bright (Liu and Yamamoto 2009).

3.2.2 PPPs IN INDIA

India is another developing country that has a huge construction market. The economic development has a steady improvement in India. As early as the 1950s, Five-Year Plans were initiated to develop the economy and industrialize the country. The industrial growth and production had an impressive range of 3 percent to 4 percent of GDP per year during that period (Sarangi 2002). In 1991, the liberalization process was introduced into India. A higher industrial economic growth rate with 7 to 8 percent per year was generated. In order to catch up with the industrialized countries as soon as possible, many other policies and regulations were issued. Since then, there has been a remarkable improvement in India's economic development (Sarangi 2002). The total GDP of India has reached 1,816 billion dollars in 2012.

As in China, India's rapid economic development has resulted in increasing demand for public infrastructure. Due to the low urbanization and poor infrastructure situation in India, the need for public infrastructure service is urgent and the government alone cannot raise enough capital for all the projects. It is crucial for the Indian government to find new methods to attract more capital to be invested in the projects. According to Sarangi (2002), the Indian government has tried different ways and models to solve this funding problem in infrastructure construction, but none of them worked (Sarangi 2002). Under these circumstances, the public-private partnership was introduced and applied in India.

Earlier application of PPPs in India was part of the "Mega City" in fiscal year 1994 to 1995, which was under the eighth Five Year Plan (Sarangi 2002). In that project, a total capital of 6.5 million dollars (Rs. 400 million) was shared equally by the public authorities and the private sector. However, due to the lack of experience and absence of a PPP mechanism, the private sector lost interest in extending the financing assistance in the

project and the early attempts at PPP was not so successful. This situation came to a turning point in 2000. With more and more experience accumulated, the Indian government has established initiatives on operating and industrializing the PPP policy to help accelerate infrastructure development since 2000 (Priya and Jesintha 2011). These actions effectively popularized the application in India and as a result, a total number of 20 states in India have engaged in 300 PPP projects (Priya and Jesintha 2011).

According to the PPP India database (2011), there are total of 300 PPP projects with a sum of 22.2 billion US dollars (Rs. 135,876 crores) in 20 states. Among all the states, Maharashtra is in the first place in terms of the total contract value (Rs. 31140.8 crores, which is equal to 5.1 billion dollars); Rajasthan leads with respect to the number of projects (37 projects), followed by Andhra Pradesh (36 projects), Karnataka (28 projects) and Tamil Nadu (26 projects). It is also noteworthy that 93 percent of the projects (278 projects) are financed by the Indian domestic private sector and foreign companies and institutions cover the other 7 percent (22 projects). Furthermore, the domestic private sector contributed to the PPP projects with an investment of 21.9 billion US dollars (Rs. 134,145.57 crores), which is 98.7 percent of the total while the foreign private sector only provided 281 million dollars (Rs. 1,725.85 crores), which is just 1.3 percent of the total project cost. In addition, the leading domestic PPP project investors in India are the Larsen & Toubro Company and Malaysian companies (Priya and Jesintha 2011).

There are five major types of PPP's applied in India, namely lease contract, Build-Operate-Transfer (BOT), Build-Operate-Own-Transfer (BOOT), Build-Operate-Own (BOO) and Build-Operate-Lease-Transfer (BOLT) (Sarangi 2002). These PPP models, regarded as innovative and cost-effective approaches to delivering public infrastructure services, have been used in a variety of areas in India, including transportation, urban infrastructure, ports, tourism and power plants. Based on information from the PPP India database, Table 3.4 shows the distribution of PPP projects and project value in India.

Table 3.4 Distribution of PPP projects numbers and project value in different infrastructure services in India

Infrastructure service	Number of projects	Project value (US dollars)
Airports	6	3.3 billion
Energy	32	2.9 billion
Ports	38	7.0 billion
Railways	3	164.4 million
Roads	186	7.8 billion
Urban development	35	1.0 billion

Source: www.pppindiadatabase.com

It can be observed from Table 3.4 that transportation-related projects dominate in both the number and total project value, covering over 65 percent of the projects in number and 38 percent in the investment value. The National Highways Authority of India (NHAI) invested 77 private sector projects. Due to India's special geographic location, there are a large number of port construction projects (38 projects with 7 billion dollars). Most of the

projects are in BOT or BOOT models and the private sector is selected through a bidding process with both domestic and international competitors (Priya and Jesintha 2011).

The Indian government has realized the importance of PPP models to the delivery of public infrastructure service. The finance Minister has claimed that there will be an increase in funding to implement PPP projects. Also, the chairman of NHAI, Shri Brijeshwar, said that there would be more than 100 PPP projects worth 16 billion dollars as part of their work plan in the next three years. More necessary actions will be made to attract both foreign and domestic investors. Although India's experience with PPP is inadequate compared with developed and industrialized countries, it is definitely true that India is a potential and promising market for PPP models.

3.2.3 PPPs IN AFRICA – WITH SPECIAL REFERENCE TO SOUTH AFRICA

Africa is a continent that has its own strong characteristics. The natural resources in Africa are very rich but the African people are poor. Africa is deemed as the poorest inhabited land in the world. The public infrastructure situation (such as highways, hospitals, education infrastructure and power plant) falls far behind the world's average level. However, with the help of the United Nations and other countries, African countries made great progress on economic development recently.

With the development of the economy, more and more public infrastructure services are needed. Due to the poor foundation of infrastructures in Africa, numerous basic construction projects are under construction or have been registered to be built. On the other hand, the African government cannot raise enough public capital for the projects because of the turbulent political environment and economic power (Li and Akintoye 2003). Under these circumstances, the public private partnerships (PPPs) were introduced to Africa and rapidly became an effective approach to help deliver public service.

An early attempt to apply PPPs was a water supply lease contract in Guinea (Lavigne 1995; Franceys 1997). In 1986, a ten-year leasing contract was signed between the Guinean National Water Company and a Guinean certified company. The private sector was paid by the user fees collected through the project (Franceys 1997). Franceys also reported a water management system project in Uganda, which was financed by a French Government grant. More importantly, this project paved the road for privatization in Uganda's water management system.

In Zimbabwe, the government initiated many actions to implement PPPs to increase local government service. An energy-environment management company invested capital and used its eco-environment technologies in a project to improve water and energy management of the Willowvale Industrial Park (Gidman et al. 1996). Botswana successfully applied PPP arrangements in exploiting its natural resources (Ball 1999). Ethiopia also utilized PPP models in one of its wastewater projects (Gentry and Fernandez 1997). In Cameroon, local communities conducted their own projects and asked help from foreign organizations. According to Tafah and Asondoh (2000), one PPP project in Cameroon, called the Niger Integrated Rural Development Project (NIRDP), received support and financial assistance from the Netherlands Development Organization and the European Union. These two organizations invested in the project to partnership with the

local public authority to provide a better public service to the Niger people (Tafah and Asondoh 2000).

South Africa is one of the most developed countries in Africa with relatively strong economic power. The South African government tried numerous approaches to address the tremendous public infrastructure service delivery demands from the public. Among these approaches, the PPP models worked as the most effective method (Rwelamila et al. 2003). In 1998, 7-year forecasts and a 3-year rolling spending plan were established. At the same year, the Municipal Infrastructure Investment Unit (MIIU) was set up by the South African National Government. MIIU is a non-profit organization aiming at providing grant funding and technical assistance to implement public services. With the help of the MIIU, the public authorities can obtain private sector investors and partnership together to provide the public services in a cost-effective way (Rwelamila et al. 2003). In order to build the legislation basis for PPP, Public Finance Management Act, Treasury Regulation for PPPs and Municipal Finance Management Act were established in 1999, 2000 and 2003 respectively (Gqoli 2006).

There have been many successful applications of PPP in South Africa in the area of hospital infrastructure service, education, toll roads and building construction. These projects include the Inkosi Albert Luthuli Hospital (2.1 billion dollars), Chapman's Peak Drive toll road (207.5 million dollars) and Free State social grants (119.9 million dollars). More major implemented PPP projects and details in South Africa are listed in Table 3.5.

Table 3.5 Major implemented PPP projects in South Africa

Project name	Value to government (US dollars)	Term (years)	Sign Date	Capital distribution
Inkosi Albert Luthuli Hospital	2.1 billion	15	Dec. 2001	• Equity 40 percent • Subcontract 40 percent
Chapman's Peak Drive toll road	207.5 million	30	May 2003	• Equity 30 percent • Construction subcontract 10 percent • Operation and maintenance subcontract 50 percent
Free State social grants	119.9 million	3	April 2004	• Equity 40 percent • Subcontract: o first year 30 percent o second year 35 percent o third year 45 percent
Department of Labour IT	690.1 million	10	Dec. 2002	• Equity 30 percent • Subcontract 25 percent
SAN Parks concessions	240.6 million	20	2001 to 2002	• Equity 20 percent • Subcontract 30 percent • 620 new jobs

Source: Gqoli 2006

From Table 3.5, it can be observed that all the major PPP projects were implemented from 2001 to 2004, during which time South Africa's economy had experienced a substantial growth. The public authorities benefited from these PPP projects in delivering the infrastructure services in many areas. As a result, more and more PPP projects were generated. By the year 2006, there were 72 PPP projects under construction. In addition, 51 more projects were registered to be conducted, including 9 projects related to the transportation area (Gqoli 2006).

Today, PPP is a very popular approach in both South Africa and many other African countries. Although there are a lot of challenges to deal with, these African countries have recognized that PPP is probably the most cost-effective way for them to deliver basic infrastructure services and move forward.

3.3 Differences between PPPs in developed countries and developing countries

The generalized information on the history and development of PPPs in major developed and developing countries is presented in the earlier sections. Due to different economic conditions and industrialization level, PPP characteristics vary in these countries. More specifically, the differences are:

First, it is straightforward to notice that the exposure time to PPPs is longer in developed countries; and the PPP is more systematic and mature. Developed countries are more experienced with PPPs than developing countries. Second, there have been sophisticated legislations and regulations to standardize the process of PPPs in developed countries. However, in developing countries, the PPP legislation and policy are not completed. There is even no legal guidance on PPPs in some African countries at all. The need and requirements for policy and legal reform remain urgent (Rwelamila et al. 2003). Third, developing countries are subject to more political and economic risks than developed countries. Furthermore, due to the immature economy and lack of national power, developing countries tend to experience more economic crises and have to work with immature financing systems. Fourth, the government credibility of developing countries is not as reliable as that of developed countries (Liu and Yamamoto 2009). The private investor will undertake more risks when making an investment in developing countries. Finally, developing countries need to deal with the problem of corruption. The phenomenon of corruption is more serious in developing countries, such as China and India, than in developed countries. In other words, to attract more PPP investments to developing countries, actions should be taken to enhance government credibility by curbing corruptions.

