Private Partner Selection and Bankability Assessment of PPP in Infrastructure Projects.

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Abstract

The use of Public Private Partnerships (PPPs) for infrastructure projects has garnered much international attention over the past few decades. The inclusion of private investors and operators has expanded and improved the quality of public services. When entering a PPP, the most important decision for governments is the selection of the private partner. The selection process should identify and pre-qualify those prospective partners that have the best potential for the successful development and delivery of the proposed PPP project. A successful partnership should ensure that both partners, i.e. the public sector department and the private corporation, have an effective business relationship. While private partner selection is a critical factor, essential for the successful completion of PPP projects, there is a general lack of decision making tools available to assist governments in the selection process. This research aims to assist governments with such decisions by (1) identifying and studying the criteria for selecting the most appropriate private partners for PPP projects; (2) developing a model to select the best private partner; and (3) developing model(s) and a framework that can assess a project's risk profile from the financing agencies' perspective.

This research proposes two integrated models. The first model is developed to select the best private partners for PPP infrastructure projects. The selection process is modeled using a fuzzy analytic network process (FANP) and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method to adequately handle the process's imprecision, vagueness and uncertainty. This model takes into account the possible dependencies among selection criteria as well as between alternatives and selection criteria, providing a more realistic solution than deterministic models which ignore such interdependencies. The second model is developed to improve the credit

evaluation procedure for evaluating private partners for PPP projects, wherein their bankability is assessed before accepting their request to borrow funds. Publicly-available financial information is utilized to drive a clear understanding and sound interpretation of a project's free cash flow and its forecasted future free cash flow. In this model, a set of criteria are defined from a survey conducted with credit experts, and then the TOPSIS method is used to calculate the weights of the criteria. Four criteria are used to assess private partners' financial ability based on the detailed free cash flows in multiple scenarios. The developed framework is applied to six PPP projects in Africa where the private partners of these projects were analyzed, evaluated, and prioritized based on their bankability. The model's result provides creditors with two benefits; it ranks the private partners according to their overall suitability based on the projects' characteristics and creditors' requirements, and it calculates the maximum amount a creditor would be willing to pay as a loan to each of the partners.

The developed framework is expected to contribute to the body of knowledge in four main aspects. First, it provides a structured tool for governments and decision makers to use to evaluate potential private partner's ability to achieve their strategic objectives, as well as identifying the partners' strengths and weaknesses. Second, the decision-making tool accounts for influential factors other than the already widely-considered technical and financial aspects, such as safety, environmental, political and managerial concerns. Third, the bankability assessment model combines risk and credit analysis, which enables creditors to rank projects according to their overall suitability based on a projects' characteristics and the creditors' requirements. Finally, the developed framework provides credit analysts with a tool to quantify the risks affecting projects, and to calculate the maximum amount a creditor would be willing to pay as a loan to each of the projects.

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To the soul of my beloved mother and father.

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List of Abbreviations

ADB	African Bank
AHP	Analytical Hierarchy Process
ANP	Analytical Network Process
ADSCR	Annual Debt Service Coverage Ratio
BOT	Build Operate Transfer
BOOT	Build Own Operate Transfer
BOO	Build Own Operate
BTO	Build Transfer and Operate
CAPX	Capital Expenditure
CFADS	Cash Flow Available for Debt Services
DSCR	Debt Service Coverage Ratio
DFI	Development Finance Institution
DEA	Data Envelopment Analysis
EIB	European Investment Bank
EPC	Engineering, Procurement and Construction
FANP	Fuzzy Analytical Network Process
FCFF	Free Cash Flow to the Firm
IRR	Internal Rate of Return
IFC	International Finance Corporation
LLCR	Loan Life Coverage Ratio
MMRA	Major Maintenance Reserve Account
MPPA	Million Passagers per Annam
OACA	Office de L'Aviation Civile et des Aéroports
O&M	Operations and Maintenance
OPEC	Organization of the Petroleum Exporting Countries

PPP	Public Private Partnership
PFI	Private Finance Initiative
R_d	Bond`s Rate of Interest
R_e	Required Rate of Return
SPC	Special Purpose Company
SPV	Special Purpose Vehicle
TSA	Technical Support Agreement
TSP	Technical Support Provider
TFN	Triangular Fuzzy Number
VAT	Value Added Tax
WACC	Weighted Average Cost of Capital
WK	Working Capital

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Chapter 1: INTRODUCTION

1.1 General

Many countries have established Public-Private Partnerships (PPP) for large and complex infrastructure projects as a way to reduce costs, minimize delays and optimize financial risks. PPPs are a collaborative effort between public and private sector organizations to maximize the quality of infrastructure projects (Ahadzi and Bowles, 2004). Depending on the operating country, the PPP terms can cover an array of transactions in which the private sector is given the right to operate, ranging from relatively short-term management contracts (with little or no capital expenditure), through concession contracts (which may encompass the designing, building, financing, and servicing of the entire construction and operation), to joint ventures where there is a shared ownership between the private and public sectors. In other words, PPPs fill a space between traditional government projects and full privatisation (Grimsey and Lewis, 2005). The PPP framework is considered an effective instrument for closing funding and financing gaps, as well as an opportunity to utilize the private sector's expertise to increase the efficiency of project management and service operations in the infrastructure sector (Grimsey and Lewis, 2004; Yescombe, 2011).

PPPs have at least two dimensions. The first is purely financial where PPPs enable the public sector to make use of private financial capital in a way that unlocks productive opportunities for the government and the private sector. The second dimension is organizational where PPPs are viewed as official cooperation agreements expressed through the establishment of new organizational units (Hodge et al., 2010). According to Akintoye et al. (2001), PPPs have been used in many countries around the world, which has led it to have to different definitions. Based on an extensive review of relevant literature (Tang et al., 2010), in Canada, the Council for Public-Private Partnerships (2004) defines a PPP as a cooperative collaboration designed to meet clearly defined public needs, involving public and private sector organizations and built on the expertise of each party, structured to ensure the effective allocation of resources, risk, and rewards. Along the same line, Zhang (2005) contended that PPPs cover a wide spectrum of infrastructure projects and services involving the resources and expertise of the private sector in the delivery of services and/or facilities for public use. Ng and Loosemore (2007) emphasized that PPPs should not be confused with privatization, which involves the outright sale of a government entity to a private organization so that government has no further interest in the entity. The ultimate aim of a PPP is thus to bring the private sector's expertise and discipline into the management of providing services to the public, with the investment of private financing, and to thereby deliver superior public services.

PPPs are developed with three broad objectives: to deliver significantly improved public services by improving both the quality and the amount of investment; to unlock the full potential of public sector assets, including state-owned businesses, thereby offering improved value for the taxpayer alongside wider benefits to the economy; and to allow stakeholders to receive their fair share of the benefits of PPPs. In addition, vital to any successful PPP initiative, the risk associated with each component of a project as well as each risk factor are allocated to those parties with direct control over them.

North African countries have a critical need to improve their infrastructure to address the multiple demands of a growing population. Due to years of underinvestment, the quality and quantity of North African countries' infrastructure services lags behind those of other regions, and it is estimated that the region will need $100 billion per year over the next 20 years to meet their infrastructure needs. However, fiscal constraints facing the region's governments indicate a large financing gap of approximately $30–40 billion per year. Mobilizing additional private financing and infrastructure expertise through PPPs can help to improve infrastructure provision by raising operational standards and efficiency while reducing the load on government budgets.

Nonetheless, in Africa, the volume of private investment in infrastructure and the absolute number of projects is the lowest in the North African region. The majority of PPP projects are clustered in the power sector in western North African countries. The International Finance Corporation IFC, financial institution, and the PPIAF, along with other vehicles such as the Arab Financing Facility for Infrastructure, are encouraging North African countries to create the necessary legal and regulatory framework for PPPs; as well as to facilitate the networking and sharing of experience among regulatory agencies and other similar organizations. While the infrastructure needs in the North African region are large, collaboration between the public and private sectors can help to provide access to quality infrastructures that will in turn contribute to the economic growth and development of the region (Auriol and Blanc, 2007).

1.2 Research Motivation

The lack of capital funding is increasing governments' motivation for PPP projects, but poor selection of private partners leads to execution difficulties, failures in project delivery and dangerous impacts on a country's economy. A review of the state of the art and current practices for selecting private partners in PPP projects indicates a strong need for a structured and objective selection methodology, one that can overcome the limitations of previous studies and current practices. The present research aims primarily to study, investigate, develop, and validate a new methodology for selecting the private partners for PPPs, while accounting for vagueness and uncertainty. Such a methodology will enable government personnel to make informed decisions and thereby enable successful project delivery.

1.3 Research Objectives

The main objective of this research is to develop a model that serves as a decision-making aid in the private partner selection process of PPP infrastructure projects and a model that can prioritize projects based on their bankability and estimate the maximum level of funds each project can raise from financial institutions. To achieve this overall objective, the following sub-objectives had to be achieved:

1. Investigate the literature review and the current practices in private partner selection, identifying gaps and limitations.
2. Study and identify the criteria for selecting the most appropriate private partner to work with a government agency on a PPP project.
3. Develop a model to select the most appropriate private partner.
4. Develop a model to quantify risk factors and assess the bankability of private partners in PPP projects prior to accepting their request to borrow funds.
5. Develop an automated tool that incorporates the developed models.

1.4 Research Methodology

Figure 1.1 shows the steps followed during this research. The research began by establishing a general problem statement that formed the main motivation for this research. An extensive literature review was performed, mainly addressing the selection of private partners in PPP projects. After gaps in the existing literature were clearly identified, a set of research objectives were established. The developed model is designed to select the appropriate private partner for infrastructure PPP projects. The model incorporates the selection process using the Fuzzy Analytic Network Process (ANP) and Fuzzy Weighted Average (FWA) techniques to function well with the imprecision, vagueness and uncertainty that always accompanies this process. This model can guide government officials, helping them to evaluate their potential partner's ability to achieve their strategic objectives, and to pinpoint their partner's strengths and weaknesses in order to best exploit the opportunities presented by today's construction business environment while neutralizing the most likely threats. Real world case studies are presented to illustrate the implementation and utility of the proposed model.

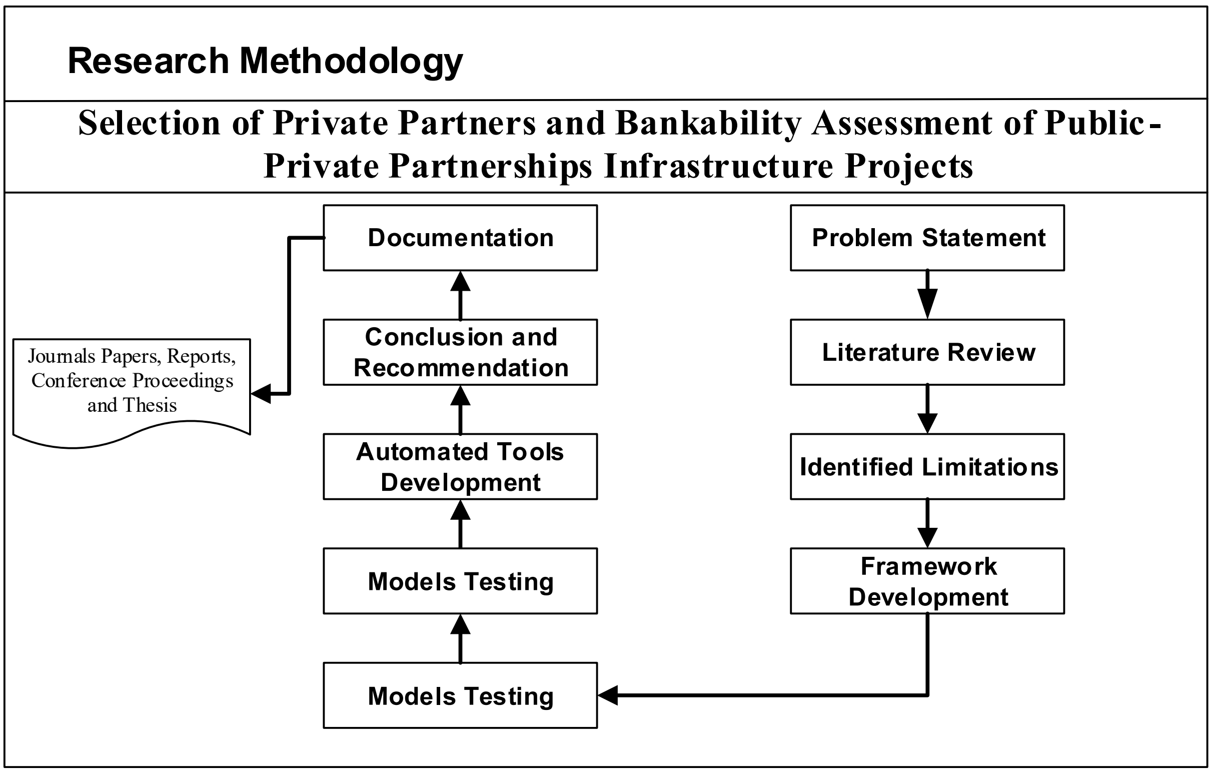


Figure 1-1: Research Methodology Overview

As illustrated in Figure 1-1, the research methodology consists of the following:

1. Background knowledge codification and problem identification;
2. Data collection through questionnaire surveys and case studies. This research collected the required information by analyzing questionnaire surveys from a variety of organizations and institutions selected for this study;
3. Development of a model using the Fuzzy ANP and the TOPSIS method for private partner selection;

4. Development of a framework to help sponsors to evaluate/assess a project from the lenders' perspective as a way to guarantee a project's bankability;
5. Verification and evaluation of the developed framework with real case studies; and
6. Assessing the model in a conclusion section and suggesting recommendations for future research.

1.5 Thesis Overview

This thesis is presented in eight chapters. The second chapter presents a comprehensive literature review, oriented towards evaluating existing tools and techniques for selecting private partners for PPP infrastructure projects. The identified gaps in the literature are highlighted at the end. The third chapter explains the developed methodology in detail. It consists of two main parts; the first part addresses the Private Partner Selection Model, and the second part explains the Bankability Assessment of the private partner in PPP projects Model. Chapter four presents the data collection method and the case studies utilized for the framework evaluation. Two questionnaire surveys were conducted to identify the private partner selection criteria and the bankability assessment factors for PPP projects Chapter five explains the private partner selection model implementation, along with its application on four real case studies. The components of the developed model are explained in detail, with step by step calculations of one of the case studies. A complete analysis of the obtained results of all four case studies is presented at the end of the chapter. Chapter six presents the bankability assessment model's implementation, along with its application on six real projects in Africa. Chapter seven describes the developed automated software tool, its input/output interface, and its main features. Finally, chapter eight presents a summary of this thesis, highlighting the developments made in the research, along with the research contributions and limitations. It also lists some proposed opportunities for future work.

Chapter 2: Literature review

2.1 General

This chapter describes the literature relevant to this research, presented in five main sections. The first section describes the basics of PPP and the private partner selection process from a sponsor's perspective, such as that of creditors, banks, or private equities. The second section describes the financial analysis of PPP projects. The risk factors of PPP projects found in the literature are presented in the third section/The fourth section outlines the basics of the analytical network process for Multiple Criteria Decision Making (MCDM). Finally, the fifth section highlights the gaps and limitations identified in the literature on private partner selection in PPP projects.

2.2 PPP Overview and Partner Selection

According to the World Bank (2006), there is a serious lack of infrastructure in many African countries, a factor which is one of the most significant limitations to economic growth and achievement of the Millennium Development Goals. Africa is already spending \$45 billion a year on infrastructure. The bulk of this infrastructure spending comes from domestic sources. However, infrastructures' providers waste \$8 billion a year on excessive staffing, distribution losses, under-collection of revenues and inadequate maintenance. African utilities are unable to collect close to \$2.4 billion a year of their billed services. A more efficient use of existing resources could release an additional \$17.4 billion in financing for infrastructure every year. However, even if the full potential of efficiency gains could be realized, a substantial funding gap of US\$31 billion would remain, particularly for water and power infrastructures in fragile states.

Closing Africa's US\$31 billion-per-year infrastructure funding gap is a critical effort that individual countries and the international investment community can make to address the massive shortfalls in infrastructure development. External financing for Africa's infrastructure was buoyant in the years leading up to the global financial crisis, swelling from $4 billion in 2002 to $20 billion in 2007. Domestic financing in many countries during the same period benefitted from market growth and the high prices of natural resources. The World Bank and the International Monetary Fund have encouraged developing countries to implement the system of public private sector participation through financial assistance schemes. PPPs are being used across Europe, in Canada and in the US, as well as in a number of developing countries as part of a general trend to increase the involvement of the private sector in the provision of public services, under the rubric of privatization, deregulation, outsourcing and downsizing of government. The trend towards PPPs in developing countries includes, in particular, investment in infrastructure projects (i.e. energy, telecommunications, transport and water) as well as in the port sector. (Panayides et al., 2014). Table 2.1 represents the role of PPP projects for eight countries or regions: Canada, the European Union, India, Japan, Spain, Taiwan, the United Kingdom and the United States. For example, in Canada, the government expected that a $1.2 billion in PPP Fund, would directly leverage a $5 billion in PPP infrastructure investment (Podkul, 2010).

However, the current global financial crisis has seriously hindered that growth, reducing the funds available for infrastructure. This situation further underscores the need for a massive effort to overhaul Africa's infrastructure and to examine the demand for it. Pressure to change the standard model of public funding arose initially from concerns about the level of public debt, which grew rapidly during the economic crisis. Governments sought to encourage private investments in infrastructure regardless of the procurement approach. The participation of the private sector has been offered through the public private partnership (PPP) route using the Build-Operate-Transfer (BOT) model and its variants. A business relationship between a private-sector company and a government agency for the purpose of completing a project that will serve the public is the definition of a PPP project. PPPs in infrastructure projects are a powerful tool for achieving sustainable development in different countries (Abdel Aziz, 2007; Dey, 2010; Gunawan et al., 2000).

Table 2-1 PPP Projects in Different Countries

Country (region)	The role of PPPs in infrastructure projects	Source
Canada	The government expects the $1.2 billion PPP Canada Fund to directly leverage $5 billion in PPP infrastructure investment in Canada.	Podkul (2010)
European Union	PPP schemes will facilitate economic recovery efforts and therefore are promotable at the national and international levels.	EN (2009)
India	PPPs account for 36% (US$186 billion) of infrastructure projects in 2007–2012.	Roy (2010)
Japan	PPP investment doubled to ¥10 trillion between 2010 and 2020.	Cabinet-Office (2010)
Spain	PPPs accounted for €17 billion of railway and road projects during 2010–2011.	Alves (2010)
Taiwan	PPPs account for one third (NTD 3.99 trillion) of infrastructure built between 2008 and 2015.	PCC (2009a)
United Kingdom	Approximately £200 billion worth of investment is planned during 2011–2015, distributed among various economic infrastructure sectors. The majority of this investment will be provided by the private sector.	HM-Treasury (2011)
United States	California enacted comprehensive PPP-enabling legislation in 2009.	Gibbons et al. (2010)

2.2.1 PPP concept

The public private partnership (PPP) model is being increasingly adapted by many countries around the world as a means to provide infrastructure services. Evidently, rapid social and economic growth will continue to engender massive demand for investment in many countries (Jin, 2010). Similarly, increasing pressures on governments following the world-wide economic downturn suggests there will be an increasing demand for the use of PPPs. According to Garvin (2004), PPP has become the most popular choice for bringing private sector expertise and discipline into the management of the delivery of public services, alongside private financing. Gavin (2004) also states that PPPs make it possible to achieve greater value for investments, as they encourage more buildable and innovative designs, lowering capital and operating costs while ensuring higher operational standards. Jiao et al. (2011) andZhang (2005) also contend that PPPs cover a wide spectrum of infrastructure projects and services involving private sector resources in the delivery of services and/or facilities for public use. Many PPP projects are held up or even terminated due to the wide gap between private and public sector expectations and the lack of mechanisms to attract long-term financing from private sources at affordable rates (Business, 1996). There are many types of risks associated with a PPP project, which vary case by case (Sapte, 1997; Zayed and Chang, 2002).

2.2.2 PPP Models

In the broadest sense, PPPs can cover all types of collaboration across the interface between the public and the private sectors involved in delivering public infrastructure. The term PPP refers to a wide range of collaborations. Various approaches have been used to classify these collaborations. One of these is to refer to the wide variety of arrangements based on the involvement of the private and public sectors in the various phases of a project's life cycle (Pakkala, 2002). However, the most common way of referring to the different types of collaborations is based on the extent to which the responsibilities and risks are transferred from the public sector.

Figure 2.1 shows the risk transfer continuum and characteristics of various PPP models. The risk transfer to the private sector increases as we move from maintenance management to divestiture. Critical risks such as market risk are completely transferred to the private sector in the BOT and divestiture PPP models (Jin, 2009).

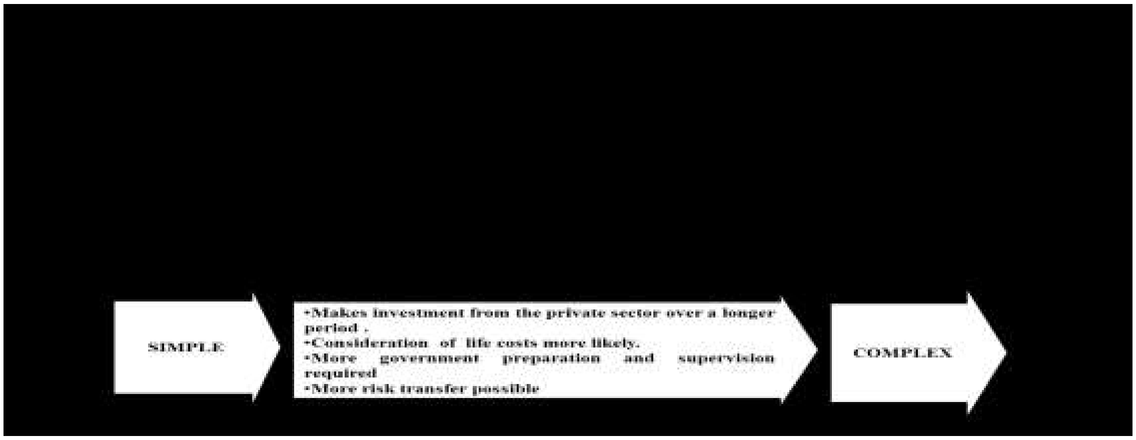


Figure 2-1: PPP Models' Risk Transfer Continuum and their Characteristics (adapted from World Bank, 2004b)

All of the aforementioned PPP models can be further grouped into two categories based on whether private sector participation is being sought for new projects or for existing facilities or services. The private partner responsibility varies based on the type of PPP model, as shown in Figure 2.2. For example, the Design Build Operate Maintain (DBOM) model requires higher private partner responsibility than Design Build Maintain (DBM).

Figure 2-2: PPP Models for New Projects and for Existing facilities (adapted from Eggers and Startup, 2006)

2.2.4 Types of Public Private Partnership:

Many types of PPPs are being used around the world. Most of them operate in similar ways, with only their names varying according to their country or locality, whereas in some cases there are major differences in how this approach is used. Some of the most commonly-used types of PPPs are listed below:

- Design Build Finance Operate (DBFO) – similar to BTO, where the government will retain title of the land and lease it to the private consortium over the life of the concession agreement (Levy, 1996);
- Operation and Maintenance (O&M) – the private company operates and maintains a publicly owned asset;
- Private Finance Initiative (PFI) – commonly used in the United Kingdom, with a strong emphasis on private financing;
- Build Operate Transfer (BOT) – one of the most traditional types of PPP, used in the early days mainly for transport-related economic infrastructure projects. BOT involves the construction of the facility as well as its operation. At the end of the contract period the facility will be transferred back into the hands of the government;
- Build Own Operate (BOO) – commonly used in Australia at the beginning of PPP projects;
- Build Own Operate Transfer (BOOT) – commonly used in Australia in the early days of PPP projects. Similar to BOT but with a larger emphasis on ownership;
- Build Transfer Operate (BTO) – a method of relieving the consortium of furnishing the high cost insurance required by a project during operation of the facility (Levy, 1996);

- Joint Venture (JV) – public and private sector jointly finance, own and operate a facility (Grimsey and Lewis, 2004); and
- Leasing – where all or a substantial part of all risks associated with funding, developing and operating a facility are assumed by the private sector, with the public sector entity taking the facility on lease.

2.2.3 PPP projects' contractual structure

The contractual structure of PPP projects includes a network of contractual agreements that determine the stakeholder's power distribution (Nikolaidis and Roumboutsos, 2013). PPP infrastructure projects' contractual structure provides a proper legal structure for the interrelations between the various project stakeholders through a complex network of contractual agreements. The most important benefit from this legal documentation is to define a project's structuring, including financing, to establish the overall fiscal environment. This includes the regulatory system and end user charges, controlling the competition and facilitating the negotiation of stakeholders' rights, the preparation of documents, and allocating the risks and insurance requirements (Walker and Smith, 1995). A reliable contractual structure is one of the critical factors for the success of PPPs in infrastructure development (Zhang, 2005). Merna and Dubey (1998) have established that a solid contractual structure will enable the effective allocation and management of risks to a project's parties.

2.2.4 Concession Agreement

The concession agreement is the contract signed between the public sector entity and a project's company. The sponsors of a project's private partnership company include companies that are owners of the project, contractors, operators, and equipment suppliers (Yescombe, 2002). If there is more than one sponsor in a project's company they need to sign a shareholder agreements. A shareholders' agreement includes all the articles of association for that project's company; its directors, the regulation of its shareholders' equity contribution, its division policy and restrictions on the disposal of shares until the project's completion or repayment of loans (Tiong, 1997; Walker and Smith, 1995). A concession agreement is the key legal document that defines the rights of the public and private sector parties and that also establishes the framework for the allocation of risk and rewards among them. Concession agreements also provide for regulations in the market, curbing tendencies toward monopoly behaviour (Hodge and Greve, 2007). This agreement is the core document from which the system of contractual documents emerges and ties all the participants in the project together, establishing the framework that enables the equity and debt financing of a project and its implementation (Zhong and Mol, 2008). From the financiers' perspective, a concession agreement should be structured so that it provides lenders with a satisfactory level of financial security (Clifton and Duffield, 2006; Liou and Huang, 2008; Medda, 2007). The complexity in contractual relationships between participants, combined with the long concession periods makes PPPs distinct from the traditional infrastructure development routes in many ways. First of all there is a broad range of uncertainties and risks associated with PPPs; the concessionaire assumes more responsibilities and more risks than traditional contractors, and the financial issues in PPP projects are more complicated. Moreover, the allocation of risks and rewards among the various participants is a difficult and complicated task (Zhang, 2004).

The typical contractual structure of PPP infrastructure projects as indicated in Figure 2.3, which is comprised of several key contractual agreements: concession agreements, loan agreements, a shareholder's agreement, operating contracts, advisory agreements and construction contracts (Hamilton, 1996). Six major participants are identified in every PPP project: as shown in Figure

2.3, the equity providers, the public entities, debt providers, general contractor, suppliers and operators.

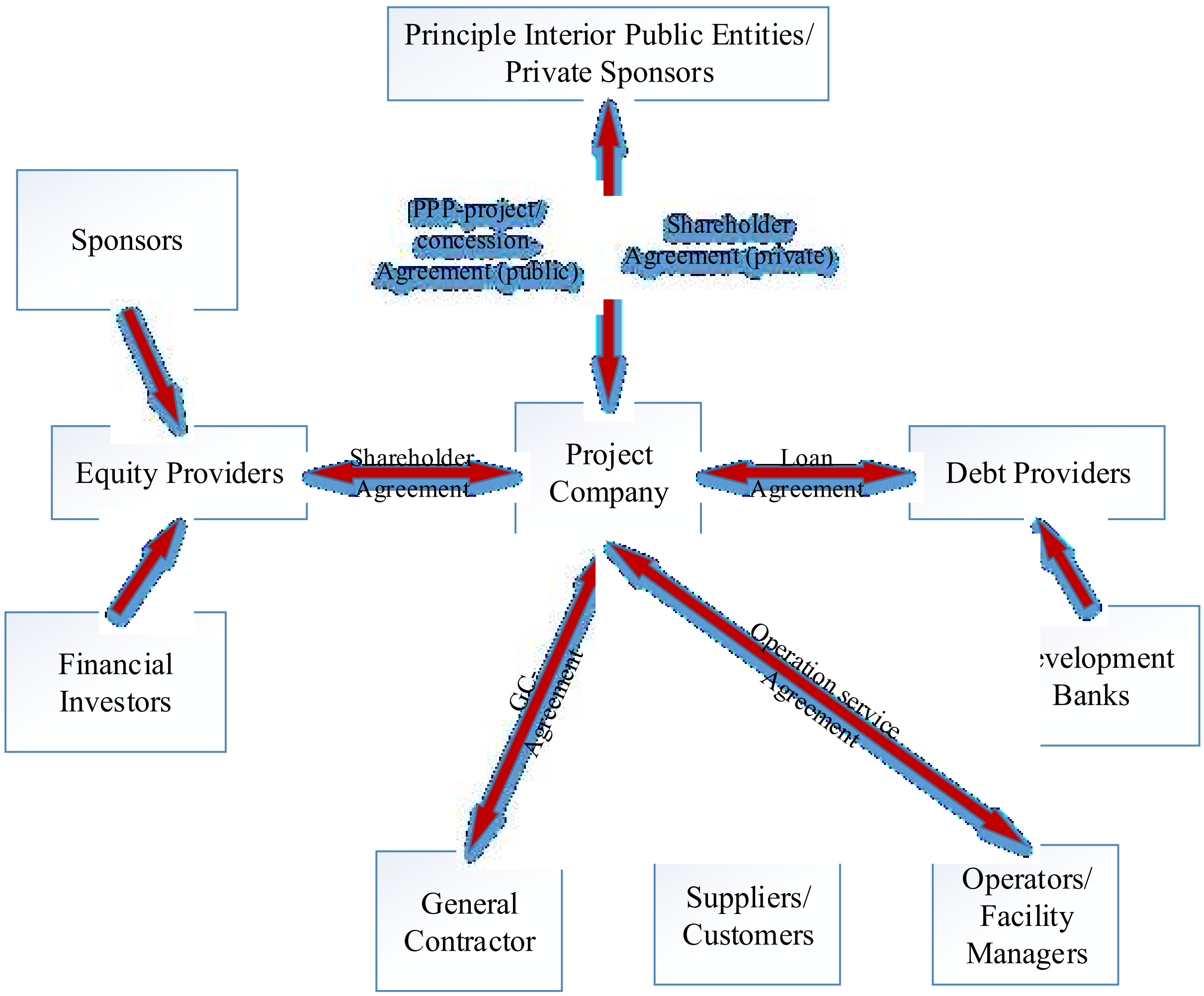


Figure 2-3: Infrastructure as an asset class (Weber, 2010)

Consultants and advisors are utilized to perform the necessary due diligence to ensure a project's feasibility. Once a project is considered achievable, the objective of the next phase is to provide a detailed and thorough assessment of its economic sustainability of the project.

It worth mentioning that non-success situations in PPP projects can occur once the facility begins its operations, i.e., during the concession period. During the regular commercial activity, in fact, the level of competition of the PPP project may appear to be unsatisfactory with respect to competing facilities and, in even worse scenarios, either the winning bidders may decide to withdraw from the PPP or the Public Institution (i.e. the Port Authority) may decide to cancel the concession contract prematurely (Olivier, 2010). The important role of government engagement, especially in a volatile economic situation, should not be ignored.

2.2.5 Critical success factors for PPP projects

Researchers have proposed various lists of critical success factors for PPP projects, summarized as risk identification and allocation, financing strategies, the tendering process, concessionaire selection methods and criteria, and many more, such as the government's roles and responsibilities. The most important factor is the decision making process prior to starting a PPP project (Zhang, 2005). Many decisions are required of the public contracting authority that will oversee a PPP process, including the initial decision of whether to carry out a project as a PPP or via traditional procurement procedures. Other major considerations are: what phases to delegate to the private partner, what risks will be transferred to the private partner and which partner to choose for a PPP project. Much attention has been paid to the first three issues, while only a small proportion of the research contributions focus on the selection of the private partner.

In general, a PPP project's private partner is awarded their contract through a public tender, serving the public's interest by means of the competition among contractors. The tendering processes of PPPs are more complicated and costly than those of conventional procurement processes (Kwak et al., 2009). Addressing tendering procedures is strategically relevant, especially in PPP infrastructure projects. Most of these markets are characterized by oligopolistic competition, with actors taking full advantage of their strategic power. In cases like this, government contracting authorities must design the tendering process so as to maximize their outcome (Meunier and Quinet, 2010). There are three relevant issues regarding tendering in PPP: the procedure to follow for the tender, where the phases can form the PPP tendering procedure; the different awarding methods used in PPP projects; and the evaluation criteria used in those awarding methods.

An understanding of PPP success in infrastructure projects has to take into account some of the appropriate dimensions in order to capture the degree of success in the diverse moments of a project's overall timeline (Panayides, 2014):

- The degree of private commitment in the deal: the level of private commitment, which is agreed to at the time of the financial closure, has been expressed as a tool capturing the attractiveness of the PPP proposal and the degree of success from a public perspective (Vining and Boardman, 2008).
- Operational performance over time: a parameter that can be measured by absolute output values like kilometers of construction, or by relative ones such as market share in the field of operation.

2.2.6 Private partner selection

The essence of public-private cooperation is a combination of private capital, private project execution and the delivery of public services or facilities. A PPP is a combination of the tasks and objectives of the two sectors with different goals. The public sector's goal is to invest within the PPP for social or political well-being, while the private sector cooperates for commercial and business purposes which can be satisfied through its required rate of return. Therefore the relationship between the public and private sectors is crucial to the success of PPP projects, as a poor relationship would result in misunderstandings and conflict. It is worth mentioning that this relation should be analysed separately for each country due to the different formal and non-formal relations.

When conducting an industry-wide survey study, Chan et al. (2003) found that ‘improved relationships amongst project participants’ and ‘improved communication amongst project participants’ were the greatest advantage of using the PPP concept. Through interviews, Consoli (2006) found that different stakeholders’ demands, contractual arrangements, and various philosophical standpoints created tension between the involved parties. Apparently, friction is the major cause of poor relationships.

One major purpose of the PPP arrangement is the transfer and allocation of risks to the party that is the most capable of efficiently managing these risks. The purpose of the PPP is to optimize risk allocation between public and private sectors to achieve the best project value (Grimsey and Lewis, 2004). The main objective of partner selection is to reduce a project's risk, maximize its value and maintain the relationship in the long run. In many studies, research revealed that a critical component of the success of a PPP project was the selection of a private-sector partner that could provide the best overall arrangement throughout the PPP development process (Abdel Aziz, 2007; Chan, 2001). Researchers found that another important success indicator was the selection of the partner that offered both the best value and the capability to deliver the required services (Zhang, 2004). Governments and companies use contractors at all levels, ranging from large companies that manage megaprojects to a single worker carrying out a simple job lasting just a few minutes. Frequently, contract workers carry out much of the work at a facility, and they are often responsible for carrying out some of the most hazardous activities. Therefore, the management of the operator/contractor interface is very important, but it is also difficult. Contract companies vary extremely in size. Some are small organizations with limited responsibilities, while others are not only large, they are responsible for much of the high-risk work that is carried out on mega projects like those for oil and gas, and in infrastructure projects. Therefore, there is not a "one-size-fits-all" contractor management program (Sutton, 2015).

Some project owners emphasize the cost as the most important criteria and therefore choose the lowest bidders. Turksis (2008) introduced 8 criteria for selecting the best contractors: a history of reasonable bid price submissions; a work history that indicates specialization and quality of workmanship in a particular construction skill; a contractor's degree of quality control; the decorum, conduct and non-disruptiveness of contractor staff and the subcontractor's coordination of operations that will cause noise, vibrations, dust, odors, safety concerns and other activities; responsiveness to warranty issues; flexibility and cooperation when resolving delays; and the ability to meet the project schedule. These criteria can be modified according to different situations, but following a technique based on such criteria for choosing the best contractor is likely to lead to on-time completion and achieving the estimated quality within the projected budget.
There are also some newer studies, which base their selection method on only the risk profile of contractors. Assessing the risk management capability (RMC) of contractors prior to their selection for a project would contribute significantly to a project's successful delivery (Rasheed and Abdullah, 2014). The ability of an organization to effectively manage risk management is an apt representative of their risk management maturity level on projects (Akkirajul et al., 2010). Studies conducted by Hopkinson (2011) and Mu et al. (2013) present techniques, like RMC, to systematically evaluate the risk management maturity level of a contractor. They have shown that the risk management maturity level of organisations depends on different attributes. For example, a contractor can have a high maturity level in risk management resources but a low maturity level in risk management process and practice.

The private partner also plays a critical role in the successful development and long term operation of PPP projects. Proper partner selection therefore has even greater significance for governments, as the duration of partnerships has increased dramatically in recent years. The selection of a suitable private partner is of crucial interest to a government, especially considering that the ultimate responsibility for services remains with the government, which will have to undertake remedial action for an unacceptable or substandard performance delivered by a private partner. Otherwise, the government will face serious political, social and financial problems if a PPP project is unsuccessful.

There are many methods for ranking the candidate partners for PPP projects. The most viable and reputable partner is chosen depending on the stage of the procedure and which selection method is applied. Table 2-2 provides a brief description of some of the methods found in the literature for supplier prequalification selection; a detailed description of these methods is presented in the following paragraphs.