It is also noteworthy that in order to attract investors to make enough investments, there are some unique features of PPP's in developing countries. These features are different from the ordinary PPP scheme but can be applied effectively. For example, in some PPP projects, the South African Government has accepted some recommendations that when the private sector is in an agreement with an institution, although the private party functions as an institution, it does not have to accept the risks from the PPP project. The Government defines this form of agreement as a borrowing transaction, which is very

different from the agreements from the developed countries (Government of Gazette 2000). Also, there is a special PPP style generated in South Africa called build-operate-train-transfer (BOTT) model. This kind of model has not yet been used in any other countries. Moreover, in Africa, most of the private sectors in a PPP project are non-profit making organizations. In fact, it is donor entities that help fund the projects.

Although more and more developing countries are now recognizing PPPs as a cost-effective way for them to deliver public service and move forward, many obstacles remain to be overcome in order to implement PPPs successfully and narrow the gap between developing countries and developed countries.

3.4 Summary

This chapter presents background information on PPP practices around the world, including both developed countries and developing countries. More specifically, the history and development of PPPs in the UK, the U.S., Australia, China, India and Africa are introduced with special reference to transportation related projects. Comparisons between PPPs in developed countries and developing countries are also made subsequently, leading to the identification of five major differences.

4. RISKS ASSOCIATED WITH PPP PROJECTS

As discussed in Chapter 2, there are a wide range of stakeholders in a PPP project and the structure of the financing scheme is complicated, where several arrangements/agreements and contracts are formed and signed. Shen et al. (2006) pointed out that the PPP project would suffer more risks than other traditional project activities due to the different objectives and interests of the stakeholders associated with the projects. There are also risk transfers between different stakeholders during the whole process. These risks have close relationships with the viability of the PPP project. Therefore, the identification, quantification and allocation of the risks become crucially important for a PPP project (Shen et al. 2006).

4.1 Risk identification

Risk identification is a significant process for the PPP project because various risks are identified with their respective impact on the project. According to Yuan et al. (2008), there is a wide range of risk identification technologies, including Work Breakdown Structure-Risk Breakdown Structure (WBS-RBS) method, checklist method, flow charts method, and questionnaire and consultant of experts (Yuan et al. 2008).

4.1.1 RISK IDENTIFICATION THROUGH WBS-RBS METHOD

The term WBS stands for work breakdown structure and RBS represents risk breakdown structure. This method has been applied to identify the risks in an international construction project in Russia (Wirba et al. 1996). A work hierarchy tree and a risk hierarchy tree are established to structure the WBS-RBS matrix. Based on the intersection of this WBS-RBS matrix, events can be measured to identify risks in the project.

The first step of WBS-RBS method is to set up the risk hierarchy tree. As illustrated before, there are various classification methods to classify risks based on the criteria used. The most commonly applied method is to divide the risks into external and internal risks. In this way, the risks related to the external environment and those related to the management of internal resources are separated. Figure 5 presents the RBS for PPP projects (Yuan et al. 2008).

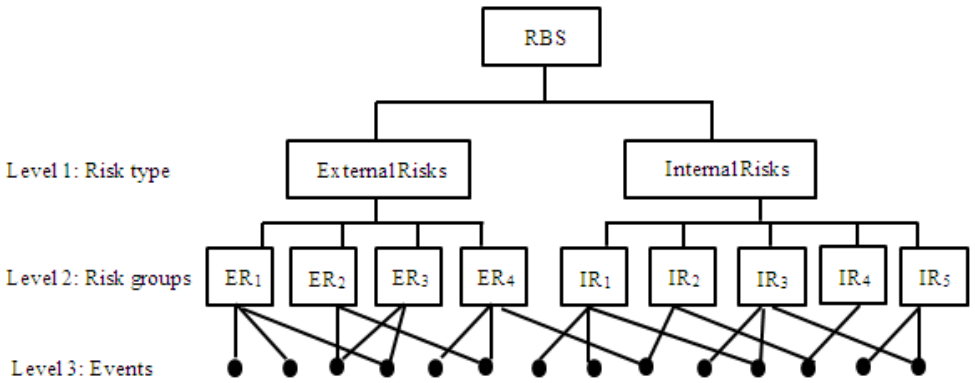


Figure 5. RBS for PPP projects

As can be seen from Figure 5, risks are classified into two types and each type is divided into different groups. For example, the external risks include political risks, legal risks and economic risks while the internal risks consist of financing risk, construction risk, and operation risk. These risks in level 2 are then related to one or more events in the projects. For instance, a construction cost overrun, may result from an increase in construction material costs (external risk), policy change (external risk), or conflicts between contractor and subcontractor (internal risk). Similarly, the work hierarchy tree is established based on previous research and case studies (Grimsey and Mervyn 2002; Li et al. 2005; Smith et al. 2000). The events in level 3 of Figure 5 come from the work hierarchy tree, which divides the project into stages and work packages.

Based on the risk hierarchy tree and work hierarchy tree, a form is developed with interconnection between the RBS and WBS, which generates a matrix. The elements of WBS are located in the rows while those from RBS are in the columns. In WBS-RBS matrix, WBS is used to define the work package and scope, while the function of RBS is to reflect the structure and the hierarchy of the risks effectively. By seeking the risks in work package and identifying the interconnection of WBS and RBS, the checklist of risks is obtained (the shaded area) (Yuan et al. 2008). The WBS-RBS matrix is presented in Figure 6.

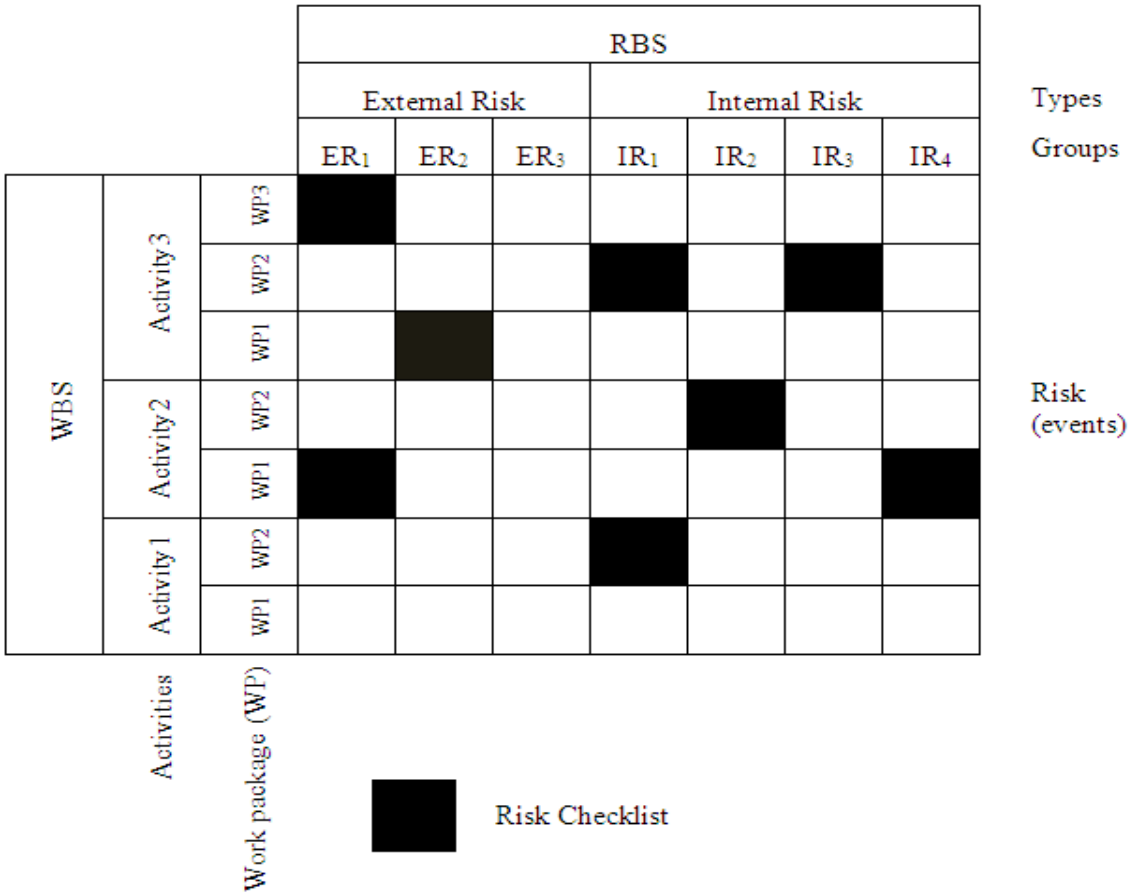


Figure 6. WBS-RBS matrix and risk checklist for PPP projects

4.1.2 RISK IDENTIFICATION THROUGH CHECKLIST METHOD

According to Asenova and Beck (2003), the checklist method is used frequently by financial organizations. Each financial organization has its own standard format or scheme to identify risks in PPP projects. These formats or schemes are typically based on experience and knowledge gained from previous projects. The checklist of risks is an accumulative form of all the risks incurred in previous projects and is more like a risk database. This method of risk identification relies heavily on previous experience with PPP projects. With more and more projects conducted, more experience is accumulated and more risks are identified. The expanded checklist of risks provides a broad initial judgment on the risks involved in the project and the feasibility of the project (Asenova and Beck 2003). Risks in a new project can be identified quickly with the help of the previous risk checklist of a project similar in type.

4.1.3 RISK IDENTIFICATION THROUGH FLOW CHART METHOD

The flow chart method is an effective risk identification method, which is particularly useful to depict flow processes (Chinyio and Fergusson 2003). For example,

the flow charts method can be applied to represent the flow of materials in a factory. The flow chart can clearly show the movement of the process until it comes to the end. As a result, a project is divided into different links and it is easy to identify the responsibility of each processor or sector. It is obvious to see which link or processor goes wrong if there is a failure. Sectors/processors are equally spotted at different locations along the flow chart line. In this way, the risk generated by operator/processor (like mistakes or absenteeism) can be easily and quickly identified. This method has been applied by construction companies that deliver PPP projects, especially in risk identification of waste management projects (Chinyio and Fergusson 2003).

4.1.4 RISK IDENTIFICATION THROUGH QUESTIONNAIRE AND CONSULTANT OF EXPERTS

From time to time, the techniques available to one company may not offer sufficient insight into identifying some risks. As a result, the risk checklist at hand cannot be used to address risks effectively. This situation happens when a company or authority is engaged in a project related to a new area. For example, a road construction company may invest in a water supply project. Previous experience and information is unavailable to deal with the new project. It is obvious that the road company needs advice or suggestions from a professional water supply company or expert. Under this circumstance, the method of questionnaire and consultant experts should be used to assess the project feasibility. The company prepares a questionnaire regarding project risk or strike action questions that may disrupt the project and sends it to expert institutions or individual experts in this area. Consulting experts are like an extension of experience because different experts specialize in different areas and have built up a lot of experience. Therefore, by questionnaire and consultation with experts, the company can get insight responses that ensure that risks can be identified quickly and accurately. This method is one of the most commonly used methods to identify risks in PPP projects. In addition to the approaches above, other methods, such as site visits and organizational charts, are also used to identify risks in PPP projects (Chinyio and Fergusson 2003).

4.2 Risks with PPP procurements

As known from the literature review undertaken, risks in PPP projects can be classified into different groups according to different criteria used. Internal risks come from inside the project and exist within any given year of the project's life-cycle, for example, the income projection for any given year. Moreover, internal risks can be controlled to some extent by the decision making process for each stage. On the other hand, external risks come completely from outside the project and cannot be found in any of the official statements in the project contract, such as the rate of inflation or oil price. These risks are more undesirable because they are out of control of the project sectors (Songer et al. 1997). According to Beidleman et al. (1990) and Garnett (1992), the development risk includes permitting, credit, technology, inflation and bid risks; the construction risk consists of cost overruns, completion and political risks; operation risk comprises cost overruns,

performance of the facility, equity resale and reliability risks; and ongoing risks include currency values and interest rates. Some of the main risks in PPP projects are briefly discussed in the following sections.

4.2.1 PROJECT RISK

Project risks are the accumulation of all the uncertainties that may influence the project objective, including budget, economy and political environment, quality, and time limit. There are a number of factors that can cause project risks, such as finance, policy, technology and detailed contractual items. Moreover, the schedule uncertainty caused by the approval process can result in large and unexpected costs. Also, the project risk increases if there are unplanned change orders.

4.2.2 FINANCIAL RISK

There are numerous financial risks in different stages of a PPP project's whole life cycle. Xenidis and Angelides (2005) identified 27 financial risks associated with BOT projects in one study, including 4 public-rooted risks, 16 concessionaire-rooted risks and 7 market-rooted risks (Xenidis and Angelides 2005). Most of these risks also exist in other types of PPP projects. A total number of 21 out of 27 financial risks occur during the operation and maintenance stage, followed by the bidding preparation stage (18 out of 27 risks) and concessionaire formation to contract signing stage (17 out of 27 risks). This categorization also indicates that special attention should be paid to the operation and maintenance stage in terms of financial risks.

4.2.3 INVESTMENT RISK

The investment risk of PPP project refers to the probability of failure to ensure required infrastructure-generated revenue to service debt (deemed as the minimum requirement) and/or achieving an adequate return on the investment (Kakimoto and Seneviratne 2000; Pantelias 2009). Investment risk is directly related to infrastructure-generated costs and revenue. The most commonly used mechanism to obtain infrastructure-generated revenue is through user charges, in the form of toll collection. Other types, such as leasing of roadside facilities or services, are also used (Pantelias 2009). Infrastructure operation and maintenance costs occur because of the operating personnel, expected or unexpected wear of the facility due to its utilization and aging, and other fixed and non-fixed operation costs. It is obvious that, for an infrastructure facility, the life-cycle revenues are always supposed to exceed the life-cycle costs in order to generate profit.

There are a large number of engineering variables in the quantitative models used to assess investment risk. A lot of research has been done to identify the elements (variable) of the investment risk. As a result, numerous risks are identified, including the individual project risk, which comprises delay risk and construction cost overrun risk; competitive risk, which contains demand risk and market share risk; market risk, which consists of political risk, inflation risk, economic environment risk and interest rate risk (Seneviratne and Ranasinghe 1997; Javid and Seneviratne 2000; Kakimoto and Seneviratne 2000). More

specifically, individual project risk can be dealt with by the project contractor's experience in providing reliable and accurate cost estimations and plan schedules. Competitive risk can be accounted for by pre-analyzing the project before undertaking it, which leads to accurate estimates of the project market share and its competitors. In addition, these accurate estimates also affect the infrastructure-generated revenues. Market risk is part of the investment risk, taking interest, discount and inflation rates into account. Political risks and economic risks should be accounted for when the PPP project is undertaken in areas or countries where the political and economic environment is not stable (Pantelias 2009), i.e., some countries in Africa like Cameroon and Libya.

Investment risk is interrelated with the financial viability of the project. The investment risk depends on the income and outcome cash flows before the equity returns, which plays an important role in determining the profitability of the project based on the proposed financing scenario and anticipated operational characteristics. It can accommodate the target MARR together with the serving of debt when the project's operation period comes to an end. Therefore, investment risk addresses the general requirements of the equity investors and lenders. It can be furthermore be used by all the stakeholders to make their own decisions (Pantelias 2009):

The public authority can apply investment risk to develop regulations and policies regarding the procurement of the same kind of projects. Since the investment is directly related to the bidding process and value for money, the public sector can use it to determine the project's attractiveness to the private sector.

Using the investment risk, the lenders can evaluate the project riskiness with respect to the repayment of the outstanding debt based on their expected internal rate of return. Therefore, the financing structural details in financing the project and final leverage of the project are determined.

The equity investors can evaluate their own return under different scenarios. They can use the results of different scenarios to further negotiate their contribution to the project financing in order to obtain the minimum required amount of return.

4.2.4 CREDIT RISKS

Credit risk occurs when the debtors are not able to fulfill their contractual obligations to pay their loans with interest within the agreed time period. It arises from the default of the debtor with respect to settling a credit facility. Sometimes, the credit risk is related to the economic environment.

4.2.5 LEGAL RISK

Legal risk arises when new regulations and legislation are introduced, which can influence the existing transactions. It is also associated with actions of non-compliance or fraud with security laws (Hardcastle and Boothroyd 2003). The result of the legal risk can sometimes be very serious because it may become illegal for the parties to perform their expected obligations.

In industry practice, there is usually a combination of risks from different classification methods. For example, in the risk analysis of a Texas highway project, the risks are divided into three groups (TxDOT 2006):

- Design, construction, completion and technical risks;
- Environmental, operation, maintenance and other liabilities;
- Financial, economic and political risks.

4.3 Risk allocation

Risk allocation is a more project-specific process, which is related to the specific project and the detailed contract items. In most cases, risk allocation keeps consistency. However, some risks allocated to the private sector in one project might be allocated to the public authority in another new project based on the arrangement signed by the contractors. The allocation of risks may also vary in different countries and areas in order to attract more investment. For example, the site availability of construction risk is deemed as a public responsibility by Li et al. (2005) and Lam et al. (2007) while Ng and Loosemore (2007) allocated the risk to the private sector. A number of researchers and organizations have conducted research to obtain their risk allocation scheme. Ke et al. (2009) conducted a comparative analysis of different risk allocation schemes documented in a wide range of literature, including Arndt (1998), Wang and Tiong (2000), Victorian Department of Treasury and Finance (VDTF) (2001) in Australia, National Treasury of South Africa (NTSA) (2004), Li et al. (2005), Ng and Loosemore (2007) and Lam et al. (2007). The result is presented in Table 4.1.

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Table 4.1 Summary table of risk allocation preferences from different literature

Risk factor		Arndt (1998)	Wang and Tiong (2000)	VDTF (2001)	NTSA (2004)	Li et al. (2005)	Ng and Loosemore (2007)	Lam et al. (2007)
Political	Termination of cession by government		Public		Public		Public	
	Expropriation and nationalization		Public		Public	Public	Private	
	Political opposition				Public	Public		
	Change in law	Share	Share	Public	Share	Share	Private	Share
	Unstable government					Public		Public
	Project approval and permit	Share		Private			Share	Private
	Influential economic events			Private		Private		
	Changes in industrial code of practices	Share		Private	Share	Private		
Construction	Availability of finance	Private		Private		Private		
	Improper design	Private	Private	Private	Private	Private	Private	Private
	Insolvency of subcontractors	Private	Private		Private	Private		Private
	Quality risk	Private	Private	Private	Private	Private	Private	Private
	Site safety	Private						Private
	Availability of labor/materials		Public			Private		Private
	Ground conditions			Private		Private	Private	Public
	Site availability	Share		Private		Public	Private	Public
	Construction/design changes			Public	Public		Public	Private
	Labor disputes and strikes		Private	Private				Private
	Land use				Public	Public	Public	
	Waste of materials	Private				Private	Private	
	Construction cost overrun	Private	Private	Private	Private	Private	Private	
	Construction completion	Private	Private	Private	Private	Private	Private	
	Supporting utilities risk	Share	Share				Public	
	High financial cost	Private	Private			Private		
	Unproven engineering techniques	Private	Private	Private	Private	Private		
	Protection of geological and historical objects		Private	Private				
Operation	Operation cost overrun	Private			Private	Private	Private	
	Operator default	Private	Private	Private			Private	
	Quality of operation	Private	Private	Private	Private		Private	
	High maintenance cost	Private		Private	Private	Private		
	Frequency of maintenance	Private		Private	Private	Private		
	Low operating productivity	Private	Private		Private	Private		
	Residual assets risk	Private		Public	Private			
	Condition of facility		Private	Private				

Risk factor		Arndt (1998)	Wang and Tiong (2000)	VDTF (2001)	NTSA (2004)	Li et al. (2005)	Ng and Loosemore (2007)	Lam et al. (2007)
Legal	Contractual risk		Share					Public
	Third party tort liability					Private		Public
	Ownership assets		Share	Share	Private		Private	
	Insolvency of Concession company		Private		Private			
Market	insufficient income	Private	Private			Private		
	Fluctuation of material cost (by government)		Public	Public	Public		Public	
	Fluctuation of material cost (by private sector)		Private	Private	Private		Private	
	Tariff change		Private	Private	Private	Private	Private	
	Market demand change	Share	Private		Share	Private	Private	
	Exclusivity		Share	Private				
Economic	Inflation risk		Share	Share	Share	Private	Share	Share
	Interest rate		Share		Private	Private	Share	
	Foreign currency exchange		Public		Private			
Others	Force majeure	Share		Share	Share	Share	Share	
	Residual risk					Private	Public	
	Weather	Public			Public	Private		Share

Table 4.1 source: Ke et al. (2010), Arndt (1998), Wang and Tiong (2000), Victorian Department of Treasury and Finance (VDTF) in Australia (2001), National Treasury of South Africa (NTSA) (2004), Li et al. (2005), Ng and Loosemore (2007) and Lam et al. (2007)

In addition, Ke et al. (2010) also identified risks (a few of them are not listed in Table 4.1) associated with PPP projects in China and applied a two-round Delphi survey to analyze the risks and their allocation. Responses from experts with in-depth knowledge and rich experience in PPP projects gave a preferred allocation of the risk factors in China, as presented in Table 4.2.

Table 4.2 Preferred allocations of risk factors

Allocation	Category	Risk factor
Risks to be solely allocated to the public sector	Country	Expropriation and nationalization
Risks to be mostly allocated to the public sector	Country	Government's reliability
	Country	Government's intervention
	Country	Poor political decision-making
	Project	Land acquisition
	Country	Corruption
	Country	Approval and permit
	Project	Supporting facilities risk
	Country	Uncompetitive tender
	Project	Competition (exclusive right)
	Country	Change in law
	Country	Tax regulation changes
	Country	Immature juristic system
Risks to be equally shared by both parties	Country	Public/political opposition
	Project	Tariff change
	Country	Force majeure
	Project	Payment risk
	Country	Environmental protection
	Project	Insufficient financial audit
	Project	Subjective evaluation
	Project	Improper contracts
	Market	Inflation
	Market	Foreign exchange and convertibility
	Country	Ground/weather conditions
	Market	Market demand change
	Project	Third party reliability
	Market	Interest rate
Risks to be mostly allocated to the private sector	Project	Construction/operation changes
	Project	Residual assets risk
	Project	Organization and coordination risk
	Project	Consortium inability
	Project	Private investor change
	Project	Private investor change
	Project	Delay in supply
	Project	Construction completion
	Project	Financial risk
	Project	Operation cost overrun
	Project	Technology risk

Source: Ke et al. (2010).