Table 2-2: Supplier Prequalification and Selection Methods

Method	Advantages	Disadvantages
Bespoke Approach (BA)	Incorporates several decision techniques simultaneously	Relies heavily on subjective interoperations and binary decisions.
NPV	Easy comparison	Does not consider technical aspects.
Scoring System	Considers several criteria	Uses equal weights for the criteria.
Kepno -Trego Technique	Uses more criteria Differentiates between essential & non-essential criteria	Uses simple weighting for the criteria.

Some methods are applicable to supplier prequalification and others are used in the final awarding process. Zhang (2004) classified four commonly-used prequalification methods: binary, simple scoring, multi-attribute methods, and other methods. These methods are used to assess the tenders of pre-qualified bidders. Wang et al. (2010) depicted the bid evaluation reports with some methods from practice and case studies, including the lowest price or shorter period. This approach is similar to the traditional procurement method where the awarded concessionaire submits the lowest price for carrying out a project, or requests the shortest concession period. This procedure, however, is criticized by many scholars for not accounting for non-price factors.

The Kepnoe-Tregoe technique has generally been adopted in Hong Kong BOT projects. This technique is based on the distinction between the criteria that the private partner must include and that criteria which the government wants them to include (Zhang et al., 2002). The former is an "on-off" criterion: all proposals not satisfying the required criteria must be rejected. The remaining bids are evaluated on what criteria a committee considers when choosing the sponsor that best meets their requirements. The withdrawal of this method is at the discretionary power of the decision makers in the so-distinguished "must" and "want" factors.

The third method is the Least Present Value of Revenues (LPVR), in which the bidder with the lowest price is awarded the contract and allowed to operate the concession until the budgeted value of the project has been obtained. Previously, this cut-off time had been a government-decided date. El-Mashaleh et al. (2013) developed a model for a private partner selection based on data envelopment analysis (DEA). DEA is a robust nonparametric linear programming approach that is widely used for performance measurements and decision making. One limitation of DEA is that its discriminatory power relies on the number of DMUs compared to the number of variables (input + output). A rule of thumb indicates that the minimum number of DMUs should be three times the number of the variables (Charnes et al., 1990). McCowan et al. (2007) proposed a model to evaluate BOT projects from the concessionaire's point of view, implementing a multi-attribute approach.

Zhang (2002) provided a net present value (NPV) approach and a weighted average scoring system that was utilized by the state of California in the United States (Levy, 1996). The NPV approach suffers from a major limitation because it is only based on a calculation of the lowest NPV of s/tariffs over the concession period, and does not consider technical competency or financial strength, both of which are very important.

Other methods mentioned in the classification offered by Zhang (2004) are:

- Simple scoring;
- NPV;
- Two envelope method;
- Multi-attribute analysis; and
- Binary method + NPV.

Government agencies evaluate and rank potential private partners in order to select the best ones for the next stage of the tendering process; this ranking obviously has an enormous effect on the final selection and the winner of the project. The government agency usually forms an assessment panel to evaluate the proposals submitted by pre-qualified promoters. Usually, the chairperson and some members of the deciding group are from the transportation (or utility, as appropriate) authority and other members are from related government areas, such as financial, legal, and environmental departments. This group of decision-makers evaluates all aspects of the proposals. The net present value (NPV) and the score system are the most common evaluation techniques to date (Zhang, 2004). Some governments also use different approaches like the Kepno – Trego technique or the single-criterion evaluation technique, based on their specific needs or priorities (Zhang et al., 2002). Multi-attribute analysis is most commonly used in PFI projects in the United Kingdom and is the most highly-recommended method (Kwak et al., 2009).

The Bespoke Approach (BA) is one of the first approaches for classifying the contractor selection criteria provided by Hatush and Skitmore (1997), and focuses on two basic stages in contractor selection: (1) pre-qualification, and (2) bid evaluation. Holt (1998) and Valentine (1995) referred to this as a two-stage procedure: (1) pre-qualification, and (2) tender evaluation. Pre-qualification is the process that compares the key contractor-organizational criteria among a group of contractors who wish to tender. This model can have various criteria with which to assess the offers, however the decision is a binary one as opposed the other techniques.

The NPV method, and a similar evaluation technique, the internal rate of return (IRR), are both based on the discounted cash flow model. This model combines all the cash flow profiles of a project for the project period adjusted for the time value of money, and represents them as a measure of their profitability, such as their NPV or IRR. The NPV method shows the difference between the present value of the revenues and the present value of the expenditures of a project. This calculation is based on the assumed investors' required rate of return (R_e). We can also think of the R_e as an opportunity cost of investment for each investor. The higher the required rate of return an investor's demand for a particular investment, the lower its NPV will be. This rate is a benchmark for investors. If a project provides them with positive NPV, they will end up with a higher wealth level compared to the situation where they would invest their capital to the amount equal to that positive NPV number. Some governments evaluate a proposal's commercial and financial package by performing an NPV; the lower the NPV, the lower-priced the offer. For utilities projects, the comparison is straightforward as it is generally based on a government's off take agreement. It is more complicated for highway projects, as traffic levels are not normally guaranteed. Nevertheless, as long as there are adequate traffic studies and conservative traffic forecasts, governments will be able to compare the NPV of the cash flow based on the toll revenues, operation and maintenance costs, financing charges, and loan repayments (Tiong and Alum, 1997).The main advantage of using the NPV method is that proposals can easily be compared based on numbers. The disadvantage is that it does not consider or evaluate the technical aspects of proposals (Tiong et al.,1997).

The score evaluation system is commonly used by government agencies, which set up selection criteria and weight the financial, technical, and other aspects of proposals. Points are given to each selection criterion, and the proposal with the highest overall score is considered to be the best. The advantage of this method is that several criteria are used in comparing the proposals. The disadvantage is that it assumes that all criteria are of equal importance (Tiong et al., 1997).

The Kepno-Trego technique first separates the ‘‘must’’ or essential criteria from the ‘‘want’’ criteria, and any tender that fails to meet any ‘‘must’ ’criterion is rejected at the outset. Next, the degree to which the ‘‘wants’’ are satisfied is evaluated, with overall scores being derived for each bid (Kumaraswamy and Zhang, 2001) . The Kepno – Trego technique is preferable to the NPV because it includes more criteria than strictly financial ones, and it is better than the score system because it segregates the essential criteria from other criteria. However, the Kepno – Trego technique does not indicate the relative weight for each criterion or consider how criteria are interrelated and affect each other, but rather simply weights the effect of each criterion separately. The result of this evaluation stage is the selection of a few proposals for the short list, which are then considered in the next stage of the process.

Despite the importance of private partner selection in PPP projects, the available literature has not given it as much attention as the value on investment and risk management aspects. Based on this literature review, the research indicates that before awarding a PPP contract to a private sector bidder, public sector officials need to look into the potential private partner that could best perform the PPP project and undertake the financial and technical responsibilities. The private partner in a PPP project assumes more risks than the contractor in traditional projects; which means that the private partner must have multiple capabilities in order to be successful in a PPP project. This situation justifies the need for our selection model.

In addition to concluding that the careful selection of a private partner is one of the critical success factors of PPP projects, it has been argued that the most significant reason for the widespread adoption of the PPP approach has been its ability to mobilize private capital for infrastructure development (Dey, 2004). In the Build-Operate-Transfer (BOT) PPP model the financing of projects using private resources is done through using 'project finance'.

2.3 Financial Analysis of PPP projects

PPP infrastructure projects have attracted much international attention over the past several decades. The inclusion of private investors and operators has significantly improved the servicing quality and the profitability of these infrastructure projects. The prevailing tighter regulatory environment in the banking system as the consequence of 2007-2008 financial crises has contributed to a widening gap between the amount that is being invested in infrastructure and the amount that ought to be. It will cost $57 trillion to build and maintain the world's roads, power plants, pipelines and the like between now and 2030, according to consultants at McKinsey & Company. That is more than the value of today's infrastructure. By one estimate, infrastructure spending currently amounts to $2.7 trillion a year (about 4% of global output), yet $3.7 trillion is needed (McKinsey Global institute, 2014).

The main concept of PPP is to provide alternative financing for public infrastructure projects. The most common way to develop PPP infrastructure projects using the BOT model is through the project finance (PF) method. Project finance is synonymous to large-scale project financing in which substantial funds need to be raised in order to provide a great deal of debt or equity capital, which in turn increases a project's cash flow. High cash flows enable sponsors to increase their leverage with significant debt service obligations and expand their overall business (Dailami and Hauswald, 2000; 2007). In other words, project finance is "limited or no recourse financing." That is, the financing is not primarily dependent on the credit support of the sponsors or the value of the physical assets involved; instead lenders focus on a project's cash flows.

This situation is achieved and codified in the contractual arrangements between the project company and the other participants. The project financing cycle can lasts over a year, or continue during the life of project as a rolling over budgetary system and lending syndicates can include over a dozen creditors who examine the transaction. Thus, the level of conflict-related due diligence performed by financiers may be much higher and subject to more cross-verification compared to other transactions (Crossin and Banfield, 2006). Achieving the financial closure in any project is difficult. Financial closure in PPP projects is the point at which the entire project's parties (government, sponsors, investors, and lenders) reach a legal agreement on the project structure and financing plans.

At the core of the PPP arrangement, Sponsor Company can establish a Special Purpose Vehicle (SPV). A corporation can use such a vehicle to finance a large project and reducing the risk associated with that, without putting the entire firm expose to that risk. This can also provide the project with higher credit rating due to the fact that the SPV is usually a subsidiary company with an asset/liability structure and legal status that makes its obligations secure even if the parent company goes bankrupt or have a problem in paying its obligation (Fabbozi, 2014).

PPPs are a subset of the PF market. The fundamental difference between PPPs and other PF deals is their "public" dimension. That is, the project output in PPPs is a function of government policy (health, transport, education etc.), and a government department or local authority is typically the client and de facto regulator of the contract. In a PPP, project risks are transferred to the party best able to manage them. By making the private sector responsible for managing more risk, governments reduce their own financial burden. There are significant number of studies offer in incoherent picture of PPP outcomes with regards to its benefits and disadvantages (Barlow et al., 2013), which are mainly discussing about the balance among Public Responsibility, Private Responsibility, and the degree of Public Sector Risk Rwelamila, Pantaleo D., Lucy Chege, and Tjiamogale E. Manchidi (2008). Therefore risk assessment is an inseparable part of the credit analysis.

There are two forms of financing arrangements, known as equity and debt financing. Equity is injected by the construction investors, Facilities Management investors and third party equity investors, whereas debt finance is provided by debt investors. Barry (2001) reported that investors find PPP an attractive form of investment and that many banking institutions in London were keen to provide the necessary project financing for PPP projects. Hence, the financial resources of PFI projects in the UK could be said to be enormous, with the banking form of financing as the most common type. Nowadays, given the current global economic climate, securing financing funds is more difficult. Finnerty (1996) suggested that the promoter needs to carefully consider all sources of funds to determine the financing package that provides the lowest capital cost. Sasson (1998) subsequently stated that the successful financing of projects is achieved by providing different classes of investors with instruments that are suitable to their respective risk/return profiles. According to Tiong (1990), each of the parties involved in a "promoters investors company" must be connected by the appropriate contracts and agreements, with the SPV acting as the highest-level security package. This will encourage cooperation among the parties throughout the concession period. It is critical for the promoters to understand that the ability to retain risks and offer guarantees does provide a competitive advantage to being awarded a concession. Tiong (1995) examined the ability of the financing package to award a concession when assessing the technical design during the selection process. The concessionaire needs to formulate and implement innovative financial instruments and processes to meet the specific requirements. These may include modeling and forecasting financial markets, hedging financial risks, investment management, asset/liability management, the structuring of sales/purchase transactions, and simulation of the impacts of various financial or product market scenarios on the revenue streams. Merna (1999) concluded that the success of any project is determined by the financing package rather than its engineering. Lenders must analyze all aspects of a business from the planning and construction phase to the implementation phase and beyond. A complete risk assessment must be conducted to evaluate whether a project is bankable and can generate sufficient cash flows to service the debt.

2.3.1 Phase 1 – Advisory and Developing the Structure

The initial phase includes developing the structure of the entire project and examining its potential feasibility through the use of outside contractors and advisors. Developing the structure forms the base upon which the financing will depend on. It should indicate all the potential risks and identify which party within that structure can best manage and minimize those risks. Determining who the contractual parties are and what their role is within the overall structure helps the lender to determine what the risks are, who is responsible for these risks and how they can be minimized or controlled. Action must be taken to ensure that these risks are allocated appropriately. The project structure must be defined according to the PPP project concession agreements with the principal initiator, the shareholder agreements, contractor agreements, operational and service agreements, as well as the loan agreements. The structure must also define how much equity and debt will be used. PPP projects usually have a high debt-to-equity ratio at 90%-10% or 85%-15%. As stated earlier, this is because the cost of debt is cheaper than the cost of equity. The reason lenders are willing to contribute with such high leverage is because the risk is partially allocated to all of the involved parties. However, the project company bears the greatest risk because it is the central contractual partner in the entire structure. The goal is to mitigate all the risks exposed to the project company by spreading them to the other contractual partners.

2.3.2 Phase 2 – Project Analysis

As mentioned above, the ability to raise financing is based on a project's ability to generate sustainable future cash flows. An analysis of the different project factors is necessary to provide confirmation to the lender that a project has the capacity to meet its future debt obligations using their cash flows. Phase 2 involves a detailed analysis and examination of all the project's key factors for successful project finance. An assessment of the different factors along with their risks must be defined and thoroughly analyzed.

2.4 Risk Factors in PPP projects

It is financially accepted that a fund lender is concern about the level of the cash available to meet the borrower's obligation. Analysts need to evaluate this from available financial information, which requires a clear understanding of free cash flows and the ability to interpret and use the information correctly. Accurate cash flow forecasting is essential at the tendering and construction stages for all contractors. It provides contractors with information regarding the amount of capital required, the amount of interest that needs to be paid to support an overdraft and the evaluation of different tendering strategies (Ghim and Tiong, 2002). As the projects' construction progresses, and as the varying risk factors change, how cash flow will be affected is an important question to the project manager. It serves as a cost control tool or revenue generating during the construction phase. The need for simple and fast techniques in cash flow forecasting has been acknowledged in previous research like (Kaka and Ammar 1996; Malik, 1996) and, as a result, cash flow forecasting models have been developed. These models tend to follow the same concept and mechanism. Ideally, cash flow forecasts should be based on the construction program and a bill of quantities.

Risk analysis consists of a sequence of different measures to identify, assess and allocate project risks. The aim of this procedural chain is to focus attention at potential factors that could have an impact on project cash flows, to analyze both qualitatively and quantitatively the possible effects of an adverse event on project earnings and consequently on its bankability. The effects of cash flow volatility have generated much interest in the literature from the perspective of risk analysis (Botshekan et al., 2012).

Besides recognizing the risk factors, managing the risk is an important task as well. Risk management is a process consists of the identification of exposures to risk, the establishment of appropriate ranges for exposures (given a clear understanding of an entity's objectives and constraints), the continuous measurement of these exposures, and the execution of appropriate adjustments whenever exposure levels fall outside of accepted range. The process is continuous and may require alterations in any of these activities to reflect new policies, preferences, and information.

When it comes to predicting required rate of returns for the investors or creditors of the project, analytical approaches can be divided into two major categories: top-down and bottom-up approach. In top-down forecasting, analysts use macroeconomic projections to produce return expectations for industry in general. These can then be further refined into return expectations for various market sub-sectors and sub-industry groups within the composites. At the last stage, such information can, be adjusted into projected returns for individual project. By contrast, bottom-up forecasting begins with the microeconomic viewpoint for the fundamentals of individual project. An analyst can use this information to develop predicted investment returns for each project. If desired, the forecasts for individual project returns can be aggregated into expected returns for related industry groupings, market sectors, and for the economy as a whole.

It is recommended that in the more volatile developing countries' environment, analyst follow the TOP-Down approach. This step was conducted by reviewing several previous researches on risk factors in a credit assessment of infrastructure projects. Following are the list of those which have been used in our model later in the thesis.

2.4.1 Market Risk:

The risk inherent to the entire market or an entire economy. This risk affects the overall market, not just a particular project or industry. This type of risk is both unpredictable and impossible to completely avoid. It cannot be mitigated through diversification, only through hedging or by using the right asset allocation strategy.

2.4.2 Environmental Risk:

Enterprise environmental factors refer to both internal and external factors that surround or influence a project's success. These factors may come from any or all of the enterprises involved in the project. Enterprise environmental factors may enhance or constrain project management options and may have a positive or negative influence on the outcome. This risk mainly consists of typical factors such as: organizational culture and structure, existing human resources, personnel administration policies.

2.4.3 Political Risks:

If the economy of the country is healthy, with fast growth, rapid policy liberalization, low debt, and high reserves, then the answer to this question matters less. Poor political leadership is unlikely to create a crisis. However, if the economic indicators and policy are flashing warning signals, the key issue becomes whether the government will implement the necessary adjustment policies. Cutting the budget deficit, which usually requires some combination of higher taxes and lower spending, is always painfully difficult, especially if the economy is weak already. Other key policy changes are reforms such as privatization and the ending of monopolies. The risk that an investment's returns could suffer as a result of political changes or instability in a country. Instability affecting investment returns could stem from a change in government, legislative bodies, other foreign policy makers, or military control. The outcome of a political risk could drag down investment returns or even go so far as to remove the ability to withdraw capital from a project`s investment.

2.4.4 Legal Risk:

The risk of uncertainty due to legal actions or uncertainty in the applicability or interpretation of contracts, laws or regulations. Some of the common examples in this area are: contract formation, perfection of an interest in collateral, netting agreements. Nearly every business transaction is subject to some form of contract law. Any contract has two parties, each responsible for doing something for the other. If one party fails to perform or believes that the other has engaged in a fraudulent practice, the contract can be abrogated, which can lead to litigation, especially if large losses occur or expects to happen. The possibility of such a claim being upheld in court creates a form of legal/contract risk.

2.4.5 Technical & Operational Risks:

This is the risk of loss from failures in a company's systems and procedures or from external events. This kind of risk addresses project-level concerns. The general risks in this category can be defined as: Technology components aren't fit for purpose due to the low quality, or when technology components aren't scalable and the components that can't be scaled to meet performance demands and then they aren't interoperable. Computer failure or broke down, and human failure like manageable unintentional errors are the common example of this type of problem

2.4.6 Completion Risk:

Mainly refers to the probability of loss from cost overrun, failure to pass completion tests or abandonment of the project.

2.4.7 Counterparty Risk:

This is a type (or sub-class) of credit risk and is the risk of default by the counterparty in many forms of derivative contracts. This kind of risk is common in derivatives or financial hedging contracts (Loon and Zhong, 2014). Credit Risk is the risk of loss caused by a counterparty or debt issuer's failure to make the promised payment. Projects' bonds in developing countries, as an asset class, are different in that the manager mostly is borrowing in a foreign currency. The authorities therefore cannot simply inflate its way out of a problem in servicing the debt, and so the risk of default is correspondingly higher compare to the same projects in developed countries.