4.4 Summary

This chapter discusses risks associated with PPP projects from the aspects of risk identification, risks with PPP procurement and risk allocation. First, several methods regarding risk identification are introduced, including WBS-RBS method, checklist method, flow chart method, questionnaire and consultant of experts method. Then, risks associated with PPP procurement are discussed in terms of project risk, financial risk, investment risk, credit risk and legal risk. Finally, an overview of risk allocation is presented based on a comprehensive literature review. Resources and models that are available to conduct analyses related to PPP projects will be introduced in the next chapter.

5. TOOLS AND MODELS APPLICABLE TO PPP ANALYSES

Because of the increasing trend of using PPPs by many countries in the world, there has been research on how to analyze various issues associated with PPP projects, through both computer toolkits (software) and mathematical models. As a result, a number of toolkits have been developed, such as the toolkit developed by the World Bank with support from the Public-Private Infrastructure Advisory Facility (PPIAF) and the benefit/cost analysis tool developed by the Federal Highway Administration (FHWA); at the same time, researchers have explored various mathematical models, such as Monte Carlo Simulation method and the Method of Moments, for quantifying risks associated with PPP projects.

5.1 Dealing with PPP problems through toolkits

5.1.1 PPP TOOLKIT FOR IMPROVING PPP DECISION-MAKING PROCESSES

This toolkit is supported by the World Bank, PPIAF and AusAID South Asia Region Infrastructure for Growth Initiative. The co-developer of this toolkit is the Department of Economic Affairs, Ministry of Finance, Government of India (DEA) (User guide 2010). This toolkit is a web-based analysis tool (available at: http://toolkit.pppinindia.com) to help improve the quality and decision making process in PPP infrastructure projects in India. It contains five different infrastructure sectors so far: highways, water and sanitation, ports, municipal solid waste management and urban transport. The toolkit can be used by both public authorities and private sectors and is applicable to facilitating the decision making process at Central, State and Municipal levels (User guide 2010).

The toolkit comprises of four phases, namely the PPP identification phase, full feasibility study, PPP preparation and clearance phase, PPP procurement phase and contract management and monitoring phase, as shown in Figure 7.

Figure 7. The PPP toolkit process

As previously introduced, the toolkit is web-based and can be accessed at http://toolkit.pppinindia.com/. To use the toolkit, a sector should be specified on the homepage using the drop-down menu. For example, if the project is a highway related

project, then the State Highway menu should be chosen, as presented in Figure 8. The toolkit and other material will be customized to the highway sector correspondingly.

Figure 8. Screen shot of PPP toolkit homepage

After choosing the State Highway sector, click on the button Go to enter the toolkit. The login username and password are required to use this toolkit. The user must register to get started. Once registered and logged in, the user can add new projects and edit the profile by clicking on the links, as shown in Figure 9.

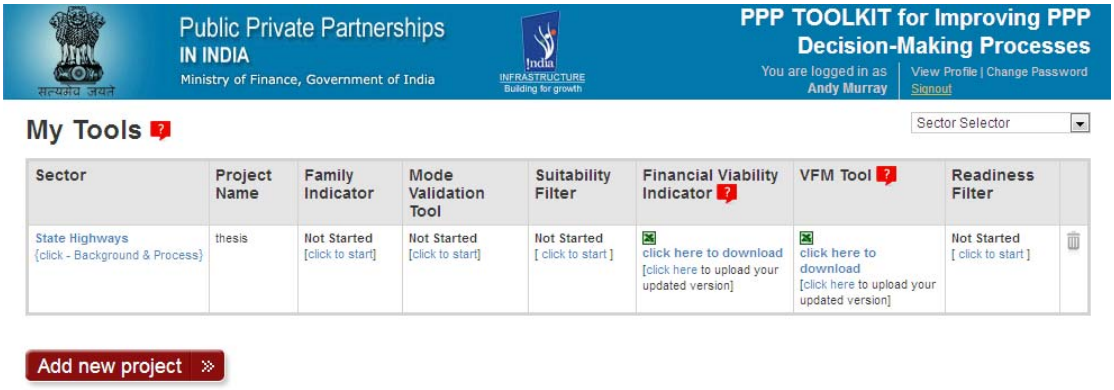


Figure 9. Screen shot after logging in

As can be seen from Figure 9, there are 6 tools within the PPP toolkit: PPP family indicator tool, PPP mode validation tool, PPP suitability filter, financial viability indicator model, value-for-money indicator tool, and readiness filter.

The family indicator tool is designed to help group PPP modes that share certain important characteristics into several "families". The user is asked questions regarding the type of project, such as whether the private sector would be responsible for the construction

and operation, who would be responsible for the design and what will be the primary revenue source. Then, the tool uses a decision tree to help make preliminary suggestions of which PPP family might fit best based on the answers (User guide 2010). The screen shot of the family indicator is shown in Figure 10.

Figure 10. Screen shot of the PPP family indicator tool

As can be seen from figure 10, after answering each of the specific questions, the family indicator tool gives the results, which makes preliminary suggestions on the role of the private sector and the suggested PPP "family". More specifically, the private sector's role based on the answer is to finance, construct, manage, maintain, collect tolls and transfer the highway to public authority; the project is categorized as a BOT toll project.

The mode validation tool applies a risk allocation approach to test the preliminary suggestion on the best PPP group for the project. Since risk allocation is a key factor in choosing the PPP mode, the goal of mode validation tool is to prompt the practitioner to think in detail about how to best allocate the risks between the public and private sectors. By clicking on the link, this tool allows the user to specify their own preferred risk allocation. Then a comparison between the preferred allocation and the typical risk allocation in the toolkit is made. If there is a big difference between the two allocation methods, the users should think over the decision of whether another allocation method would be more appropriate in this project. In this way, the user can obtain a better sense of the best fit PPP mode (User guide 2010). The screen shot of the mode validation tool is presented in Figure 11.

	Risk Type	Sensitivity	Relevance during the concession	Preferred Allocation (Step 2)	Typical allocation under BoT Toll
A. PRE OPERATIVE TASK RISKS					
A.1	Delays in land acquisition	High	0-5 years	Public Sector	Public Sector
A.2	External linkages	Low	0-5 years	Public Sector	Public Sector
A.3	Financing risks	Medium	0-5 years	Shared	Private Sector
A.4	Planning	Medium	0-5 years	Private Sector	Private Sector
A.5	Approvals	High	0-5 years	Public Sector	Public Sector
B. CONSTRUCTION PHASE RISKS					
B.1	Design Risk	Medium	0-5 years	Private Sector	Private Sector
B.2	Construction Risk	Medium	0-5 years	Private Sector	Private Sector
B.3	Approvals	Low	0-5 years	Private Sector	Private Sector

C. OPERATIONS PHASE RISKS						
C.1	Technology Risk	Low	Throughout	Private Sector	Private Sector
C.2	Operations & Maintenance Risk	Medium	Throughout	Private Sector	Private Sector
C.3	Traffic Risk	High	Throughout	Private Sector	Private Sector
C.4	Payment Risk	High	Throughout	Private Sector	Private Sector
C.5	Financial Risk	Medium	Throughout	Private Sector	Private Sector
D. HANDOVER RISK EVENTS					
D.1	Handover Risk / Terminal value Risk	Medium	Last 3 year	Private Sector	Private Sector
E. OTHER RISKS					
E.1	Change in Law	Low	Throughout	Public Sector	Public Sector
E.2	Force Majeure	Low	Throughout	Shared	Shared
E.3	Concessionaire risk	Medium	Throughout	Private Sector	Public Sector
E.4	Sponsor risk	Medium	Throughout	Private Sector	Private Sector
E.5	Concessionaire event of default	Medium	Throughout	Private Sector	Private Sector
E.6	Government's event of default	Low	Throughout	Public Sector	Public Sector

Number of matches to preferred risk allocation (Step 3)

BoT Toll	**18 of 20**
BOT Annuity	**16 of 20**
BOT Shadow Toll	**17 of 20**
Score of 20 = perfectly matched	

Performance-Based Maintenance Contracts	**9 of 12**
Score of 12 = perfectly matched	

(for projects where capex is not the focus)

Figure 11. Screen shot of the mode validation tool

After filling in the preferred risk allocation, the comparison is made immediately with the typical risk allocations. The green field means that the allocation matches with each other while the yellow field means that they do not match with each other and further consideration is needed. As a result, a summary table showing the number of matches to the preferred risk allocation is presented. In this case, the most matches occur within the BOT toll project, indicating that this project can be grouped into BOT toll projects, which is consistent with the result from the PPP family indicator tool.

Since the type of PPP project has been identified, next step is to filter PPP suitability. The suitability filter is an effective and preliminary test to qualify value for money. The filter provides a series of questions regarding different factors that might impact the suitability of defining a project as a PPP project. The answers are recorded and scored. The result will present the level of difficulty (e.g., difficult or attractive) to develop the project as a PPP project based on the total score. In this way, the tool can eliminate some projects that are deemed not suitable as PPP project at the very beginning, so that capital and resources will not be wasted. Furthermore, the results of the filter tool can also be used to identify the weak part in the PPP project. Consequently, the practitioner is able to take action to improve the identified areas and strengthen the quality of PPPs (User guide 2010). The screen shot of the suitability filter tool is presented in Figure 12.

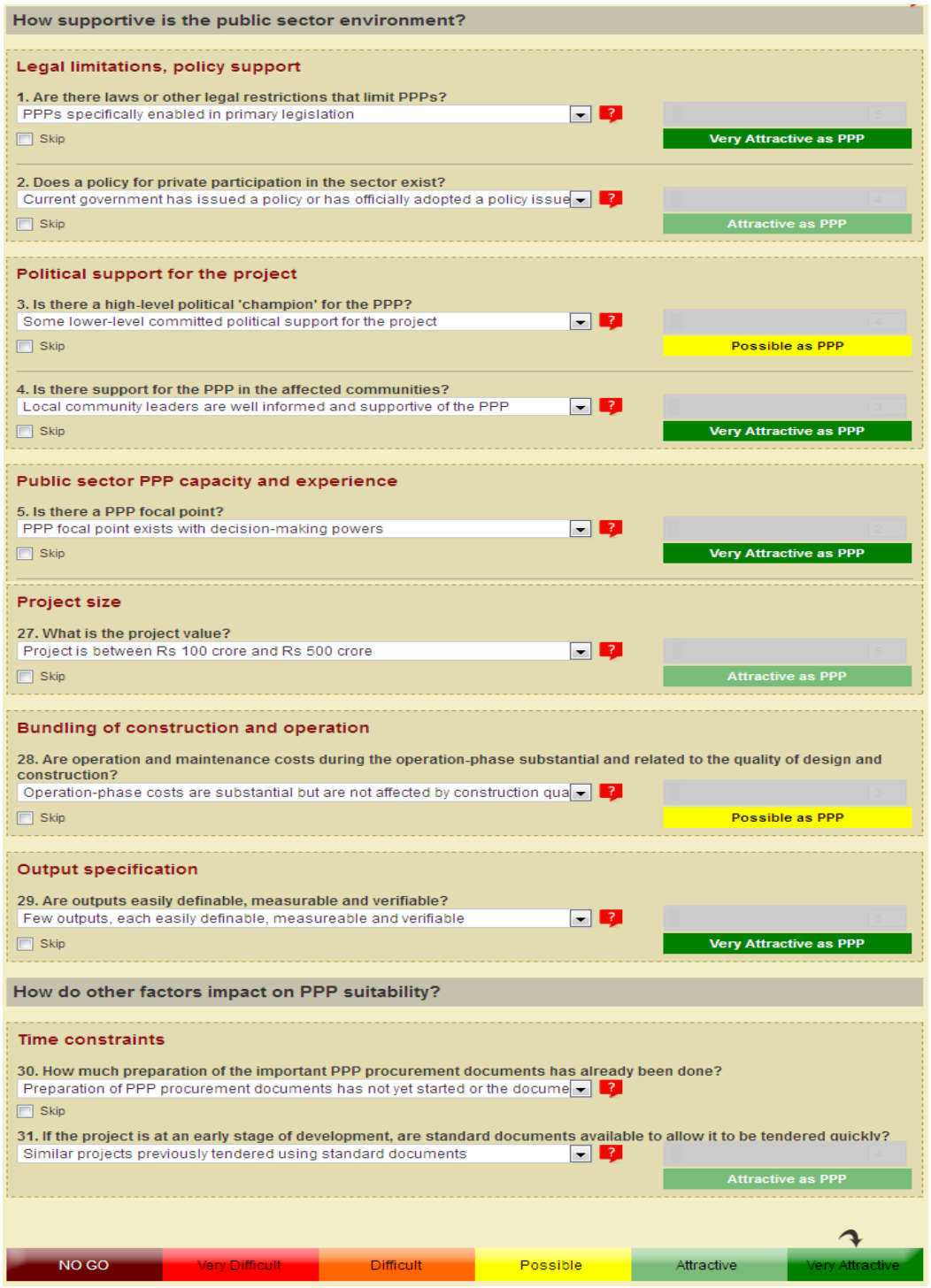
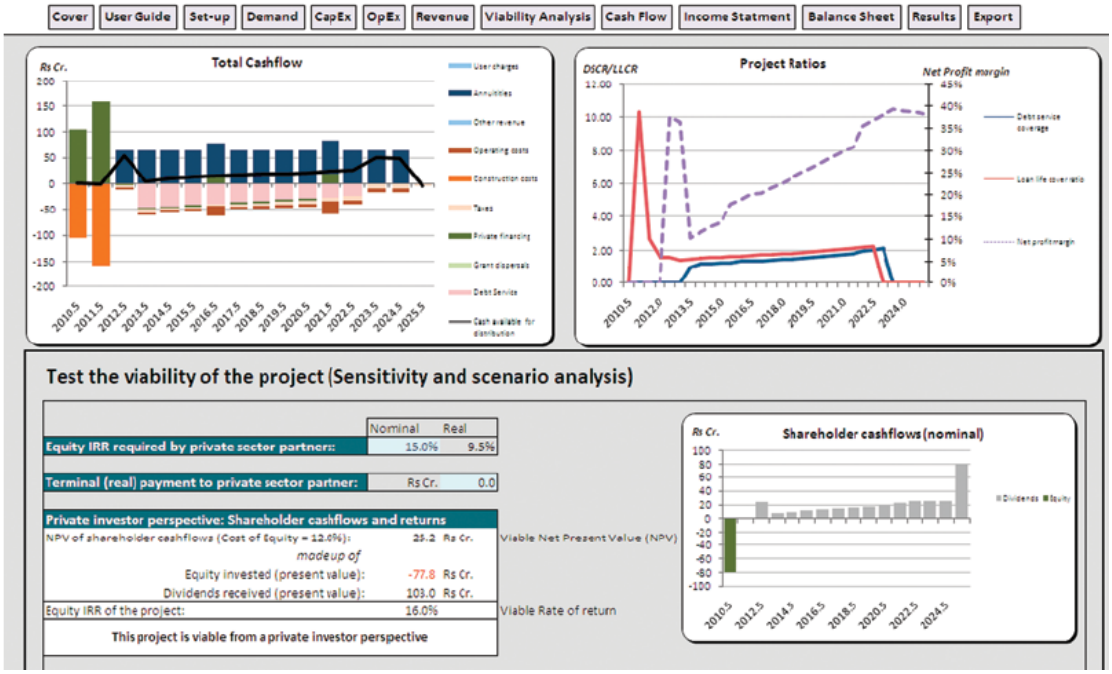


Figure 12. Screen shot of the suitability filter

It can be observed from Figure 12 that there are a total of 31 questions grouped into 5 categories, namely how supportive the public sector environment is, how supportive the private sector is, how significant the potential barriers to a PPP are, how well suited the project characteristics are to a PPP and how other factors impact the PPP suitability. The users are expected to answer all these questions to obtain the final suitability of the project. If a question does not apply to the project, the user can click on the skip button. The final result will be presented in six groups, which are no go, very difficult, difficult, possible, attractive and very attractive with the suitability of PPP increasing. In this case, the suitability filter suggests that the project is very attractive, which means that it is very suitable to regard the project as a PPP project.

Next step is to apply the financial viability indicator model. The financial viability indicator model is an Excel-based tool and is designed to help make financial assessment of the PPP project. This model is developed for the private sector to assess the likely financial viability of the project. Comparisons are made between the expected after-tax return of the equity and the financial revenue returned from the PPP project to provide insight information on how attractive the PPP project will be to the private sector. The user needs to input a wide range of information, including the initial costs, maintenance and operation cost, expected IRR by the private sector, estimation of user charges, annual revenue and other cash flow that makes the project attractive to the private sector. After entering the required information on the project, the cash flow chart, sensitivity and scenario analysis will be presented, as shown in Figure 13.

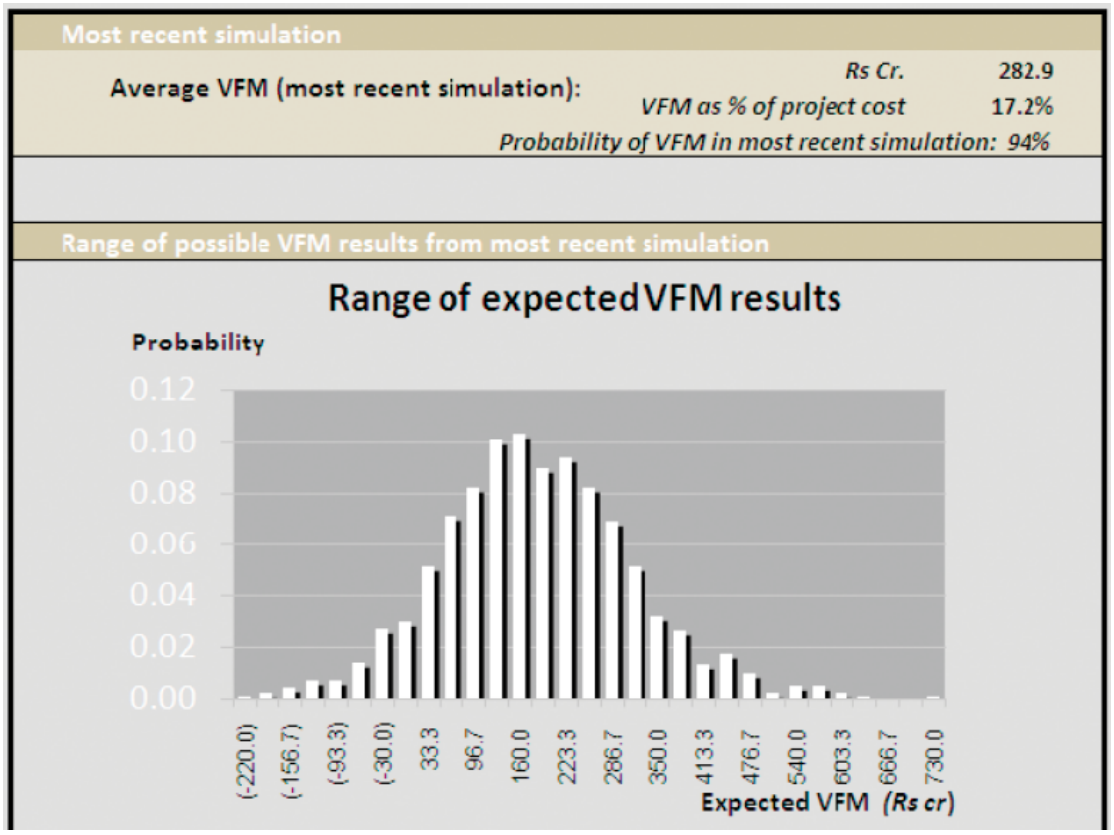


(Source: User guide, 2010)

Figure 13. Screen shot of the financial viability indicator model

From Figure 13, it can be observed that the cash flow of each year is illustrated through the whole life cycle of the concession period. Furthermore, based on the input financial information, the equity IRR from the project is calculated and compared with the expected IRR from the private sector. As a result, the suggestion on the viability of the project is provided. In this example, the equity from the project is 16 percent, which is larger than the expected IRR (15 percent). Therefore, this toolkit suggests that this project is viable from the private investor perspective.

The results of the financial viability indicator model perform as an input to the value for money (VfM) indicator tool. The VfM tool uses a quantitative VfM test to compare the estimated cost of the project by public sector with that of conducting the project as a PPP. This test relies on the uncertainties in the estimation of transferred risks. Since the input risk models in this toolkit are in distributions, the VfM indicator model incorporates these risks and returns a distribution of VfM with probability for each value respectively. This VfM distribution gives a good indication of whether this PPP project would deliver VfM or not. If the VfM is positive, then the PPP project will provide VfM and if it is negative, then the PPP project is not going to deliver any VfM. The screen shot of the VfM indicator is presented in Figure 14.



(Source: User guide, 2010)

Figure 14. Screen shot of VfM indicator

As can be seen from Figure 14, the distribution of the VfM is presented with a mean value of 282.9 Rs cr (45.9 million US dollars), which means that the VfM is positive and the project can deliver profit to the sectors. In addition, there are cases where the VfM is negative because of the risks and uncertainties in the project. However, the corresponding probability is very small. Therefore, in terms of VfM, the project is also viable and is expected to provide VfM.