Assessing this risk, using what is known as risk analysis, involves a large array of economic and political factors. Much of analysis for the developing countries' projects comes down to predicting policy moves and therefore often hinges on politics—that is, whether a government has the power to follow the necessary policies to stabilize the economy. Emerging market bonds are usually analyzed by developed market investors in terms of their spread over domestic Treasuries compared to similarly rated domestic corporate debt.

A minimum requirement an appropriate risk management system must fulfill from a lenders' point of view is the principle that the project should be able to cover debt service with its cash flows even in a worst-case scenario. Therefore, lenders resort to key figures such as the so called debt service cover ratio (DSCR), which determines a projects capability to cover debt servicing from its cash flows, to evaluate a project. From an investor's perspective, the objective of risk management is to assure that the project is able to generate a proper return on equity in a base-case scenario which corresponds to the incorporated risk. (Böttcher and Blattner, 2006)

2.5 Analytic Network Process (ANP)

The Analytic Network Process (ANP) is one of the more recent methodologies in Multiple Criteria Decision Making (MCDM). It is based on a relatively new theory introduced by Saaty (1996) that extends the framework of the Analytic Hierarchy Process (AHP) by considering the interconnections among decision factors. Unlike AHP, the Analytic Network Process (ANP) does not assume a one-way hierarchical relationship between decision levels. In other words; ANP generalizes AHP by replacing hierarchies with networks. ANP is also more versatile than AHP in terms of its applicability for both qualitative and quantitative data sets (Yu and Tzeng, 2006). In ANP, judgments are derived from the fundamental scale of AHP by answering twofold questions that clarify the extent of influence of any given pair of elements with respect to a third criterion (Saaty, 2004).

To better understand the nuances of ANP, the difference between a hierarchy and a network are illustrated in Figure 2.4. A hierarchy is defined as having a source cluster or a goal, if available alternatives are added in the model, the hierarchy will include a cluster or a sink node that pronounces the alternatives of the decision making problem. Furthermore, as the name suggests, a hierarchy has a linear top-down format with zero interaction between higher and lower levels. However, once alternatives are input to the model, there is a loop at the lowest level confirming that every alternative in the level depends on itself; therefore the elements are considered to be independent from one another. In a network however, an outer-dependence exists, where influences could flow forward from one cluster to another as well as travel back, either directly from the second cluster or through an intermediate cluster via a path. It is the nature of the problem and the degree of dependence within the network model that define the configuration of this path.

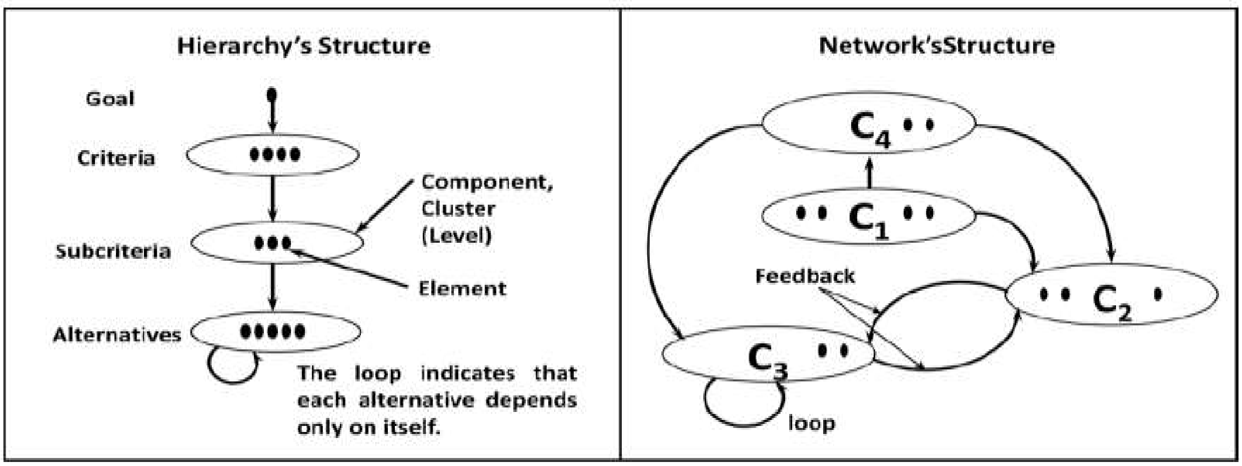


Figure 2-4: (AHP & ANP) use a system of pair wise comparisons to measure the weights of the components of the structure (Saaty, 2005).

Since the introduction of ANP by Saaty (1996), it has been adopted by many researchers and institutes to address multi-criteria decision analysis problems in various fields of study. ANP has been most notably applied in such fields as strategic decision making (Cheng and Li, 2004; Dagdeviren et al., 2005), product planning (Karsak et al., 2003), project selection (Lee and Kim, 2000; Meade and Presley, 2002; Cheng and Li, 2005; Dikmen et al., 2007a), optimal scheduling (Momoh and Zhu, 2003) and performance prediction (Ozorhon et al., 2007).

The ANP solution involves four steps: problem structuring and building a model, preparing pair-wise comparison matrices of independent component levels, formation of the super-matrix, and selection of the most appropriate alternative (Dikmen et al., 2007b). More precisely, in assessing the suitability of the ANP approach when using qualitative components, it is recommended to observe the following steps (Cheng and Li, 2005; Satty, 2008):

1) Describe the decision problem in detail, including its objectives, criteria and sub criteria, and highlight the possible outcomes of that decision. Give details of the various influences to determine how the decision may come out.

2) Determine the control criteria and the sub criteria, and obtain their priorities from paired comparisons matrices.

3) Determine the most general network of clusters (or components) and their elements that apply to all the control criteria. The clusters and their elements should be numbered and arranged in a convenient way.

4) Determine the clusters of the general feedback system with their elements, and connect them according to their outer and inner dependence influences, for each control criterion, and sub criterion. An arrow is drawn from a cluster to any cluster whose elements it influences.

5) Determine the approach to be followed in the analysis of each cluster or element, influencing other clusters and elements with respect to a criterion, or as influenced by other clusters and elements.

6) Construct the supermatrix by laying out the clusters in the order they are numbered and all the elements in each cluster, both vertically on the left and horizontally at the top for each control criterion. Enter the appropriate position; the priorities derived from the

paired comparisons are entered as sub columns of the corresponding column of the supermatrix.

7) Perform pairwise comparisons on the elements within the clusters themselves, according to their outer or inner dependence (influence on each element in another cluster they are connected to or on elements in their own cluster). In making comparisons, one must always have a criterion in mind.

8) Perform paired comparisons on the clusters with respect to the given control criterion. The derived weights are used to weight the elements of the corresponding column blocks of the supermatrix. A zero is assigned in the case of no influence.

9) Obtain the weighted column stochastic supermatrix.

10) Compute the limit priorities of the stochastic supermatrix.

11) Synthesize the limiting priorities by weighting each idealized limit vector by the weight of its control criterion.

2.5.1 Fundamentals of ANP

The Analytic Network Process (ANP) follows a multi criteria theory of measurement that draws upon individual judgments based on the fundamental scale of absolute numbers as shown in Table 2.3, to determine the relative priority scales of absolute numbers (Saaty, 2005). The fundamental scale for the pair wised comparison in the ANP builds upon two main questions; (1) given a control criterion, which of two elements is more dominant with respect to that criterion, and (2) which of two elements influences a third element more with respect to that criterion. The comparison is conducted to express the qualitative judgments between criteria numerically. Garuti and Sandoval (2005) reported that the ANP provides a way to clear all the relationships among variables, significantly decreasing the gap between model and reality.

The use of the pairwise comparison to formulate the relations among variables helps to direct attention to a given connection at a time, allowing more precise and inclusive analysis. The simplification level needed to build hierarchy models requires an unusual effort to identify and handle the multiple interconnections that a real problem has between components. In addition, the ANP relies on the accumulated experience and knowledge of decision makers, instead of merely supplying them with data which may provide little decision support (Mulebeke and Zheng, 2006).The priorities derived from pairwise comparison matrices are entered as parts of the columns of a super matrix. The super matrix represents the influence priority of an element on the left of the matrix on an element at the top of the matrix, with respect to a particular control criterion.

Table 2-3 Saaty's Fundamental Scale for Pairwise Comparison Importance Intensity Definition Explanation (Saaty, 2005)

Degree of Importance	Definition and Explanation	Remarks
1	Equal importance	Two activities contribute equally to the objective.
3	Moderate importance	Experience and judgment slightly favour one activity over another
5	Strong importance	Experience and judgment slightly favour one activity over another
7	Very Strong importance	An activity is favoured very strongly over another
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order if affirmation

The Unweighted super matrix is constructed from the priorities derived from the different pairwise comparisons. The columns for a node contain the priorities of all the nodes' pairwise comparisons, compared with respect to it and influenced with respect to the control criterion. The weighted super matrix is the multiplication of each entry in a block of the component at the top of the super matrix by the priority of influence of the component on the left by the cluster matrix. Each column in the weighted super matrix has a sum of 1, and thus the matrix is stochastic. The ANP then searches for steady state priorities from a limit super matrix. To obtain the limit super matrix, the weighted matrix is raised to high powers. The limit of these powers is equal to the limit of the sum of all the powers of the matrix (Saaty, 2001).

This use of the fuzzy analytic network process as a method to select the private partner in PPP infrastructure projects. Using this method, the decision to select the private partner is based on several criteria, which include information about a project's financial, technical, safety and environment, managerial and political policy aspects. The analytic network process (ANP) is used to reach that decision, by setting forth a goal and then defining the criteria and sub-criteria which will help the public sector select the private partner that is most suitable to take on a particular project. The ANP process is used to solve complex decision problems, as it is a method that involves multi-purpose decision making techniques. The ANP is thus a very useful tool to assist the Public Sector in selecting private partners for PPP projects. A pair-wise comparison must be done for the criteria and sub-criteria for choosing the partner in order to prioritize the selection process policies. Generally, there is almost always uncertainty when converting the decision maker's judgement into crisp values. To take into account these uncertainties, fuzzy decision variables are used instead of crisp values.

2.5.2 Triangular Fuzzy ANP

A model is developed for this research according to Chang's extend method (Chang, 1996). A fuzzy interval is used instead of crisp values in order to incorporate the inherent uncertainty in this type of decision making. A triangular fuzzy number is utilized for this purpose. A triangular fuzzy number is the special class of fuzzy number whose membership is defined by three real numbers, expressed as (l, m, u) as shown in Figure 2.5 The mathematical expression for the triangular membership function is given in Equation 2.1. The interval is obtained after comparison of the 'ith' element with the ''jth'', and is represented in the form of ''$\tilde{a}_{ij}$''. The reciprocal of ''$\tilde{a}_{ij}$'' represents the preference of the ''jth'' element over the 'ith' of Equation 2.2

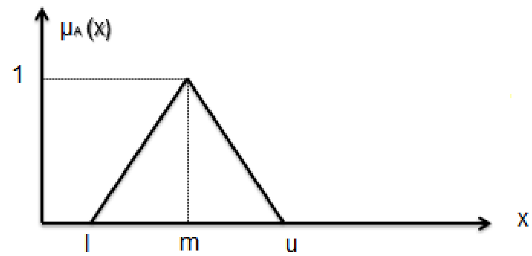


Figure 2-5: Triangular Fuzzy for three real numbers (Chang 1996).

$$\mu_A(x) = \begin{cases} \frac{(x-l)}{(m-l)}; & l \le x \le m \\ \frac{(u-x)}{(u-m)}; & m \le x \le u \\ 0; & otherwise \end{cases} \qquad 2.\ 1$$

Where: $\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij}) = \tilde{a}_{ij}^{-1} = (1/u_{ij}, 1/m_{ij}, 1/l_{ij})$

$$for\ \ i,j = 1,2,\dots,n\ \ and\ \ i \ne j \qquad 2.2$$

Finally, the comparison matrix is obtained for every control criterion as shown in Equation 2.3, where ''a_{ij}'' shows the degree of relative importance of the ith element compared to the jth element, with respect to the control criterion.

$$\tilde{A} = (\tilde{a}_{ij})_{m\times n} = \begin{bmatrix} (1,1,1) & (l_{12}, m_{12}, u_{12}) & \dots & (l_{1n}, m_{1n}, u_{1n}) \\ (l_{21}, m_{21}, u_{21}) & (1,1,1) & \dots & (l_{2n}, m_{2n}, u_{2n}) \\ \vdots & \vdots & \vdots & \vdots \\ (l_{n1}, m_{n1}, u_{n1}) & (l_{n2}, m_{n2}, u_{n2}) & \dots & (1,1,1) \end{bmatrix} \qquad 2.3$$

Since ANP only works with crisp values, the fuzzy priority thus obtained must be converted into a crisp priority vector. A number of different methods have been proposed, but the Fuzzy Extend

Analysis proposed by Chang (1996) is quite simple and easy to implement. The steps for Chang's Fuzzy Extend analysis are provided below.

Step 1: Compute the normalized value of row sums (i.e. fuzzy synthetic extent) by fuzzy arithmetic operations as shown in Equation 2.4.

$$\widetilde{S_i} = \sum_{j=1}^{n} \tilde{a}_{ij} \otimes \left[\sum_{k=1}^{n} \sum_{j=1}^{n} \tilde{a}_{kj}\right]^{-1} \qquad 2.4$$

Step 2: Calculate the degree of possibility of $\widetilde{S_i} \geq \widetilde{S_j}$ by using equations 2.5 and 2.6,

$$V\left(\widetilde{S_i} \geq \widetilde{S_j}\right) = sup_{y \geq x}\left[min\left(\widetilde{S_i}(x), \widetilde{S_j}(y)\right)\right] \qquad 2.5$$

$$V\left(\widetilde{S_i} \geq \widetilde{S_j}\right) = \begin{cases} 1 & m_i \geq m_j \\ \frac{u_i - l_j}{(u_i - m_i) + (m_j - l_j)} l_j \leq u_i & i.j = 1, \dots, n;\ j \neq i \\ 0 & otherwise \end{cases} \qquad 2.6$$

Where:

$$\widetilde{S_i} = (l_i, m_i, u_i)\ and\ \widetilde{S_j} = \left(l_j, m_j, u_j\right)$$

and $V\left(\widetilde{S_i} \geq \widetilde{S_j}\right)$ is the ordinate of the highest intersection point.

Step 3: Find the degree of possibility for $\widetilde{S_i}$ to be greater than all the other $(n - 1)$ convex fuzzy numbers S_j by use of equation 2.7

$$V\left(\widetilde{S_i} \leq \widetilde{S_j} \mid j = 1,2, \dots, n,\ \ i \neq j\right) = min_{j \in (1, \dots, n)\ i \neq j}\left[V\left(\widetilde{S_i} \geq \widetilde{S_j}\right)\right]$$

Where: $i = 1,2, \dots, n$ 2.7

Step 4: Obtain the weight or the priority vector $W = (w_1, w_2, \dots, w_n)^T$ of the fuzzy comparison matrix A as given by equation 2.8.

$$W_i = \frac{V\left(\widetilde{S_i} \geq \widetilde{S_j} \mid j = 1,2, \dots, n,\ \ i \neq j\right)}{\sum_{k=1}^{n} V\left(\widetilde{S_k} \geq \widetilde{S_j} \mid j = 1,2, \dots, n,\ \ j \neq k\right)}$$

Where: $i = 1,2, \dots, n$ 2.8

Eigenvectors obtained from a pair-wise comparison matrix are entered in an orderly manner to form a matrix called the super matrix. The column vector represents the impact, with respect to a control criterion, of a given set of elements of a component on a single element of the same or of another component listed at the top. If there is no relationship between two elements the corresponding entry in the super matrix is zero. The structure of the super matrix is shown in Equation 2.9. In the present case there are three clusters: C_1 – Goal, C_2 – Criteria and C_3 – Alternatives. The elements of the clusters are e_{11} – Goal, e_{21} – Financial, e_{22} –Technical, e_{23} – Safety & Environmental, e_{24} – Managerial, e_{25} – Political Policy, e_{31} – Partner A, e_{32} – Partner B, and e_{33} – Partner C.

$$
W = \begin{array}{c} \\ C_1 \begin{array}{c} e_{11} \\ e_{12} \\ \vdots \\ e_{1n_1} \end{array} \\ C_2 \begin{array}{c} e_{21} \\ e_{22} \\ \vdots \\ e_{2n_2} \end{array} \\ \vdots \\ C_N \begin{array}{c} e_{N1} \\ e_{N2} \\ \vdots \\ e_{Nn_2} \end{array} \end{array}
\begin{array}{c}
\begin{array}{cccc} C_1\, e_{11}\; e_{12} \cdots e_{1n_1} & C_1\, e_{21}\; e_{22} \cdots e_{2n_2} & \cdots\cdots & C_N\, e_{N1}\; e_{N2} \cdots e_{Nn_N} \end{array} \\
\begin{bmatrix} W_{11} & W_{12} & \cdots & W_{1N} \\ W_{21} & W_{22} & \cdots & W_{2N} \\ \vdots & \vdots & \cdots & \vdots \\ W_{N1} & W_{N2} & \cdots & W_{NN} \end{bmatrix}
\end{array}
\qquad 2.9
$$

The super matrix thus obtained must first be reduced to a matrix, each of whose columns sums to unity, resulting in a column stochastic matrix. A few columns may consist of more than one eigenvectors each summing to one so the total sum is some integer more than one. These columns are normalized to obtain a different matrix, known as a weighted super matrix. This is done by determining the influence of the clusters on each cluster with respect to the control criterion. This process yields an eigenvector of the influence of all the clusters. The priority of a component of such an eigenvector is used to weigh all the elements in the block of the super matrix that corresponds to the elements of both the influencing and the influenced cluster. This automatically results in a super matrix with column sums equal to one. This super matrix is raised to large powers until it converges, forming a limiting priority matrix which represents all of the possible interactions in the system. The values of this limit matrix are the desired priorities of the elements of the decision network with respect to the goal (Saaty, 1996).

2.5.1 TOPSIS Model

In the literature, many authors have used multi-criteria decision-making methods to assess the financial performance of the projects. The method that has in numerous studies been recognized as a useful and systematic tool for measuring financial performance is the Analytic Hierarchy Process AHP (Saaty, 1980). Ta et al. (2000) used the AHP approach to make a selection of financial entities. Frei and Harker (1999) applied the AHP approach as an alternative to the DEA method in order credit performance and explore the relationship between financial and operational performance. Yurdakul and Iç (2004) applied the AHP method to investigate the credibility of companies which is necessary in bilateral relationships between production companies and banks.

However, the AHP method is often criticized in the literature for failing to take into account risks and uncertainties during the process of evaluation (Chan et al., 2008; Dyer et al., 1992). Although AHP has found wide application for solving multi-criteria decision-making problems in real situations, this approach fails to provide satisfactory results in situations that can be characterized as uncertain.

TOPSIS (technique for order preference by similarity to an ideal solution) method is presented in Cheng and Hwang (1992), with reference to Hawng and Yoon (1981). It represents a classical multi-criteria decision-making method. This method ranks alternatives according to their distance from the positive ideal solution and negative ideal solution. Positive Ideal Solution represents an alternative that maximizes the benefit criteria and minimizes the cost criteria, while Negative Ideal Solution has the opposite logic, i.e. it maximizes the cost criteria and minimizes the benefit criteria (Benitez et al., 2007). The TOPSIS method takes into account both positive ideal solution and negative ideal solution distances, whereby the optimal alternative is the one that is in geometric terms the closest to positive ideal solution, and the farthest from negative ideal solution (Seçme et al., 2009).

After forming an initial decision matrix, the procedure starts by normalizing the decision matrix. This is followed by building the weighted normalized decision matrix in Step 2, determining the positive and negative ideal solutions in Step 3, and calculating the separation measures for each alternative in Step 4. The procedure ends by computing the relative closeness coefficient. The set of alternatives (or candidates) can be ranked according to the descending order of the closeness coefficient (Iason et al., 2014).

Triantaphyllou (2000) stated that "The best (optimal) alternative can now be decided according to the preference rank order of Cj*. Therefore, the best alternative is the one that has the shortest distance to the ideal solution. The previous definition can also be used to demonstrate that any alternative which has the shortest distance from the ideal solution is also guaranteed to have the longest distance from the negative-ideal solution".

2.5.2 Cash Flow Analysis Model

On August 1995, an article was published in Individual Investor. In that article, Jonathan Moreland puts up a very brief idea of assessment of the difference among earnings and cash. He states that at least as crucial as a company's economically yielding material profit is its liquidity, whether or not it is taking in adequate money to meet its indebtedness. Cash flow information is generally more reliable than earnings information because earnings may include noncash income and expenses items that are arbitrary. Work by Fazzari et al. (1988), Hoshi et al. (1991), Houston et al. (1997), Lamont (1997), Shin and Stulz (1998), Allayannis and Mozumdar (2004), Rauh (2006), Fee et al. (2009), Attig et al. (2012), and Erel et al. (2015) document a strong correlation between cash flow and investment.

The literature on analyst cash flow forecasts can be divided into two streams. The first stream of literature presents the role that analyst cash flow forecasts play in monitoring managerial behavior. Both Call (2008) and McInnis et al. (2011) show that analyst cash flow forecasts help to reduce earnings manipulations and improve earnings quality. It also mitigates the problem in comparison among different capital structure projects.

The second stream of literature argues the usefulness of the information in analyst cash flow forecasts. Research by Call et al. (2009) and Call et al. (2013) suggests that analyst cash flow forecasts contain information that is helpful for analysts and investors.

By injecting raised capital to the projects with long-term benefits, the project is producing value. But how much value? The answer depends on the project's expected free cash flow and also on the cost of the capital. The main approach to the evaluation of PPP contracts decisions by public managers is the use of benefit/cost ratio (B/C), traditional discounted cash flow (DCF) techniques such as the net present value (NPV), land expectation value (LEV in the case of forestry exploitations), and internal rate of return (IRR). The main deficiency with these approaches is the failure to evaluate the level of variable risks level in different scenarios (Maior, 2013).

2.6 **Identified Gap and Limitations**

The literature review presented above indicated the following limitations:

- Despite of the several research efforts found in literature, there is limited amount of research work on developing structured methods for the selection of private partners in PPP projects.
- The current practice for selecting those private partners can be influenced by corruption and subjectivity of government officials.
- There is an increased demand in PPP projects due to limited funds available for governments, which requires proper methods for selecting private partners and ensure successful projects delivery.
- Current processes for selecting contractors for construction projects cannot be implemented on PPP projects, because it does not consider the effects of all relevant criteria and variables especially those affecting PPP projects.
- The lack of transparent private partner evaluation methods with a pre-set of evaluation criteria, might encourage promoters to raise their proposals cost which in turn impact the public sector with higher cost and lower benefits.
- There is limited research work on developing tools to assist project's sponsors to evaluate their bankability, which in turn enables objective ranking of their projects.
- Several financial assessment models for the lender evolution of PPP projects' bankability were attempted, however they failed to consider risk factors and their relative impact on the lender's decision of whether or not to provide the requested finance.
- Most previous research focused on developing models to evaluate PPP projects using metrics such IRR and NPV. However, in order to have a comprehensive assessment, other factor must be considered such as inflation rate, inflation pass-through rate, traffic growth rate, and the average risk factors for each project.

- It was also evident that there is a relative shortage in data for PPP case studies due to its relative novelty in many countries and the level of sensitivity and confidentiality of public sector data.

2.7 Summary

This chapter presented a comprehensive overview of previous research work in the area of selecting private partners in PPP infrastructure projects. Concepts of PPP project were described in details outlining the models and methods developed for the selection of private partners. In depth investigation of current practice in financial analysis of PPP projects was explained highlighting common factors and techniques utilized. Several risk concepts were studied to identify those related to the PPP project in order to integrate them in the proposed model. The Fuzzy Analytical Network Process (FANP) was explained in details along with the TOPSIS method for ranking solutions. Finally, gaps and limitations of current practice and literature review were identified and explained in details.

Chapter 3: Research Methodology

3.1 General

The developed methodology is designed to address the research gaps and limitations identified and described in detail in chapter 2. This methodology consists of two models: a private partner selection model and a bankability assessment model. Figure 3.1 depicts the main sections of this chapter, which begins with a detailed description of the research approach and the methodology developed in this research. Next, the two developed models are explained in detail, followed by a short summary.

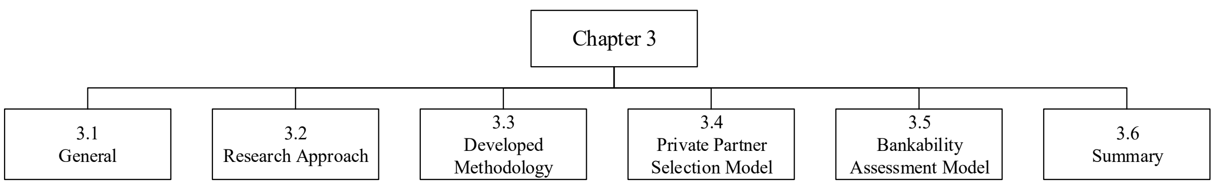


Figure 3-1: Chapter 3 Overview

3.2 Research Approach

The motivation for this research is based on the identified need for decision support tools for private partner selection in PPP projects. The research approach followed in this thesis is outlined in the flow chart of Figure 3-2, where the private partner selection criteria are identified through a comprehensive literature review. A questionnaire is then distributed to experts and practitioners in the area of PPP, to examine the applicability of these criteria for PPP projects, and their degrees of importance. The survey results are used to design the models introduced in the thesis. The models are applied to real case studies, where their performance is evaluated and their results are documented.

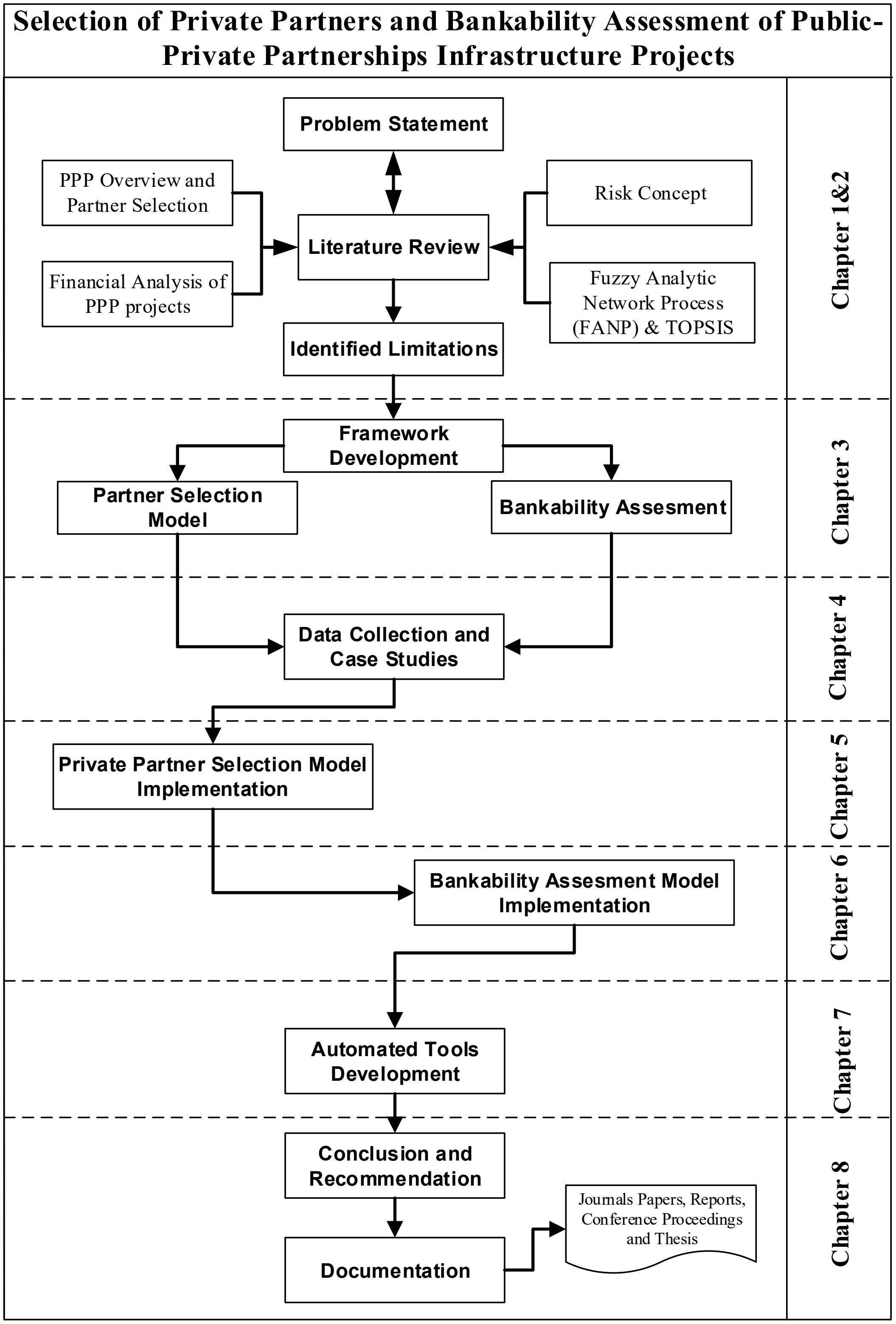


Figure 3-2: Research Approach

3.3 Developed Methodology

The aim of this research is to provide decision makers with a structured tool to select and evaluate private partners for PPP projects. The developed methodology is illustrated in Figure 3.3, where the two main models are developed: the private partner selection model and the bankability assessment model. The inputs of the developed methodology are the project data, accounting data, discounting rate, and the potential partners' information. The output of the developed methodology are the private partners' ranking, the project's prioritizing and the maximum amount of funds to be borrowed. Each of these models is subsequently described in detail.

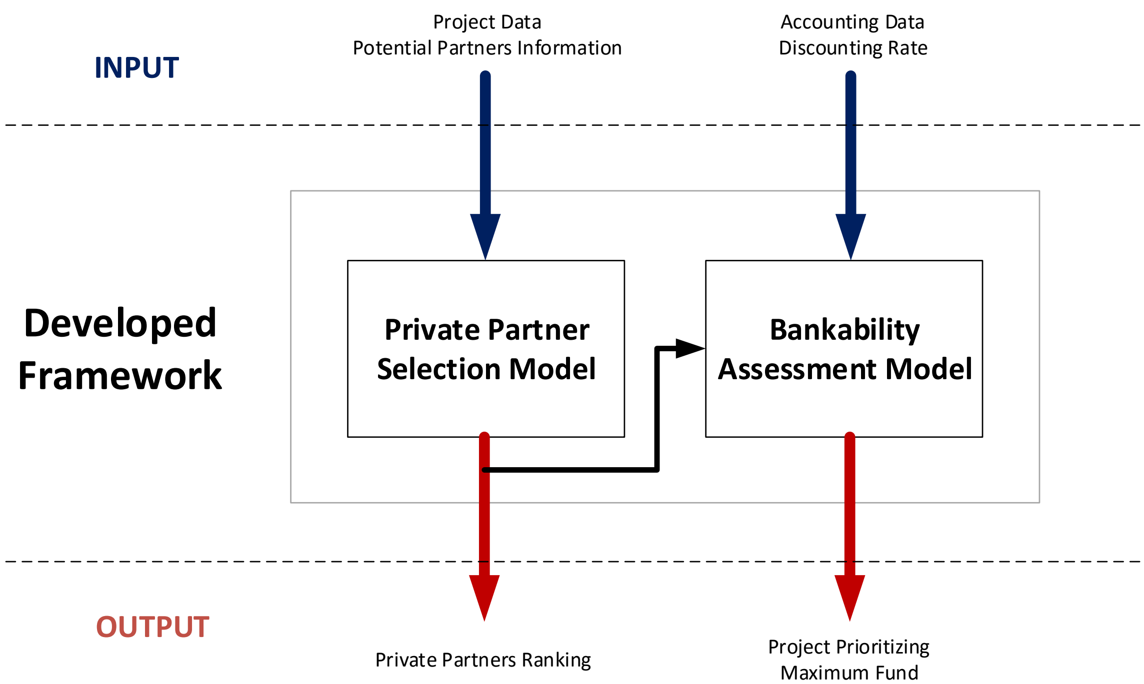


Figure 3-3: Developed Methodology

3.4 Private Partner Selection Model

The aim of the developed model is to assist government agencies in selecting private partners in PPP projects. The efficient selection of suitable private partners plays an important role in the successful delivery of PPP projects. Unsuccessful PPP project can cause significant political and social problems to governments, as well as financial losses. The developed model is based on the Fuzzy Analytical Network Process (FANP) to account for uncertainty and ambiguity. The model development process is illustrated in Figure 3.4, where the selection criteria are gathered from a detailed literature review covering all recent publications on PPP infrastructure projects. A list of 34 criteria where identified (9 main criteria and 25 sub criteria); a detailed description of these criteria follows in section 3.4.1. This list was sent to 12 experts in the domain of PPP infrastructure projects for review. They provided their feedback and recommendations on the most important criteria. The list was modified according to the expert's opinions so that it included 23 criteria (5 main criteria and 18 sub criteria). A questionnaire was designed according to the selected criteria and sent to 35 practitioners and professionals in the area of PPP infrastructure projects. The 30 responses received were analyzed using a spread sheet application designed to calculate the criteria's weights according to the questionnaire's responses. The questionnaire survey is explained in detail in section 3.4.2. The collected data was utilized to calculate the criteria priority weights using the FANP and TOPSIS methods, as explained in detail in sections 3.4.4 and 3.4.5, respectively.

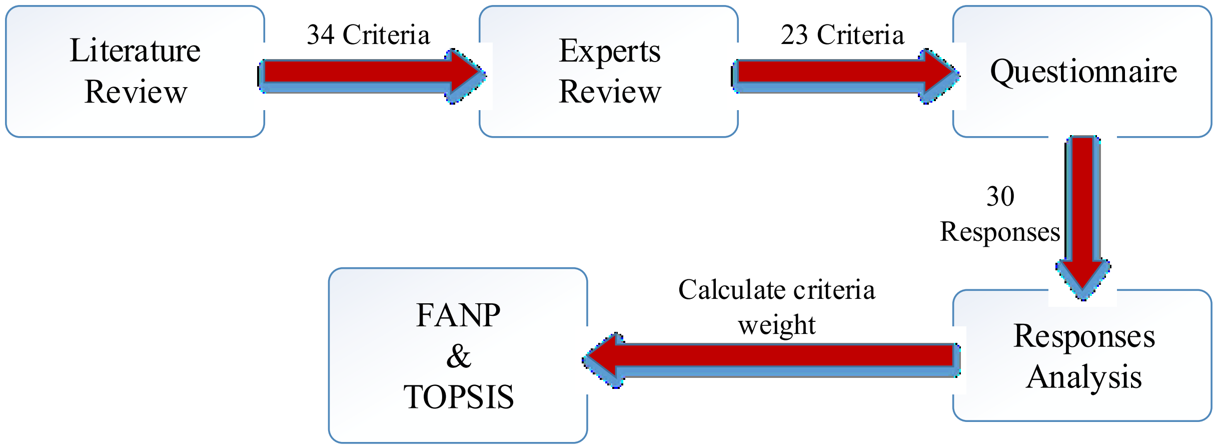


Figure 3-4: Private Partner Selection Model Development Process

3.4.1 Selection Criteria Identification

The first step in the model development is identifying the appropriate selection criteria. An initial list of main selection criteria was compiled from the literature as follows:

- Financial (Askar and Gab-Allah, 2002; Schaufelberger and Wipadapisut, 2003; Tiong, 1996; Tiong and Alum, 1997; Zhang, 2005; Rudzianskaite et al., 2010; Interviews with experts).
  - Equity/ Debt: Equity refers to the capital invested by sponsor(s) of the PPP project and others. The main providers of equity are project sponsors, government, and third-party private investors. Debt refers to borrowed capital from Banks and other financial institutions.
  - Foreign Financing: the branch of economics that studies the dynamics of exchange rates, foreign investment, and how these affect foreign trade.
  - Government Control on tolls: a type of economic system in which a government controls its country's industries and decides what goods should be produced and in what amounts.

    - Schedule of revenues: a schedule of financial instruments that defines the dates at which payments are made by one party to another
- Technical (Askar and Gab-Allah, 2002; Schaufelberger and Wipadapisut, 2003; Tiong, 1996; Tiong and Alum, 1997; Zhang, 2005; Sachs et al., 2007; Wang and Dai, 2010; Interviews with experts).
    - Design Standard: Detailed engineering drawings and/or specifications promulgated by public or private organizations that leave little choice to design engineers and technicians.
    - Construction technologies and methods: refers to the study of the methods and equipment used for building structures. Construction technology makes it possible to learn about construction management and acquire skills in the engineering of construction. It can also mean the sum total of processes for product and procedural improvement in the construction industry.
    - Operation and maintenance policy: To establish and set out the direction that Real Property Services must follow in order to provide service excellence in the facilities maintenance.
    - Construction programs and the means to meet them: A comprehensive schedule of construction activities indicating timelines and milestones to be achieved. Also includes which resource person is responsible for each activity; the competencies of the activity implementers coupled with the preparations towards project execution and the technology utilized should be convincing enough to demonstrate the ability to meet said objectives or milestones.