The last step of this toolkit is the readiness filter that is designed for both public and private sector in a form of checklists, which contain a series of questions related to the project design. The person in charge should answer the questions. As a consequence, the readiness filter provides the overall assessment of the project and gives suggestion whether the project should proceed to the next stage. The screen shot of the readiness filter is shown in Figure 15.

Figure 15. Screen shot of the readiness filter

This toolkit is a very useful tool to help improve the decision-making process of infrastructure PPP projects. Any user who can get access to the Internet can use this toolkit by inputting the parameter values pertinent to a specific project and gain very insightful information (e.g., cash flow, distribution of VfM) on the project.

5.1.2 BENEFIT-COST ANALYSIS TOOL DEVELOPED BY FHWA

The benefit-cost analysis tool developed by FHWA is called BCA.Net, which is used to support the highway project decision-making process. Similar to the toolkit introduced previously, BCA.Net is also a web-based tool that can enable users to manage economic analysis data, select from an array of sample data, evaluate and compare the benefit and cost strategies and develop alternative strategies for managing highway facilities (FHWA 2013). In addition, this tool can also be applied to evaluate reconstruction and preservation strategies, as well as operational efficiency.

BCA.Net is a web-based tool that can be accessed at https://fhwaapps.fhwa.dot.gov/bcap/BaseLogin/LoginReg.aspx. This tool requires username and password to login. The screen shot of the BCA.Net homepage is presented in Figure 16.

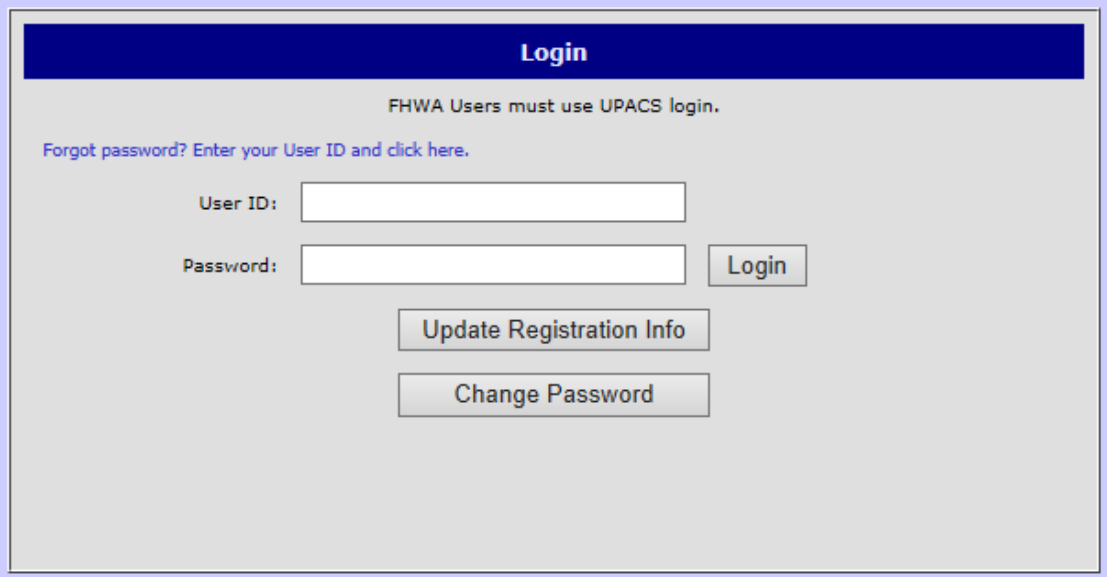
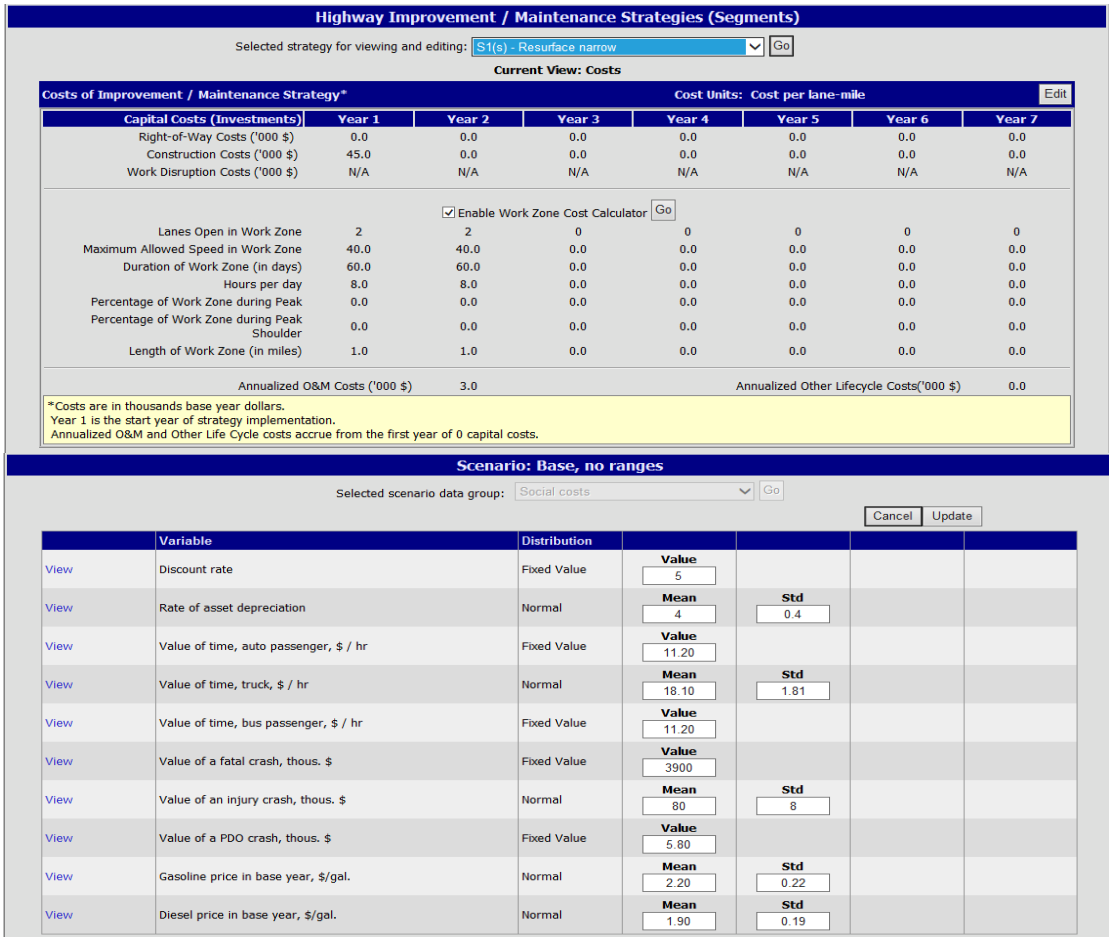


Figure 16. Screen shot of BCA.Net homepage

New users need to register first and then login with the username and password. In order to evaluate projects through BCA.Net, the users are expected to input a range of economic data, including project characteristics, the capital cost, construction, operation and maintenance costs, annual revenue, and economic beneficial value to users. In addition, information on the pavement is also required, such as road type (e.g., urban freeway or urban arterial), number of lanes, deterioration rate, and pavement condition. All these data can be obtained from the existing planning and engineering documents. The users can define the mean and standard deviation of the input data. The screen shot of the input is presented in Figure 17.



Highway Improvement / Maintenance Strategies (Segments)

Selected strategy for viewing and editing: S1(s) - Resurface narrow Go

Current View: Costs

Costs of Improvement / Maintenance Strategy* — **Cost Units: Cost per lane-mile** — Edit

Capital Costs (Investments)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Right-of-Way Costs ('000 $)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction Costs ('000 $)	45.0	0.0	0.0	0.0	0.0	0.0	0.0
Work Disruption Costs ('000 $)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
☑ Enable Work Zone Cost Calculator Go							
Lanes Open in Work Zone	2	2	0	0	0	0	0
Maximum Allowed Speed in Work Zone	40.0	40.0	0.0	0.0	0.0	0.0	0.0
Duration of Work Zone (in days)	60.0	60.0	0.0	0.0	0.0	0.0	0.0
Hours per day	8.0	8.0	0.0	0.0	0.0	0.0	0.0
Percentage of Work Zone during Peak	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percentage of Work Zone during Peak Shoulder	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Length of Work Zone (in miles)	1.0	1.0	0.0	0.0	0.0	0.0	0.0
Annualized O&M Costs ('000 $)	3.0				Annualized Other Lifecycle Costs('000 $)		0.0

*Costs are in thousands base year dollars.
Year 1 is the start year of strategy implementation.
Annualized O&M and Other Life Cycle costs accrue from the first year of 0 capital costs.

Scenario: Base, no ranges

Selected scenario data group: Social costs Go

Cancel Update

	Variable	Distribution				
View	Discount rate	Fixed Value	Value 5			
View	Rate of asset depreciation	Normal	Mean 4	Std 0.4		
View	Value of time, auto passenger, $ / hr	Fixed Value	Value 11.20			
View	Value of time, truck, $ / hr	Normal	Mean 18.10	Std 1.81		
View	Value of time, bus passenger, $ / hr	Fixed Value	Value 11.20			
View	Value of a fatal crash, thous. $	Fixed Value	Value 3900			
View	Value of an injury crash, thous. $	Normal	Mean 80	Std 8		
View	Value of a PDO crash, thous. $	Fixed Value	Value 5.80			
View	Gasoline price in base year, $/gal.	Normal	Mean 2.20	Std 0.22		
View	Diesel price in base year, $/gal.	Normal	Mean 1.90	Std 0.19		

Figure 17. Screen shot of BCA.Net input page

The user should select a base strategy and some alternative strategies (if any) to implement the project. After completing the input variables and selecting the strategies, the user can click on the simulation button to run the simulation. The user can choose the simulation iterations based on the need. BCA.Net will calculate the total agency and user benefits and costs for each of the strategy. Comparisons between different strategies are made subsequently. The tool provides various measure standards such as benefit-cost ratio, net benefit value and rate of return (ROR) for the alternative strategies to the base strategy (FHWA 2013). The screen shot of the result table and statistical figure are show in Figure 18.