- Safety and Environment (Askar and Gab-Allah, 2002; Schaufelberger and Wipadapisut, 2003; Tiong, 1996; Tiong and Alum, 1997; Wang and Dai, 2010; Zhang, 2005).
    - A simple and clear policy describing how a company will manage safety and environmental impacts in its operations; thereby informing the company staff and others about its commitment to safety and the environment. Includes the framework of processes and procedures employed to ensure that the company fulfills all the tasks required to achieve its objectives.
    - Environmental policy and management plan: A simple and clear policy describing how a company will manage the construction environment and its operations.
    - Conformance to laws and regulations: Specifies how to conform to rules, such as a specification, policy, standard or law. Regulatory compliance describes the goal that corporations or public agencies aspire to in their efforts to ensure that personnel are aware of and take steps to comply with relevant laws and regulations.
    - Qualification/experience of safety and environmental personnel: Assesses the qualifications and experience of safety and environmental personnel, indicates each individual's level of experience and qualifications to handle safety and environmental issues.
- Managerial (Askar and Gab-Allah, 2002; Schaufelberger and Wipadapisut, 2003; Tiong, 1996; Tiong and Alum, 1997; Wang and Dai, 2010; Sachs et al., 2007; Interviews with experts).
    - Constitution of the management, their qualification and experience: The caliber of the people that comprise the management team, their qualifications and the level of experience they have acquired over the years.

- Leadership and allocation of responsibilities: A transparent process for establishing leadership positions and a structured analysis of how responsibilities are allocated to individual companies in the association.
- Working relationships among participants: Good working relationships and rapport among participating companies and agencies.
- Contractual relationships among Participants: The legal relationships between contracting-parties as evidenced by an offer, the offer's acceptance, and a valid (legal and valuable) consideration, and the continuing existence of a contractual relationship.

* Political situation country (Interviews with experts).
    - Political consensus: The existence of a political consensus on the need for the project.
    - Transparency: Transparency in the project selection and concession development process.
    - Business environment: There is a predictable environment for toll rate increases and/or assured traffic levels.
* Demand (Wang and Dai 2010)
    - Users Benefits: The users' willingness to pay is greatly influenced by the benefits perceived to be accrued by the users.
    - Economic: The resources, finances, income, and expenditures of a community, a government office and the business enterprise.
    - Nature of the Facility: The nature of the facility decides the economic viability of the project and the project's successful realization.

The list was examined by a panel of twelve PPP experts. Face-to-face interviews with experts and experienced practitioners were conducted to identify the factors that influence the selection of private partners. To ensure fruitful interviews, lists of questions and discussion issues stressing different aspects of PPPs were sent ahead of the targeted interview dates so that there would be adequate time to prepare and collect relevant information. In addition, considerable e-mail correspondence was conducted with a number of public clients, consultants and experts (Schaufelberger and Wipadapisut, 2003). As a result of the panel's recommendations, some factors were added, deleted, or modified. The meetings and discussions with the experts resulted in a final list, shown in Table 3.1, wherein five main criteria and eighteen sub-criteria are identified as the most important factors for selecting private partners in PPP projects. The five main criteria are the financial, technical, safety and environment, managerial and political policy aspects. Each of these criteria has several sub-criteria. For example, the financial criteria has four sub-criteria: equity/debt, government control on tolls, financial capacity and foreign financing.

Table 3-1: Identified criteria for selecting private partners in PPP infrastructure projects

Main Criteria	**Sub-Criteria**	**Reference**
Financial C_1	Equity/Debt C_{11}	(Zhang 2005), Rudzianskaite et al. (2010), Interviews with experts
	Government Control on tolls / tariffs C_{12}	
	Financial Capacity C_{13}	
	Foreign Financing C_{14}	
Technical C_2	Capacity of design firm and its proposed design standards C_{21}	(Zhang 2005), (Sachs et al. 2007), (Wang and Dai 2010),Interview with experts
	Operation and maintenance policy C_{22}	
	Construction program and ability to meet its targeted milestone C_{23}	
	Proposed Construction technology and methods C_{24}	
Safety and Environment C_3	Proposed environmental policy and management plan C_{31}	(Wang and Dai 2010), (Zhang 2005)
	Conformance to laws and regulations C_{32}	
	Qualification/ experience of safety and environmental personal C_{33}	

Managerial C_4	Demonstrated experience in the delivery of similar projects C_{41}	(Wang and Dai 2010), Interview with experts,(Sachs et al. 2007)
	Acceptance of risk transfer C_{42}	
	Leadership and allocation of responsibilities in the association C_{43}	
	Working and contractual relationships among participants C_{44}	
Political policy C_5	Understanding of legal requirements C_{51}	Interviews with experts
	Compliance with permit requirements C_{52}	Interviews with experts
	Compliance with boycott trade laws C_{53}	Interviews with experts

3.4.2 Criteria Priority Weight Calculation

Two methods were used for calculating the criteria weights, FANP and TOPSIS. The rational for using two methods is to be able to cross-check the results and make sure that the calculated weights are realistic.

3.4.2.1 Weight Calculation using the Fuzzy Analytical Network Process (FANP)

A FANP method is proposed to calculate criteria weights while accounting for uncertainties based on Chang's extend method (Chang, 1996). A Fuzzy set is used to convert the questionnaire's linguistic answers into fuzzy numbers based on a linguistic scale, as shown in Table 3-2. The linguistic scale ranges from Equal, Moderate, Strong, Very strong to Absolute. The fuzzy triangle scale is represented in the format of (low, medium, upper), while the triangular Fuzzy reciprocal scale is represented in the format of (1/low, 1/medium, 1/upper).

Table 3-2: Linguistic scale and triangular fuzzy scale for importance level (Saaty, 1996)

Linguistic Scale For Importance	**Triangular Fuzzy scale**	**Triangular Fuzzy reciprocal scale**
Equal	(1,1,1)	(1,1,1)
Moderate	(1/2,1,3/2)	(2/3,1,2)
Strong	(1,3/2,2)	(1/2,2/3,1)
Very strong	(3/2,2,5/2)	(2/5,1/2,2/3)
Absolute	(2,5/2,3)	(1/3,2/5,1/2)

Each fuzzy number criterion is averaged to calculate its geometric average. The geometric average is calculated using equations 3.1 – 3.4:

$$\widetilde{M} = \left(\bar{l},\ \bar{m}, \bar{u}\right) \qquad 3.1$$

$$\bar{l} = (\prod_{i=1}^{n} l_i)^{\frac{1}{n}} \qquad \forall_i = 1,2,3 \dots, n \qquad 3.2$$

$$\bar{m} = (\prod_{i=1}^{n} m_i)^{\frac{1}{n}} \qquad \forall_i = 1,2,3 \dots, n \qquad 3.3$$

$$\bar{u} = (\prod_{i=1}^{n} u_i)^{\frac{1}{n}} \qquad \forall_i = 1,2,3 \dots, n \qquad 3.4$$

Where n is the number of the expert's answers is the lower scale, m is the mean scale, and u is the upper scale.

A pair-wise comparison matrix is then constructed based on the calculated weights. The fuzzy triangles for the linguistic terms for question sets A, B and C are shown in Figure 3.5. This scale was proposed by Kahraman et al. (2006) and is widely used for solving fuzzy decision-making problems. The decision maker chooses a linguistic term based on the relative importance of the two alternatives being considered with respect to the criteria.

[redacted]

Figure 3-5: Linguistic scales for relative importance and satisfaction (Chang, 1996)

The developed model utilizes Chang's extend method (Chang, 1996) for transforming the numerical scale into a fuzzy number scale (Figure 3.5). A fuzzy interval is used instead of crisp values in order to incorporate the inherent uncertainty in this type of decision making. A triangular fuzzy number is utilized for this purpose. A triangular fuzzy number is a special class of fuzzy number whose membership is defined by three real numbers, expressed as (l, m, u) as shown in Figure 3.6. The mathematical expression for the triangular membership function is given in Equation 3.5. The interval is obtained after comparison of the 'i^th^' element with the ''j^th^'', and is represented in the form of ''$\tilde{a}_{ij}$''. The reciprocal of ''$\tilde{a}_{ij}$'' represents the preference of the ''j^th^'' element over the 'i^th^' of Equation 3.6

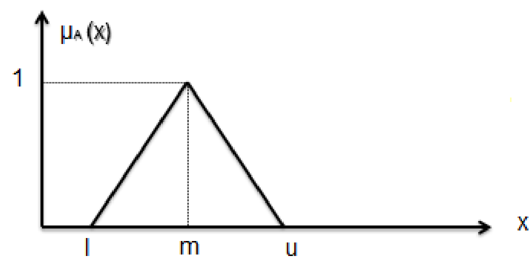


Figure 3-6: Triangular Fuzzy for three real numbers (Chang, 1996)

$$\mu_A(x) = \begin{cases} \frac{(x-l)}{(m-l)}; & l \leq x \leq m \\ \frac{(u-x)}{(u-m)}; & m \leq x \leq u \\ 0; & otherwise \end{cases} \qquad 3.5$$

Where: $\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij}) = \tilde{a}_{ij}^{-1} = (1/u_{ij}, 1/m_{ij}, 1/l_{ij})$

$$for\ \ i,j = 1,2,\dots,n\ \ and\ \ i \neq j \qquad 3.6$$

Finally, the comparison matrix is obtained for every control criterion, as shown in Equation 3.7, where ''a_{ij}'' represents the degree of relative importance of the i^th^ element compared to the j^th^ element, with respect to the control criterion.

$$\tilde{A} = (\tilde{a}_{ij})_{m\times n} = \begin{bmatrix} (1,1,1) & (l_{12}, m_{12}, u_{12}) & \dots & (l_{1n}, m_{1n}, u_{1n}) \\ (l_{21}, m_{21}, u_{21}) & (1,1,1) & \dots & (l_{2n}, m_{2n}, u_{2n}) \\ \vdots & \vdots & \vdots & \vdots \\ (l_{n1}, m_{n1}, u_{n1}) & (l_{n2}, m_{n2}, u_{n2}) & \dots & (1,1,1) \end{bmatrix} \qquad 3.7$$

Since ANP only works with crisp values, the fuzzy priority thus obtained must be converted into a crisp priority vector. A number of different methods have been proposed, but the Fuzzy Extend Analysis proposed by (Chang, 1996) is quite simple and easy to implement. The steps for Chang's Fuzzy Extend analysis are provided below.

Step 1: Compute the normalized value of row sums (i.e. fuzzy synthetic extent) by fuzzy arithmetic operations as shown in Equation 3.8.

$$\widetilde{S_i} = \sum_{j=1}^{n} \tilde{a}_{ij} \otimes \left[\sum_{k=1}^{n} \sum_{j=1}^{n} \tilde{a}_{kj}\right]^{-1} \qquad 3.8$$

Step 2: Calculate the degree of possibility of $\widetilde{S_i} \geq \widetilde{S_j}$ by using equations 3.9 and 3.10,

$$V(\widetilde{S_i} \geq \widetilde{S_j}) = sup_{y\geq x}\left[min\left(\widetilde{S_i}(x), \widetilde{S_j}(y)\right)\right] \qquad 3.9$$

$$V(\widetilde{S_i} \geq \widetilde{S_j}) = \begin{cases} 1 & m_i \geq m_j \\ \frac{u_i - l_j}{(u_i - m_i) + (m_j - l_j)} \; l_j \leq u_i & i.j = 1, \dots, n; \;\; j \neq i \\ 0 & otherwise \end{cases} \qquad 3.10$$

Where:

$\widetilde{S_i} = (l_i, m_i, u_i)$ *and* $\widetilde{S_j} = (l_j, m_j, u_j)$ and $V(\widetilde{S_i} \geq \widetilde{S_j})$ is the ordinate of the highest intersection point.

Step 3: Find the degree of possibility for $\widetilde{S_i}$ to be greater than all the other $(n - 1)$ convex fuzzy numbers$S_j$by use of equation 3.11

$$V(\widetilde{S_i} \leq \widetilde{S_j} \mid j = 1,2, \dots, n, \;\; i \neq j) = min_{j\in(1,\dots,n)\; i\neq j}\left[V(\widetilde{S_i} \geq \widetilde{S_j})\right] \qquad 3.11$$

Where: $i = 1,2, \dots, n$

Step 4: Obtain the weight or the priority vector $W = (w_1, w_2, \dots, w_n)^T$ of the fuzzy comparison matrix A as given by equation 3.12.

$$W_i = \frac{V(\widetilde{S_i} \geq \widetilde{S_j} \mid j = 1,2,\dots,n,\ \ i \neq j)}{\sum_{k=1}^{n} V(\widetilde{S_k} \geq \widetilde{S_j} \mid j = 1,2,\dots,n,\ \ j \neq k)} \qquad 3.12$$

Where: $i = 1,2,\dots,n$

Eigenvectors obtained from a pair-wise comparison matrix are entered in an orderly manner to form a matrix called the super matrix. The column vector represents the impact, with respect to a control criterion, of a given set of elements of a component on a single element of the same or of another component listed at the top. If there is no relationship between two elements the corresponding entry in the super matrix is zero. The structure of the super matrix is shown in Equation 3.13. In the present case there are three clusters: C_1 – Goal, C_2 – Criteria and C_3 – Alternatives. The elements of the clusters are e_{11} – Goal, e_{21} – Financial, e_{22} –Technical, e_{23} – Safety & Environmental, e_{24} – Managerial, e_{25} – Political Policy, e_{31} – Partner A, e_{32} – Partner B, and e_{33} – Partner C.

$$\begin{array}{c} \\ \\ W = \end{array} \begin{array}{l} C_1\ e_{11}, e_{12}, \dots, e_{1n_1} \\ C_2\ e_{21}, e_{22}, \dots, e_{2n_2} \\ \vdots \\ C_N\ e_{N1}, e_{N2}, \dots, e_{Nn_2} \end{array} \overset{\begin{array}{cccc} C_1 e_{11}\ e_{12} \dots e_{1n_1} & C_1 e_{21}\ e_{22} \dots e_{2n_2} & \dots\dots & C_N e_{N1}\ e_{N2} \dots e_{Nn_N} \end{array}}{\begin{bmatrix} W_{11} & W_{12} & \dots & W_{1N} \\ W_{21} & W_{22} & \dots & W_{2N} \\ \vdots & \vdots & \dots & \vdots \\ W_{N1} & W_{N2} & \dots & W_{NN} \end{bmatrix}} \qquad 3.13$$

The super matrix thus obtained must first be reduced to a matrix, each of whose columns sums to unity, resulting in a column stochastic matrix. A few columns may consist of more than one eigenvectors, each summing to one so that the total sum is some integer greater than one. These columns are normalized to obtain a different matrix, known as a weighted super matrix. This is done by determining the influence of the clusters on each cluster with respect to the control criterion. This process yields an eigenvector of the influence of all the clusters. The priority of a component of such an eigenvector is used to weigh all the elements in the block of the super matrix that corresponds to the elements of both the influencing and the influenced cluster. This automatically results in a super matrix with column sums equal to one. This super matrix is raised to large powers until it converges, forming a limiting priority matrix which represents all of the possible interactions in the system. The values of this limit matrix are the desired priorities of the elements of the decision network with respect to the goal (Saaty, 1996).

The model was implemented in Microsoft excel. A spreadsheet was utilized to calculate the weight of the criteria and perform the pair-wise comparison. The model consists of four main steps: questionnaire, pair-wise comparison, local priority weight calculations (Chang's method), and obtaining the final priority weight. The model flowchart is illustrated in Figure 3.7, and starts by considering several potential private partners for a PPP project. These partners are evaluated based on a set of criteria and sub-criteria, identified from the literature and from survey of experts. The ANP network is generated considering the interdependencies between the criteria and the sub-criteria. Chang's extend analysis is used to calculate the weights of the fuzzy sets based on the collected data collected from the survey. Three matrices are generated: an unweighted super matrix, a weighted super matrix, and a limited super matrix. Finally the partners are ranked, and the best private partner is selected.

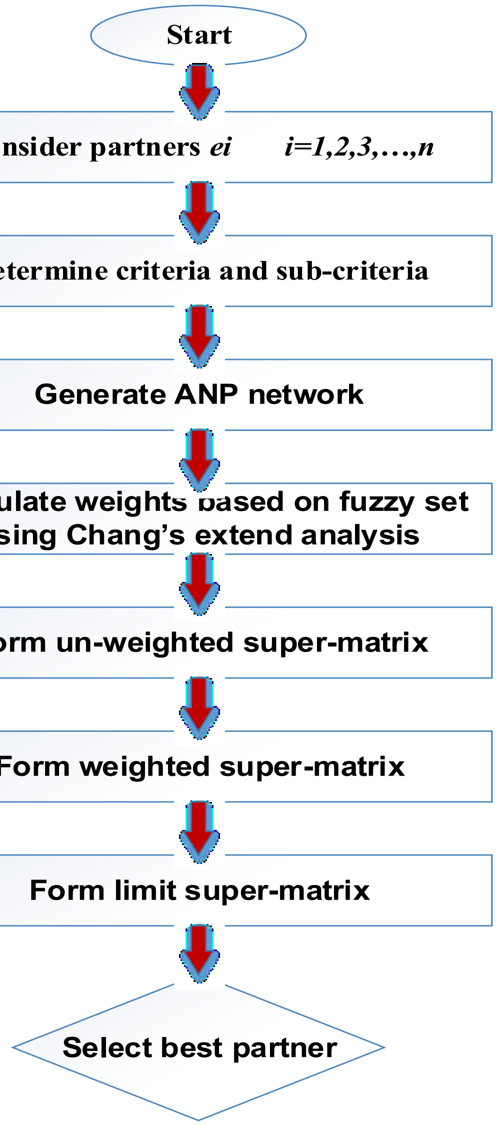


Figure 3-7: Flowchart for Fuzzy ANP methodology for Private Partner Selection

3.4.2.2 Weight Calculation using the TOPSIS Method

In order to benchmark the performance of the developed FANP model, another approach was developed using the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) multi-criteria decision analysis method. In this context, the joint performance of a private partner is aggregated for the pre-defined selection criteria, assuming that a "good" partner's scores should both be close to the best scores and far from the worst ones, and conversely, a "bad" partner would have scores that are simultaneously far from the best scores and close to the worst ones. Hence this approach is based on the distance to two reference points: one desirable and the other undesirable, which are used for ranking private partners in PPP projects. The process of conducting the TOPSIS analysis is depicted in Figure 3.8, and starts by calculating the general criteria weights based on the country where the project will be executed. Expert opinions are then utilized to evaluate each partner's ability to fulfill the selection criteria. A standard decision matrix and a weighted decision matrix are formulated based on the calculated general criteria weights and the experts' opinions. The last step is to rank the partners and to find the one most favorable.

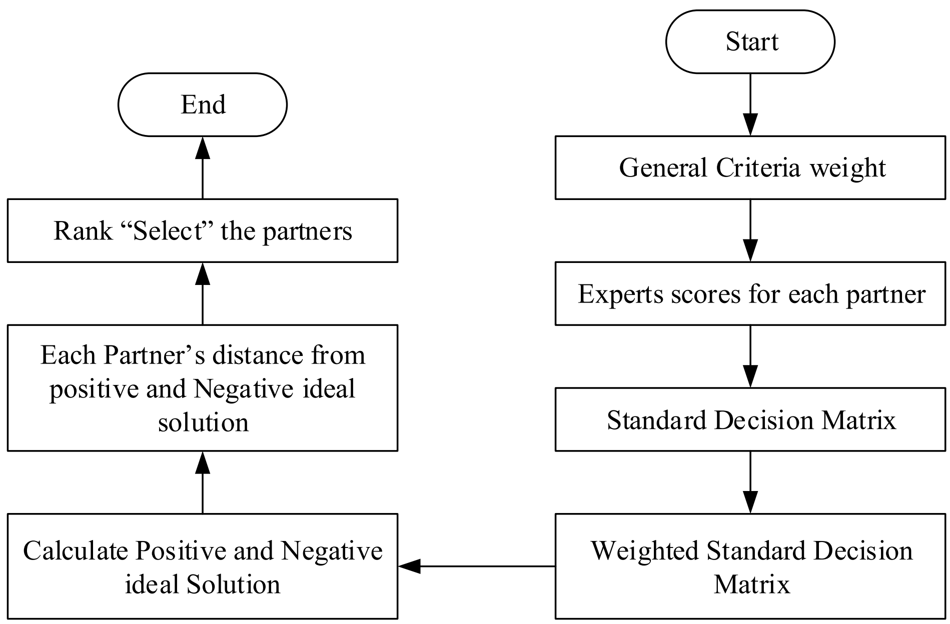


Figure 3-8: Flowchart for the TOPSIS Technique for Private Partner Selection

The first step is to define the general criteria weights in the country where the project will be executed. This approach enables decision makers to adjust the weight of the selection criteria based on their preference and their country's specific environment. The general criteria weights will thus be different for each country. The general format for these weights is presented in Table 3-3, where WF, WT, WS, WM, and WP are the weights for the financial, technical, safety & environmental, managerial and political criteria, respectively. For example, the financial criterion in case II is the most important factor, due to its undeveloped financial market, however in case III the partner's technical experience is of more importance than the financial, due to the availability of more accessible financial resources. The general criteria weight is calculated from the set of questionnaires distributed to experts from each country. The values are averages of the collected percentage weights according to the managers' replies to the questionnaire.

Table 3-3: General Criteria Weight Template

General Criteria Weights				
Financial	Technical	Safety & Environmental	Managerial	Political
W_F	W_T	W_S	W_M	W_P

After collecting the relative percentage weight for each criteria, the next step is to use the experts' opinion regarding each partner's ability to fulfill the criteria. To have a sufficient set of data, experts are asked through surveys to scale partner's ability to meet the criteria. A brief description of the terminology used in the survey is distributed as well, in an effort to promote a similar \understanding among experts.

Experts' answers are averaged and summarized, as shown in Table 3-4, where FA, FB, and FC are the financial criteria weights for partners A, B and C respectively, calculated by averaging the experts' responses. FA, for instance, is the average of the experts' opinion regarding partner A's financial capability. TA, TB, and TC are the technical criteria weights for partners A, B and C respectively. SA, SB, SC are the safety criteria weights for partners A, B and C respectively. MA, MB, MC are the managerial criteria weights for partners A, B and C respectively. PA, PB, PC are the political criteria weights for partners A, B and C respectively. F total is the total financial score for all partners, T total is the total technical score, S total is the total safety & environmental score, M total is the total managerial score, and P total is the total political score for all partners.

Table 3-4: General Criteria Weight Template

	Decision Matrix			
	Partner A	***Partner B***	***Partner C***	***Total***
Financial	F_A	F_B	F_C	F_{total}
Technical	T_A	T_B	T_C	T_{total}
Safety & Environmental	S_A	S_B	S_C	S_{total}
Managerial	M_A	M_B	M_C	M_{total}
Political	P_A	P_B	P_C	P_{total}

The values presented in Table 3-4 may have different scales, which can alter the analyses and make evaluation uneven and inaccurate. Therefore, the standard decision matrix is utilized to de-unitize the numbers and provide the relative value for each partner. The simple standard matrix is presented in Table 3-5, showing that the weight of each criterion is divided by the total criteria weight to standardize the criteria weight. For example, the financial criteria weight of partner A, F_A is divided by the total financial weight for all the F partners, F_{Total}. Where F_A is the financial criteria for partner A, T_A is the technical criteria for partner A, S_A is the safety and environmental criteria for partner A, M_A is the managerial criteria for partner A, and P_A is the political criteria for partner A. For example the financial criteria weight of partner A, F_A is divided by the total financial weight for all partners F_{Total}.

As shown in Table 3-6, the weighted standard decision matrix is calculated by multiplying the general criteria weight matrix (Table 3-4) by the simple standard decision matrix (Table 3-5). For example, the first cell in Table 3-6 is calculated by multiplying the standard score of the financial criteria of partner A by the general financial criteria weight. The rest of the cells are calculated following the same formula.

Table 3-5: Simple Standard Decision Matrix

For Each Partner
Standard Decision value of finance criterion for each partner= WSDF = $\frac{FA}{Ftotal}$ (3.14) WSDF = Weighted Standard decision for the Finance Where FA = Financial average score for Partner A And F Total= Total Finance score for all partners

Table 3-6:Weighted Standard Decision Matrix

For Each Partner
This is each of the Standard decision matrix cells times the corresponding general weight. For the partner A for example, we have: WF * $\frac{FA}{F\ Total}$ (3.15)

The last step is to find the best and the worst partner based on their scores, whereas the scores have no meaning except as a numerical tool with which to rank the partners. In the TOPSIS terminology, the most favorable solution is called the ideal solution, and the least favorable solution is called the negative ideal solution. Table 3-7 illustrates the calculation and selection of the ideal solution and of the negative ideal solution, where the ideal solution for each criteria is calculated as the maximum value for the criteria weight, and the negative ideal solution is the minimum criteria weight. The partners with the most deviations from each criteria's negative idea solution and the least deviations from those of the ideal solution will be selected as the best partner.

Table 3-7: Positive and Negative Ideal Solution

For Each Partner
Having calculated for all the partners based on the all criteria, we can find the MAX and Min value of each criteria.

To find the best-performing partner with respect to the selection criteria, the partner's distances from the ideal solution and from the negative ideal solution are calculated, as the shown in Tables 3-8 and 3-9, respectively. In Table 3-8, the distance is calculated as the square of the difference between the partner's criteria weight and the ideal solution. The goal is to find a partner with the lowest aggregate distance from the ideal solution. For example, the first cell in Table 3-9 is calculated as the difference between partner A's weighted standard score and the best score in finance criteria among the three partners.

Table 3-8: Partner's Distance from the Ideal Solution

For Each Partner
+ Separation for partners A weighted standard decision= $S+ = (WSD\ FA - MAX\ WSD)^2$ (3.16)   Where, WSD is weighted standard decision   S - = Separation for partners A weighted standard decision= $(WSD\ FA - Min\ WSD)^2$ (3.17)

The same approach is used to calculate each partner's distance from the negative ideal solution, as shown in Table 3-9. Similarly, the first cell in Table 3-9 is calculated as the distance between partners A's weighted standard score and the worst score in finance criteria among the three partners.

Table 3-9: Partner's Distance from Negative Ideal Solution

For Each Partner
You can calculate for each partner relative score and choose the highest one: $S^* = \frac{S-}{(S-)+(S+)}$ (3.18) Where: S* is each partner's Relative Value; S-: is its Distance from Min; and S+: is its Distance from Max.

Finally, each partner's score is calculated based on its calculated distances from the ideal and negative ideal solutions.

3.5 Bankability Assessment Model

The methodology addressed here presents the framework by which lenders assess PPP projects to decide upon their bankability. The fundamental metric used is the cash flow available for debt service (CFADS), which is also termed the free cash flow to the firm. First, the potential feasibility of the project must be proven and presented to the lenders with the approval of external advisors and consultants. An analysis of all the risks is then prepared, along with a description of the methods for mitigating the effects of those risks. The project should also detail the allocation of risk to all the contractual partners involved in the project. The financing phase follows, wherein the lenders decide on whether or not a project is bankable and will have the ability to generate sustainable future cash flows to service debt obligations. Lenders follow certain procedures and processes prior to deciding whether or not to provide a project with financing. These processes are listed below and shown in Figure 3.9.

- Determining the feasibility of a project;
- Project analysis by evaluating the economics of a project;
- Assessing the risk the factors that affect the project;
- Determining the a project's bankability; and
- Implementation & monitoring.

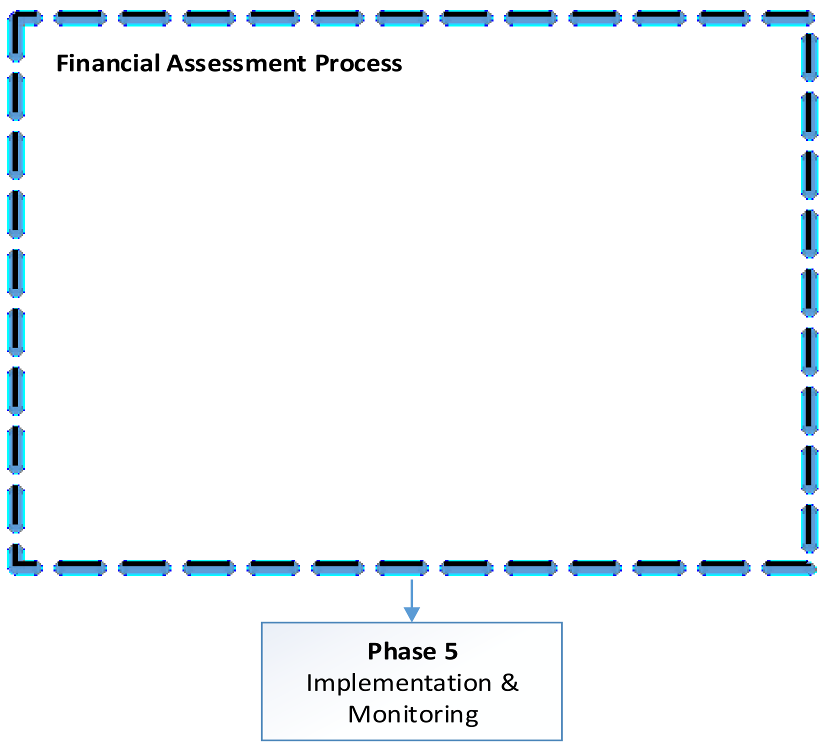


Figure 3-9: Financial Assessment Process Overview

The focus of the methodology is on Phase 4, where the lender determines the bankability of a project by incorporating all the information and data into a model that will help in the decision making process. The aim of the bankability assessment model is to assist lenders in the financial evaluation and ranking of PPP projects. Furthermore, it provides lenders with the maximum limit for funding these projects. The bankability assessment is based on the accounting factors and the project risk factors. Six main accounting factors were considered in this model, factors that were identified through interviews with creditors such as different Banks. Eight risk factors were identified using a survey questionnaire distributed to experts in PPP financing. The TOPSIS technique is utilized to calculate the weights for each of the identified risk factors. The flowchart for the developed model is presented in Figure 3.10, where the general criteria weights are calculated based on the country where the project will be executed. Next, experts' opinion are utilized to evaluate each project. A standard decision matrix and a weighted decision matrix are then formulated based on the calculated general criteria weights and the expert's opinion. The last step is to rank the projects.

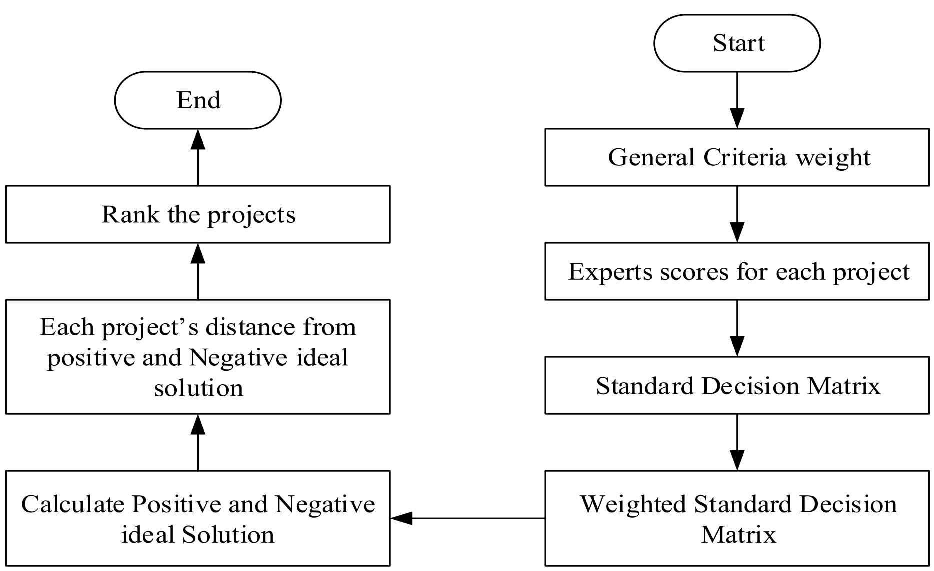


Figure 3-10: Flowchart of the Developed TOPSIS Model

3.5.1 Accounting Factors

Accounting data is needed in order to forecast any project's future financial performance, which is measured as the project present value. The forecasting accuracy depends on its time horizon. The longer the length of time being forecast, the less accurate the estimate. Also, there are many economic and financial factors which influence future accounting estimations, such as inflation and interest rates. Interviews with creditors were conducted to identify the most influential accounting factors in the bankability assessment of PPP projects, and the following six accounting factors were so identified:

- Revenue: Total amount of income for the defined accounting year;
- Cost of sale: The total costs required for delivering the service. This can be explained as the operational expenses like labor costs, the cost of materials, etc.;
- Depreciation: The implicit cost of the aging of a company's assets;
- Interest Expense: The amount of interest paid or that must be paid for each accounting period. This is a function of the outstanding debt in the capital structure of the project and of the interest rate;
- Required Working Capital: A net increase in working capital represents the net investment in current assets, less current liabilities. We find this amount by examining a company's forecasted balance sheet. Working capital can be explained as the level of short term funds required to run the day-to-day business.

- Required Capital Expenditure: The amount of investment in fixed capital needed to support the company's current and future operation. We can analyse the capital expenditure by comparing its trend over the years.

From the above six factors, the Free Cash Flow available to the Debt Service (FCFADS) can be calculated as following:

$$FCFADS= NI+ Dep+ I\ (1- T) -\Delta\ WK - \Delta CAPEX \qquad 3.19$$

Where: NI is the Net Income, Dep is the Depreciation, I is the Interest expense, and T is the tax rate in the country of operation.

The FCFADS is alternately called the Free Cash Flow to the Firm (FCFF), which is the after-tax cash flow going to all the suppliers of capital to a project.

3.5.2 Risk Factors

Two major risk factor categories are considered in this model, Financial Risks and Non-Financial Risks. Financial risks are those risks derived from any events in the financial markets, such as exchanges in commodity markets, exchange rates or interest rates, and non-financial risks are all the other types of uncertainty. A draft list of the most important risk factors were identified from the literature as the most important criteria to be considered in the PPP credit assessment process. A similar list was solicited from creditors. The overlapping criteria were identified and four criteria were thereby selected as the major factors for credit assessment. Utilizing questionnaires distributed to credit experts, the data required to identify the risk factors for individual each project process is illustrated in Figure 3.11, through the questionnaires distributed to the credit experts. The output of these steps is summarized in a number representing risk of each project. To convert that output into a number we collected credit experts' assessments of defined risk factors as a percentage through our questionnaire, and used that percentage in the first two steps of TOPSIS to aggregate the factors to find a risk premium number for each project.

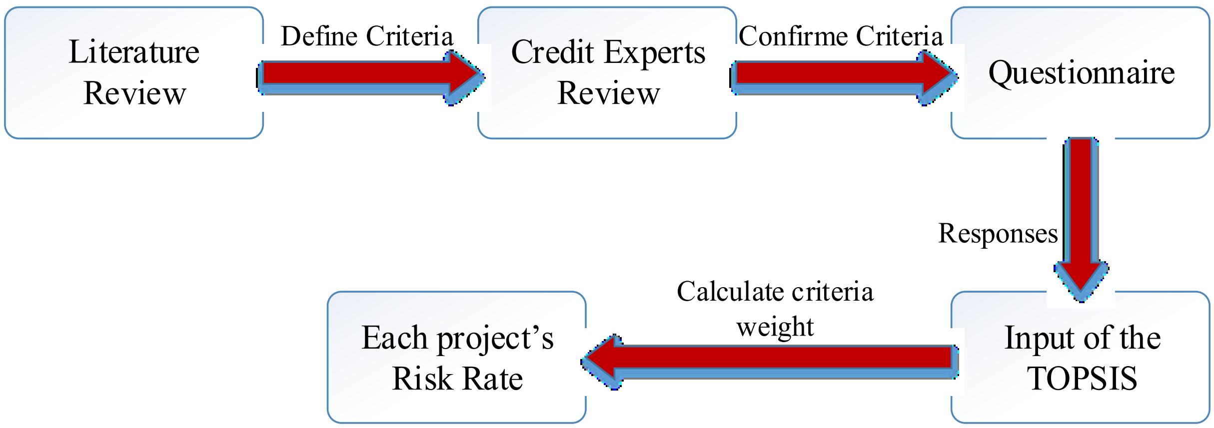


Figure 3-11: Risk Factor Identification Process

The definitions of the risk factors identified in the literature and included in the survey guide are described below:

Market Risk: The risk inherent to the entire market or to an entire economy. This risk affects the overall market, not just a particular project or industry. This type of risk is both unpredictable and impossible to completely avoid. It cannot be mitigated through diversification, but it may be mitigated through hedging or by using the right asset allocation strategy.

Environmental Risk: Enterprise environmental factors refer to both internal and external factors that surround or influence a project's success. These factors may come from any or all of the enterprises involved in the project. Enterprise environmental factors may enhance or constrain project management options and may have a positive or negative influence on the outcome. This risk mainly consists of typical factors such as: the organizational culture and structure, existing human resources, personnel administration policies, and environmental/safety regulations.

Political Risks: The risk that an investment's returns could suffer as a result of political changes or instability in a country. Instability affecting investment returns could stem from a change in government, legislative bodies, other foreign policy makers, or military control. The outcome of a political risk could drag down investment returns or even go so far as to remove the ability to withdraw capital from a project`s investment.

Legal Risk: The risk of uncertainty due to legal actions or uncertainty in the applicability or interpretation of contracts, laws or regulations. Some of the common examples in this area are: contract formation, perfection of an interest in collateral, and netting agreements.

Technical & Operational Risks: This kind of risk addresses project-level concerns. The general risks in this category can be defined as: Technology components that are not possible to use due to their low quality, or when technology components are not scalable and thus cannot meet performance demands.

Completion Risk: Mainly refers to the probability of losses from cost overrun, failure to pass completion tests or the abandonment of a project.