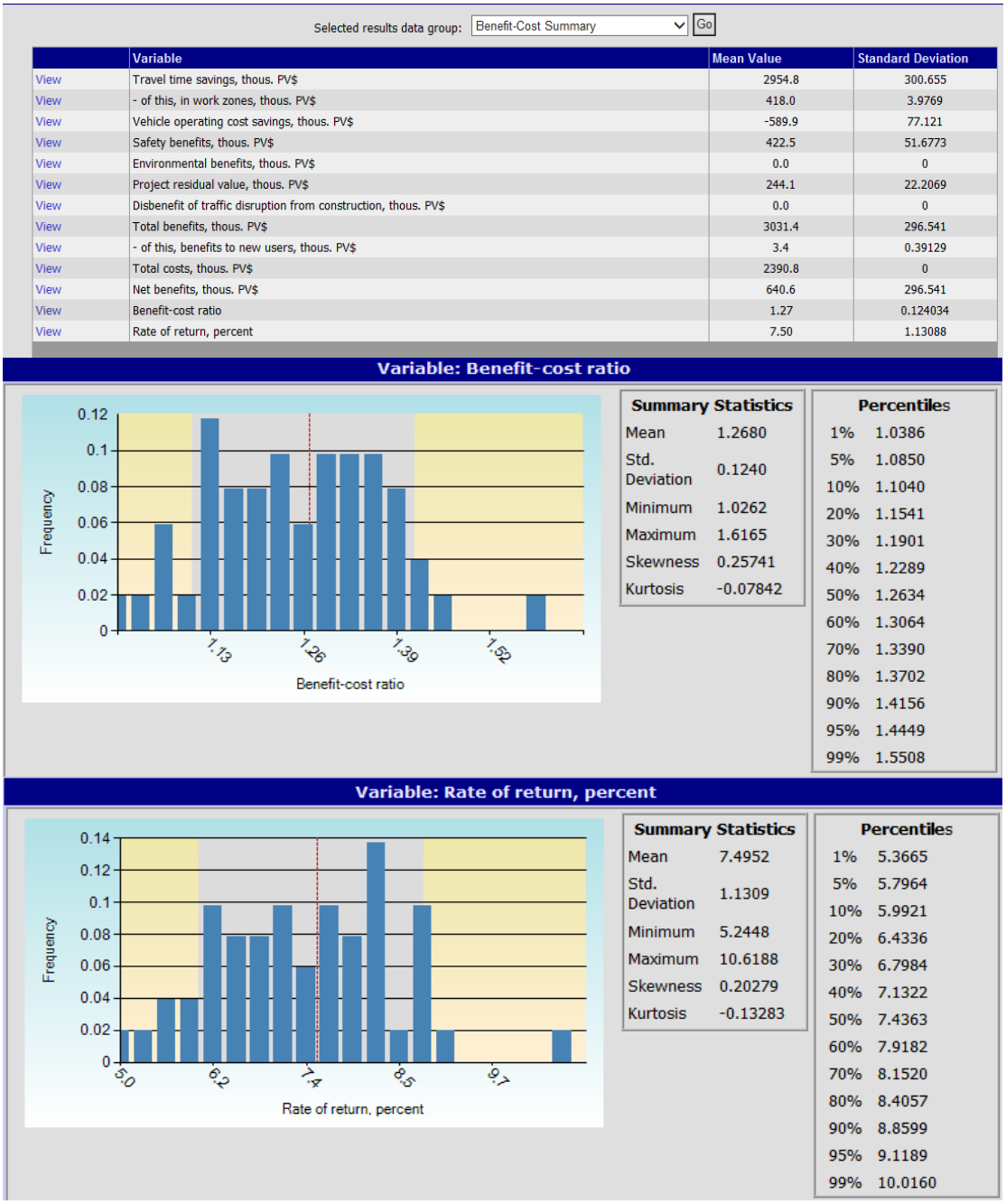


Figure 18. Screen shot of the result table and statistical information of beneficial-cost ration and rate of return

Furthermore, BCA.Net allows the user to apply risk analysis to develop probabilistic inputs and results, which can explicitly deal with uncertainties associated with the inputs and show their impact on the analysis results clearly. According to the measurement the user selected, results can be exported by BCA.Net in pdf format which can be stored in the user's computer for further use.

BCA.Net is a very useful tool to conduct economic analysis, which can return very intuitive results. This tool can help improve the decision making process effectively by presenting various financial variable measurements such as benefit-cost ratio, net present value and rate of return (ROR). However, BCA.Net has its shortcomings. It is not designed for PPP project purpose only but is feasible and applicable to PPP projects. Since it is developed by FHWA, the tool is focused on analyzing highway-related projects and is not directly applicable to other infrastructure.

5.2 Dealing with PPP problem through mathematical models

5.2.1 EVALUATING INVESTMENT RISKS

There have been various methods to evaluate long-term assets investments, such as the Net Present Value (NPV), the Internal Rate of Return (IRR), the Payback Period (PBP) and the Profitability Index (PI/BCR) (Pantelias 2009). Among these methods, NPV and IRR are the most commonly applied to date. The PBP is also used but at a secondary level of analysis (Titman et al. 2005; Pantelias 2009). Generally speaking, the NPV and IRR of a PPP project can be expressed as:

$$NPV = \sum_{t=1}^{n} \frac{FCF_t}{(1+r)^t} - IO$$

Where:

FCF_t: the annual expected income cash flow for period *t*

IO: the initial cash outlays

r: the appropriate discount rate

n: the analysis period

And:

$$IO = \sum_{t=1}^{n} \frac{FCF_t}{(1+IRR)^t}$$

Where:

FCF_t: the annual expected income cash flow for period *t*

IO: the initial cash outlays

IRR: the project's internal rate of return

n: the analysis period

Regardless of which specific method is used, the basic concept is to evaluate the relationship between the initial cash outlays and the project-generated future cash- flows, which is either negative or positive to reflect the impact of the investment. The models usually discount all initial and project-generated cash-flows to present values in order to consistently represent the time value of money.

There are also some modifications to the basic NPV equation with account for stochastic characteristics, such as considering the Risk-Adjusted (RA) variables and the

Certainty Equivalent Approach (CEA) (Titman et al. 2005). In the CEA approach, the estimation of certainty equivalent coefficient (a_t) is taken into consideration and the discount rate is fixed. The equation is:

$$NPV = \sum_{t=1}^{n} \frac{a_t FCF_t}{(1 + r_{rf})^t} - IO$$

Where:

FCF_t: the annual expected income cash flow for period *t*

IO: the initial cash outlays

a_t: the certainty equivalent coefficient for period *t*

r_{rf}: the risk-free discount rate

While in the RA approach, the discount rate used is risk-adjusted. The *NPV* is expressed as:

$$NPV = \sum_{t=1}^{n} \frac{FCF_t}{(1 + r^*)^t} - IO$$

Where:

FCF_t: the annual expected income cash flow for period *t*

IO: the initial cash outlays

r^*: the risk-adjusted discount rate

In addition, according to Panteliasa (2009):

$$r^* = r_{rf} + \beta r_p$$

$$\beta = \frac{cov(\tilde{R}, \widetilde{R_m})}{\sigma_m^2}$$

Where:

r^*: the *MARR*

r_{rf}: the risk-free discount rate

r_p: the risk premium

β: the beta of the investment

$cov(\tilde{R}, \widetilde{R_m})$: the covariance of the return of the investment regarding the equivalent market portfolio

σ_m^2: the variance of the market portfolio itself

The beta of the investment can be calculated through either the Arbitrage Pricing Model (APM) or the Capital Asset Pricing Model (CAPM). In APM, the risk is assumed to be a function of market variations and expected returns; while in CAPM, the risk is assumed to be the variance of the returns (Senerivatne and Ranasinghe 1997; Bodie et al. 2005). Based on the beta estimation, a meaningful risk-adjusted rate of return is calculated, called the Minimum Acceptable Rate of Return (MARR). MARR is the minimum discount rate that the investor accepts and makes the investment profitable. In other words, if the discount rate falls below the MARR, the investor will not invest in the project.

Another way to estimate the investment risk is through calculating the probability that the expected rate of return falls short of the targeted MARR value (Seneviratne and Ranasinghe 1997). By specifying the probability distribution of IRR, the investment risk can be quantified by calculating the exceedance probability Pf, which is equivalent to the probability that the IRR is less or equal to the MARR, namely:

$$P_f = P(R \le r^*) = \int_0^{r^*} \varphi_R(r)dr \quad , r \in R$$

Where:

r^*: the *MARR*

$\varphi_R(r)$: the probability density function (pdf) of *IRR*

Similarly, the mathematical formulation to estimate the probability that the expected NPV falls short of the targeted value is (Javid and Seneviratne, 2000):

$$P_f = P(NPV \le V) = \int_0^{V} \varphi_{NPV}(npv)dnpv \quad , V \in NPV$$

Where:

V: the targeted value from the project

$\varphi_{NPV}(npv)$: the probability density function of *NPV*

However, there are shortcomings in these methods. It is difficult to find certainty equivalent coefficients (a_t) for every type of risk in CEA method; it is also challenging to estimate beta and the risk-adjusted discount rate in the RA method because it requires the appropriate market portfolio as an input. The market portfolio, however, is difficult or even impossible to collect. As a result, most analysis conducted so far aim at obtaining the statistical distribution of IRR and estimating the investment risk by comparing the standard deviation to the corresponding standard deviations of similar projects (Seneviratne and Ranasinghe 1997).

Another approach to evaluating the investment risk is that the failure probability is formulated as a conditional probability. More specifically, it is the probability of the net operation income being less than zero under the condition that the discount rate is equal to the targeted MARR value. The expression is:

$$P_f = \Pr\{NPV(Net \;\; Operating \;\; Income) < 0 | r = MARR\}$$

5.2.2 RISK COST

The concept of risk cost comprises two aspects: one is the risk failure probability and the other is the total cost related to the risk failure. The risk failure probability can be calculated through Monte Carlo Simulation introduced previously. The total cost of a risk is the sum of all the expenses and costs related to the risk, including risk control risks, retained losses, transfer costs, adjustment expenses and administrative costs (online source: International Risk Management Institute). This total cost is more project-specific. Risk cost

may vary from risk to risk and project to project based on the specific conditions of the project itself and the information availability. The basic relationship is:

$$Risk\ \ cost_i = P_f^i \times \ \ C_i$$

Where:

$Risk\ \ cost_i$: the risk cost of the *i*th risk

P_f^i: the failure probability due to the *i*th risk

C_i: the cost that related to the *i*th risk

For the whole project, the risk cost can be:

$$Risk\ \ cost = P_f \times C = \sum_{i=1}^{n} P_f^i \times \ \ C_i$$

Where:

P_f: the failure probability of the project

C: the sum of all the related cost

5.2.3 TAYLOR'S EXPANSION

Taylor's expansion is a useful analytical tool to give comprehensive information on the mean and variance of the function with variables. As illustrated before, the risk failure probability of a project is a function of the risks that affect the total revenue and the total costs:

$$P_f = f(r_1^r, r_2^r, r_3^r \ldots r_n^r, r_1^c, r_2^c, r_3^c \ldots r_n^c)$$

By applying the Taylor expansion,

$$E(P_f) = f(\mu) + 1/2 \sum_{i=1}^{n}\sum_{j=1}^{n}\left(\frac{\partial^2 f}{\partial r_i^t \partial r_j^t}\right) Cov[r_i^t, r_j^t]$$

$$V(P_f) = \sum_{i=1}^{n}\sum_{j=1}^{n}(\frac{\partial f}{\partial r_i^t})_\mu(\frac{\partial f}{\partial r_j^t})_\mu \ \ Cov[r_i^t, r_j^t]$$

More specifically, if x_i and x_j are independent,

$$E(P_f) = f(\mu) + 1/2 \sum_{i=1}^{n}(\frac{\partial^2 f}{\partial {r_i^t}^2}) \ \ V[r_i^t]$$

$$\mathrm{V(P_f)} = \sum_{\mathrm{i=1}}^{\mathrm{n}} (\frac{\partial \mathrm{f}}{\partial \mathrm{r_i^t}})^2 \ \mathrm{V[r_i^t]}$$

Where:

t equals to *r* or *c*, representing the revenue or cost

$E(P_f)$: the expectation of failure probability

$V(P_f)$: the variance of failure probability

$Cov[r_i^t, r_j^t]$: the covariance of the variable r_i^t and r_j^t

$V[r_i^t]$: the variance of variable r_i^t

With the mean and variance defined for each of the risk variables in the failure probability, the mean and variance of the failure probability can be obtained through Taylor's expansion, which provides an analytical insight in the failure probability.

5.2.4 MONTE CARLO SIMULATION

Monte Carlo Simulation is a widely applied computational algorithm which is based on a repeated random sampling process to calculate numerical results. This method uses parameters which can reflect the probability density functions of variables as inputs. Consequently, the repetitive calculations take the randomly selected combinations of the inputs into consideration. The outputs of the simulation are the results which are presented in a cumulative density function or probability density function.

As presented previously, the equation to estimate the failure risk is:

$$P_f = \Pr\{PV(Net\ \ Operating\ \ Income) < 0 | r = MARR\}$$

And

$$NPV = \sum_{t=1}^{n} \frac{FCF_t}{(1+r)^t} - IO$$

$$IO = \sum_{t=1}^{n} \frac{FCF_t}{(1+r)^t}$$

More intuitively, the failure probability can be expressed as:

$$P_f = \Pr\left\{\sum_{t=1}^{n} \frac{Total\ \ revenue_t}{(1+r)^t} - \sum_{t=1}^{n} \frac{Total\ \ cost_t}{(1+r)^t} < 0 \middle| r = MARR\right\}$$

There are lots of risks factors that affect the total revenue and total cost of a project, making it a more stochastic value with a distribution rather than a deterministic value. Each of them can be deemed as an input variable of the total revenue and total cost models. In other words, the total revenue and total cost are functions of different risks. The relationship can be expressed as:

$$Total\ \ revenue = f(r_1^r, r_2^r, r_3^r \ldots r_n^r)$$

Where:

r_i^r: the *i*th risk variable that can affect the revenue cost

Similarly, the total cost can be expressed as:

$$Total\ \ cost = f(r_1^c, r_2^c, r_3^c \ldots r_n^c)$$

Where:

r_i^c: the *i*th risk variable that can affect the total cost

Finally, the failure probability is a function that contains all the variables included in the total revenue and total cost model. Namely:

$$P_f = f(r_1^r, r_2^r, r_3^r \ldots r_n^r, r_1^c, r_2^c, r_3^c \ldots r_n^c)$$

In fact, to quantify the risks is to deal with a wide range of risk variables. By defining the distribution of each of the risk variables, the failure probability can be obtained by the Monte Carlo Simulation. Monte Carlo Simulation has been widely applied in quantifying risks. For example, Javid and Seneviratne (2000) applied Monte Carlo Simulation to obtain the distribution of NPV of an airport parking project and compare it to the target value (Pantelias 2009).

5.2.5 METHOD OF MOMENTS

The method of moments is a useful approach to dealing with complex estimations, especially multidimensional integrals. This method is different from the traditional statistical method of moments since it is not necessary to set equal numbers of distribution moments and sample moments. In addition, it is not necessary to run numerous simulation processes and the result is in closed form. The method of moments was originally developed in the structure reliability and safety area by Zhao and Ono (2001) and applied in to the transportation area by Zhang and Damnjanovic (2006). The higher-order central moments (usually the fourth moment) of the limit state function are used to calculate the failure probability and the accuracy of the method of moments has been proven by Zhang and Damnjanvic (2006).

The method of moments is derived from the "strength-stress inference" model. The stress-strength inference method is one of the most commonly used structure reliability methods. This method deals with two random variables defining the stress (demand) and strength (capacity). A failure occurs when the value of stress (demand) is larger than that of strength (capacity). The limit state function can be expressed as:

$$G(X,Y) = strength(X) - stress(Y)$$

Where:

$G(X,Y)$: the limit state function

X: the random variable that affects the strength (capacity)

Y: the random variable that affects the stress (demand)

In the case of PPP project, the total revenue is deemed as the strength model and the total cost is regarded as the stress model. Correspondingly, *X* and *Y* can be expressed as:

$$X = r_1^r, r_2^r, r_3^r \dots r_n^r$$
$$Y = r_1^c, r_2^c, r_3^c \dots r_n^c$$

Where:

r_i^r: the *i*th risk variable that can affect the revenue cost

r_i^c: the *i*th risk variable that can affect the total cost

The failure is expressed as an event$\{G(X,Y) \leq 0\}$. The probability of failure can be established as an n-dimensional probability integral:

$$P(failure) = Prob[G(X,Y) \leq 0] = Prob(strength \leq stress) = \int_{G(X,Y)\leq 0} f(X,Y)dXdY$$

Where: $f(X,Y)$ is the joint probability density function of the basic random variable X and Y.

In order to obtain the reliability index of the fourth order method of moments, the central moments of the limit state function of $G(\boldsymbol{X}, \boldsymbol{Y})$ are introduced. The moments of the function $G(\boldsymbol{X}, \boldsymbol{Y})$ can be expressed as (Damnjanvic 2006):

$$\mu_G(\boldsymbol{X}, Y) = \int G(\boldsymbol{X}, Y) f(\boldsymbol{X}, Y) d\boldsymbol{X}\, dY$$

$$M_{kG}(\boldsymbol{X}, Y) = \int (G(\boldsymbol{X}, Y) - \mu_G)^k f(\boldsymbol{X}, Y) d\boldsymbol{X}\, dY \qquad \text{for } k \geq 2$$

Where: μ_G and M_{kG} are the mean and the k-th central moment of $G(\boldsymbol{X}, Y)$.

To avoid complex calculations, the central moment is introduced by choosing a finite number of points and their corresponding weights (Christian and Baecher 1999; Zhao and Ono 2000):

$$M_{k\boldsymbol{X}} = \sum_{j=1}^{J} P_j (u_j - \mu_{\boldsymbol{X}})^k$$

Where: u_j represents the j-th estimating point and P_j stands for the corresponding weight.

By using Hermit integration and the inverse Rosenblatt transformation, the equation above can be rewritten as (Damnjanvic 2006):

$$M_{k\boldsymbol{X}} = \sum_{j=1}^{J} P_j (G[T^{-1}(u_j)] - \mu_{\boldsymbol{X}})^k$$

Where:

$T^{-1}(u_j) = F^{-1}[\Phi(u_j)]$

F: the cumulative distribution function of the random variable

Φ: the cumulative standard normal probability

$T^{-1}(u_j)$ stands for the inverse Rosenblatt transformation at the estimating point u_j with the corresponding weight P_j. To solve the computational problem, the approximated limit state function $G(\boldsymbol{X}, Y)$ can be expressed as (Zhao and Ono 2001):

$$G^*(\boldsymbol{X}, Y) = G^* = \sum_{i=1}^{n} (G_i - G_\mu) + G_\mu$$

Where:

$G_\mu = G(\mu)$

$G_i = G[T^{-1}(u_j)]$

G_μ is the original limit state function at mean value of all basic variables; and G_i is the original function where every variable is set at its mean value except for the i-th variable, using the inverse Rosenblatt transformation at estimating point u_j.

With the mean and variance of each risk variable, the failure probability and reliability of the project can be obtained through method of moments.

5.3 Summary

This chapter introduces tools and models applicable to conducting the financial variability and risk analyses of PPP projects. Detailed discussions of the toolkit developed by the World Bank and PPIAF and the BCA.Net tool designed by FHWA are provided. In addition, mathematical models, including Taylor's expansion, Monte Carlo Simulation, and the method of moments, were discussed in terms of quantifying risks associated with PPP projects. For a specific project, both the public authority and private sector can utilize these resources to assess the financial variability and risks of the project.

6. CONCLUSIONS AND RECOMMANDATIONS

This report provides a comprehensive synthesis of information on Public Private Partnerships (PPPs) based on review of a wide range of literature. The history and development of PPPs in developed countries/regions and developing countries/regions is introduced. With the UK, the U.S., Australia, China, India and Africa (with special references to South Africa) as examples, different PPP characteristics in countries with different levels of industrialization and modernization are discussed. Subsequently, an overview of risk analyses in PPPs is presented from the perspective of risk identification, risks quantification, and risk allocation. Major conclusions from this report include:

1) With the expansion of the world economy, the need for infrastructure services is increasing, leading to the situation where public funding alone is insufficient to meet the demands for preserving existing and building new infrastructure. Public-Private Partnerships, a new and innovative approach, has therefore been gaining popularity in a number of countries, yielding many successful projects. Moreover, PPPs are becoming recognized by more and more countries as one of the most cost-effective alternative funding mechanisms for infrastructure services.

2) PPPs have been applied more in developed countries so far; and the developed countries are more experienced with the PPP process. Compared with developing countries, developed countries have more mature and sophisticated legislation and regulations to standardize the process of utilizing PPPs. In addition, the political and economic environment is more stable in developed countries, which in turn results in higher government creditability and a healthier environment for PPPs. In contrast, developing countries still have a long way to go before integrated mature PPP processes and supporting environment can be in place.

3) Risk analysis is the core part of the PPP procurement. Organized methodologies do exist for identifying risks, including the WBS-RBS method, checklist method, flow chart method, as well as the questionnaire and the expert consultant method. The key risk that warrants special attention is the investment risk as it is related to the financial viability of a PPP project. As for risk allocation, it is more a project-specific process. In other words, a risk may be allocated to different sectors in different projects depending on the detailed concession terms. The allocation of risk is determined through negotiations by all the participants in the project before the contract is signed.

4) Two web-based tools and three mathematical models are presented as methods to conduct financial variability analysis and quantify risks associated with PPP projects. The toolkit developed by the World Bank and PPIAF can be used to determine whether PPP is the best suitable form for a project, through assessing the financial viability and money for value of the project. BCA.Net, designed by FHWA, is another well-developed tool specifically for highway-related projects, with which detailed statistical information on benefit-cost ratio, net benefit value

and rate of return can be obtained to assess the financial viability of the project. In addition, risk quantification and simulation models, such as Taylor's expansion, Monte Carlo Simulation and method of moments, can serve as solid basis for quantifying risks associated with PPP projects.

In addition to the conclusions presented earlier, future research to compliment and further strengthen the findings of this report is recommended in the following sections:

1) This report is mainly based on information synthesized from a large volume of literature. As the next step of the work, case studies using data from real-world projects should be developed to demonstrate the application of the tools and models.

2) There is no doubt that missing links and inconsistent results will surface when these tools and models are applied to real-world problems. Therefore, efforts must be made to develop the missing knowledge and improve existing tools so that more consistent results can be achieved, providing reliable information to decision makers in evaluating the feasibility and financial viability of PPP projects.

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