Counterparty Risk: A type (or sub-class) of credit risk, this is the risk of default by the counterparty in many forms of derivative contracts. This sort of risk is common in derivatives and financial hedging contracts.

A questionnaire survey was distributed to credit experts to provide the weighting for each criteria. The targeted experts for this survey are categorized as follows:

- Credit Analysts: Their role consists of performing risk analyses on new and existing clients to minimize credit risk and exposure by validating strict Credit Department adherence to lenders' Credit Policy and Procedure. Duties include financial analysis, loan modifications, reporting, default management and anti-money laundering reviews and approvals. Regular interactions and relationships are fostered with borrowers, investors and industry-related professionals. This category of experts contains the greatest number of users of our model.

- Investment Bankers: Investment Bankers are entrusted with the sole responsibility of growing their lenders' portfolios by managing the partners' accounts as well acquiring new ones. Bankers develop close relationships with clients and present investment ideas and new products on an ongoing basis. They are responsible for determining the investment objectives of partners and the risk tolerance of lenders. Investment bankers will ensure that the lender has incorporated the partner's objectives into the portfolio, and they consistently review portfolios, returns, investment strategies and investment outlooks. They have the highest number of deal exposures, but those are combined with a lower level of analytical experience compared to credit analysts.
- Business Analysts: Perform financial, business and industry analyses, conduct research, and prepare supporting documentation for partner credit approval. Frequent project monitoring and calculation of the regular NAV (Net Asset Value) of each project is a common practice for this position.
- Investment Finance Analysts: responsible for ensuring the integrity of financial data from accounting data sources by carrying out analyses and reconciliations. These analysts prepare consolidated investment-related financial statements and various internal management reports.

3.5.3 Weight Calculation for Risk Factors

The survey results are used to calculate the risk factor weights using the TOPSIS technique. The process of calculating the weights can be summarized as follows:

1. Calculate general attribute weights using a simple average of all the responses for each risk factor shown in Table 3-10, where experts are asked to provide a relative value for each risk factor. For example, in Table 3-10, W_m is the average of the relative weight experts assigned for the Market risk factor.

Table 3-10: General Criteria Weights

	Mk Risk	Environmental Risk	Legal Risk	Political Risk	Technical Risk	Operation Risk	Completion Risk	Counter Risk
	W_m	W_e	W_L	W_P	W_T	W_O	W_C	W_{Co}

2. Calculate a simple decision matrix by summarizing the credit experts' assessment for each risk factor, specific for each of the projects, as presented in
3. Table 3-11, where X_{M1} is the additional percentage credit expert # 1 has assigned for that specific project's market risk, for example.

Table 3-11: Simple Decision Matrix

	Expert 1 (from survey)	**Expert 2 (from survey)**	**.........**	**Expert n (from survey)**	**Average Attribute weight = r_{in}**
Mkt Risk	XM_1	X_{M2}		X_{Mn}	$\frac{\sum_1^n XMi}{n}$
Environmental Risk	X_{E1}	X_{E2}		X_{En}	$\frac{\sum_1^n XEi}{n}$
Legal risk	X_{L1}	X_{L2}		X_{Ln}	$\frac{\sum_1^n XLi}{n}$
Political Risk	X_{p1}	X_{P2}		X_{Pn}	$\frac{\sum_1^n XPi}{n}$
Technical Risk	X_{T1}	X_{T2}		X_{Tn}	$\frac{\sum_1^n XTi}{n}$
Operation Risk	X_{O1}	X_{O2}		X_{On}	$\frac{\sum_1^n XOi}{n}$
Completion Risk	X_{C1}	X_{C2}		X_{Cn}	$\frac{\sum_1^n XCi}{n}$
Counter risk	X_{Co1}	X_{Co2}		XCon	$\frac{\sum_1^n XCoi}{n}$

4. Normalize Decision Matrix: The various factors' dimensions are transformed into non-dimensional factors for the sake of comparison. The respondent's answers are normalized using the following equation:

$$r_{in} = \frac{x_{in}}{\sqrt{\sum_{i=m}^{Co} x_{in}^2}} \qquad 3.20$$

Where X is the Average Attribute weight of each project, and R is the Non-dimensional value for each attribute.

5. Calculate the Weighted Normalized Decision Matrix by multiplying the normalized value by the general attributes' weights.

$$V = \begin{bmatrix} v_{11} & v_{12} & \cdot & \cdot & \cdot & v_{1j} & \cdot & \cdot & \cdot & v_{1n} \\ \cdot & \cdot & & & & \cdot & & & & \cdot \\ \cdot & \cdot & & & & \cdot & & & & \cdot \\ \cdot & \cdot & & & & \cdot & & & & \cdot \\ v_{i1} & v_{i2} & & & & v_{ij} & & & & v_{in} \\ \cdot & \cdot & & & & \cdot & & & & \cdot \\ \cdot & \cdot & & & & \cdot & & & & \cdot \\ \cdot & \cdot & & & & \cdot & & & & \cdot \\ v_{m1} & v_{m2} & \cdot & \cdot & \cdot & v_{mj} & \cdot & \cdot & \cdot & v_{mn} \end{bmatrix} = \begin{bmatrix} w_e r_{M1} & w_L r_{M2} & \cdot & \cdot & \cdot & w_o r_{M15} & \cdot & \cdot & \cdot & w_{Co} r_{Mn} \\ \cdot & \cdot & & & & \cdot & & & & \cdot \\ \cdot & \cdot & & & & \cdot & & & & \cdot \\ \cdot & \cdot & & & & \cdot & & & & \cdot \\ w_e r_{E1} & w_L r_{E2} & & & & w_o r_{E15} & & & & w_{Co} r_{En} \\ \cdot & \cdot & & & & \cdot & & & & \cdot \\ \cdot & \cdot & & & & \cdot & & & & \cdot \\ \cdot & \cdot & & & & \cdot & & & & \cdot \\ w_e r_{Co1} & w_L r_{Co2} & \cdot & \cdot & \cdot & w_o r_{Co15} & \cdot & \cdot & \cdot & w_{Co} r_{Con} \end{bmatrix}$$

3.21

Where R is the non-dimensional factor weight for each risk factor of each project.

6. Determine the ideal and negative-ideal solutions using the following equations:

$$A^{+} = \{(\max_i v_{ij} \mid j \in J), (\min_i v_{ij} \mid j \in J^{'}) \mid i = 1,2,...m\}$$
$$= \{v_1^{+}, v_2^{+}, ..., v_j^{+}, ..., v_n^{+}\}$$
$$A^{-} = \{(\min_i v_{ij} \mid j \in J), (\max_i v_{ij} \mid j \in J^{'}) \mid i = 1,2,...m\}$$
$$= \{v_1^{-}, v_2^{-}, ..., v_j^{-}, ..., v_n^{-}\} \qquad 3.22$$
$$where \quad J = \left\{ j = 1,2,..., n \mid j \quad associated \quad with \quad benefit \quad criteria \right\}$$
$$J^{'} = \left\{ j = 1,2,..., n \mid j \quad associated \quad with \quad \cos t \quad criteria \right\}$$

7. Calculate the separation measures from the ideal and negative ideal solutions.

- ideal separation

$$s_i^{+} = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^{+} \right)^2} \qquad i = 1,2,..., n \qquad 3.23$$

- negative-ideal separation

$$s_i^{-} = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^{-} \right)^2} \qquad i = 1,2,..., n \qquad 3.24$$

8. Calculate the relative closeness to the ideal solution using the following equation

$$c_i^{*} = \frac{s_i^{-}}{(s_i^{+} + s_i^{-})}, \quad 0 < c_i^{+} < 1, \quad i = 1,2,..., m$$
$$c_i^{*} = 1 \quad if \quad A_i = A^{+}$$
$$c_i^{*} = 0 \quad if \quad A_i = A^{-} \qquad 3.25$$

3.5.4 Project Risk Premium

Risk premiums compensate investors to encourage them to tolerate projects with extra risk exposure compared to those with no or less risk. This can be a function of a project and the partner who is willing to invest in said project. In the developed model, TOPSIS is utilized to quantify this premium. TOPSIS combines the general risk factors' importance (general weights) with each specific project's position regarding every risk factor. The output can thus be considered as the risk premium regarding each risk factor if all the input data had been formatted as percentages. The risk premium is then added to each country's risk free rate of return to provide the discounting factor, which is utilized to calculate the Present Value of the FCFF. It is worth mentioning that the risk free rate for each country is specific and can be obtained from the central bank of each country.

The TOPSIS normalization step is performed to normalize each project's expert-defined risk. Multiplying this normal value by the general attribute risks' weights provides us with a project's risk profile. This is the minimum risk premium above the country's risk free return an investor will demand for their investment in the project. Therefore, the required rate of return, R_e which is the discounting factor of the projects cash flows, can be calculated as:

$$R_e = R_f + \text{Risk Premium} \qquad 3.26$$

Where: R_e is the required rate of return from investors

R_f is the current expected risk free rate of the country where the project is executed.

3.5.5 Scenario Analysis

In order to account for different risk factors and financial factors, a scenario analysis is utilized to assess the project's feasibility against various scenarios. This approach is especially essential when analysing potential projects in developing countries. The first step in scenario analysis is to determine the factors required to build each scenario. In general, analysts should focus on the one, two or three factors whose variation will change the value of the project. The second step is to determine the number of scenarios to analyze for each of the factors. More scenarios may provide more realistic results; but collecting the data in terms of project cash flow is very difficult and susceptible to mistakes. Therefore, the common practice is to apply three scenarios for each project, consisting of three probable project outcomes: the Best, the Base and the Worst scenario. The following section presents these scenarios' parameters in detail and then explains the definition of these three scenarios. Four main parameters are utilized to build the three scenarios, as illustrated in Figure 3-12: Scenario Parameters.

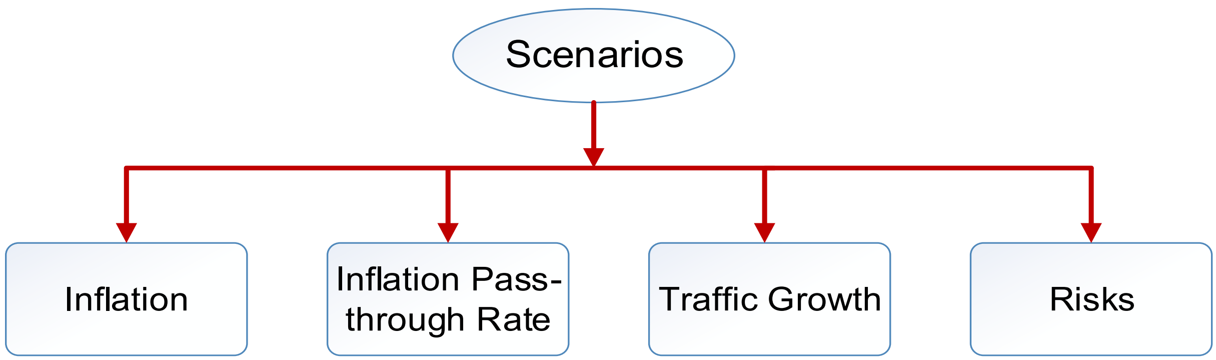


Figure 3-12: Scenario Parameters

Inflation:

Inflation erodes the purchasing power of any investment. An unexpected surge in the inflation rate has a negative impact on a project's present value calculated using the nominal rate of return, and such surges are more common in developing countries. In those countries, the political situation often limits the role of central banks to control inflation. Irvine Fisher (1907) proposed the relation between the nominal and real rate of return as follows:

$$1+i=(1+r)(1+\pi) \qquad 3.27$$

Where i is the nominal interest rate or the nominal rate of return, r is the Real interest rate or the real rate of return, and π is the inflation rate.

Inflation Pass-through Rate:

Assume a project has no real earnings growth, which means that the earnings growth is only from inflation. Based on the Gordon constant growth DDM model developed by Gordon and Sharpiro (1956), the value of this project is equal to:

$$V_0 = \frac{E0(1+\pi)}{r-\pi} \qquad 3.28$$

Where E_0 is the Current income or earning of the project and r is the Average Required rate of return for the investors. In this case with no earnings growth except that of inflation, a partner is encouraged to pay out all its earnings and retain its money.

Now, suppose that a project can pass on some or all of the inflation costs to the customers. We define λ as the percentage of the costs inflation that the project can pass through to its customers. In this case the company's earnings growth may not be expressed as $\lambda\pi$, and Equation 3.24 will become:

$$V_0 = \frac{E0(1+\lambda\pi)}{r-\lambda\pi} \qquad 3.29$$

Next, a real rate of return can be introduced, defined as r-π and represented as φ. The value of the project then can be summarized as in the following formula:

$$V_0 = \frac{E0(1+\lambda\pi)}{\varphi+(1-\lambda)\pi} \qquad 3.30$$

Where E_0 is the current year's income, λ is the percentage of inflation that can be passed on to the customers, π is the annualized inflation rate, and φ is the real rate of return.

Revenue (Traffic) Growth Rate:

Lenders examine all the factors that may affect a projects long-term cash flow and creditworthiness by assessing the project's credit strength, its expected profitability, the sponsor's equity and the risks involved in the project. Through this evaluation the lenders investigate all the costs, including those of any anticipated risks, and evaluate if a project will generate enough revenue to service its debt.

Each of the above items affect the revenue and cost value of projects. The traffic growth rate leads to an increase in revenue, and to support this increase, the project expenditure (cost) will also go up. Inflation is always a major contributing factor to revenues and especially to costs. Suppliers charge more and the cost of business increases, but due to the demand characteristics of the market, this inflation cannot be fully transferred to customers. Instead, only a portion can be applied to the selling price; a percentage termed the inflation pass-through rate. For any two projects faced with equal inflation rates, the one with a higher pass-through rate will have higher revenue and therefore more free cash flow. The Revenue Growth Rate can be expressed as:

$$\mathbf{RGR = (1+ g)*[1+\pi*\lambda]*(1+g_{fx})} \quad 3.31$$

Where RGR is the Revenue Growth Rate, g is the growth rate, π is the inflation rate, λ is the inflation pass-through rate, and g_{fx} is the return due to the change in the currency value.

Best-case scenario:

In this scenario, the parameters are set to values that realize the maximum project value. Therefore, the revenue growth rate is set to its maximum level for each country, the growth rate of cost is set to a minimum, yielding the highest level of the margin along with the lowest risk level, which results in lowering the discounting factor. However, this scenario might not be realistic.

Worst-case scenario

Worst-case scenarios provide experts with a tool to gauge the effects of potential spill overs on a project's operation which may lead to a partner's default in paying their debt. Therefore, if a firm is highly in debt, creditors generally use the worst case analysis to make their judgements about a potential default scenario. The major limitation of this scenario is that predicting a low outcome will deprive many worthwhile projects of their required capital. Therefore, not only will partners have no access to the funds they need to run their projects, but investors will also be deprived of suitable potential investments.

Base-case scenario

As explained above, the problem with both extreme cases is that they may not be realistic. To have a high revenue growth a project manager may have to lower their price and accept lower margins. Therefore it is rational to take into account the relationship between the various factors, which is the rationale behind the use of the base case.

3.5.6 Project Ranking

Having gathered and calculated the information from the previous steps, we can prioritize the projects based on their bankability. Four metrics are utilized to evaluate and rank the projects as shown in Table 3-12, which are calculated using the FCFF and the discounting rate. The sum of the accumulated score of each project is used to rank and prioritize them. The project with the highest rank will be the one deemed the most favorable from the creditor's perspective.

Table 3-12: Project Ranking Metrics

Metric	First Year PV vs. Costs	Stability of PVs	Average DSCR	First Year that DSCR=1
Formula	$\frac{PVCFi}{Ci}$	$\frac{Standard\ Deviation\ of\ Cash\ flow}{Average\ of\ cash\ flow}$	Average of each year's DSCR	
Preference	Higher	Lower	Higher	Sooner

The four metrics are described in detail below:

- First Year PV vs. Cost: The present value of any project is forecasted, taking into account all kinds of risks and uncertainty. It is thus highly preferable to have a project with a high present value. However, ranking projects based only on their PV is not appropriate, due to their different scales. A project with higher a PV may not be as preferable as a project with a lower PV when the scale of the business is taken into account. To address this issue, the PV of a project is divided by its initial proposed cost, which provides a ratio for comparing different projects while taking into account their different sizes.
- Stability of PV: To analyze the eligibility of a project to receive funding, it is not only important to have the positive present value, but also to assure lenders of a stable stream of cash flow. To address this situation, we score projects based on their free cash flow standard deviation. Again to eliminate the effect of size differences, we divide the standard deviation of each

project's average of free cash flow. A lower ratio is linked to a lower level of cash flow dispersion, and therefore is more preferable.

- Average DSCR: Lenders are extremely concerned about the solvency of their projects. The Debt Service Coverage Ratio is a quantified presentation of each project's solvency ratio.

$$DSCR=\frac{EBIT}{D} \quad 3.32$$

Where D is the total project debt and EBIT is the operating income, equal to the

$Net\ Income\ +\ Interest\ Expense\ +\ Amortization\&Depreciation$

- First Year that DSCR is equal to one: Rapid payment of debt is preferred as it lowers the interest payments for the partners and incurs less counterparty risk for credit providers. Therefore, a project with the quickest or the most ability to pay off its debt will reach a DSCR value of one more rapidly, which is considered to be the solvency breakeven point.

3.6 Summary

The successful delivery of mega infrastructure requires partnerships between the public and private sectors. Public private partnerships enhance and maximize the utilization of private sector skills, managerial capabilities and innovations. Choosing the best private partners who can deliver the technical requirements of projects and also meet the financial constraints defined by creditors is a dynamic process. This chapter described in detail the methodology developed to help make the best choice of partners, which consists of two newly-developed models: the private partner selection model, and the bankability assessment model. The private partner selection model is developed using a Fuzzy Analytic Network Process and the TOPSIS multi-criteria decision analysis method. This methodology overcomes the limitation of utilizing the hierarchal approach with crisp values for pair-wise decisions, such as the AHP and Goal-programming approaches. The use of fuzzy intervals for priority judgments resolves most of the problems related to uncertainties, and the ANP handles the various relationships between the goal, the criteria and the alternatives. Monitoring and updating are required, from data collection to the final decision step. The selection criteria was identified and listed from the literature, and then that list was refined based on a questionnaire survey distributed to experts in the field of PPP infrastructure projects. The selection criteria priority weight was calculated using the FANP and Chang Fuzzy extension, which take into account the interdependency between sub-criteria and the uncertainties in experts' judgement.

The bankability assessment model has been developed to assist creditors in assessing the bankability of PPP projects and to calculate the maximum amount of funds to be lent, thereby ranking PPP projects according to their financial and other risk factors. The developed model incorporates the lenders' perspective in assessing a project's bankability and the sponsor's creditworthiness. The available cash flow for debt service (CFADS) is used as the major metric for the assessment, while accounting for the time value of monetary and risk factors. A list of the most important accounting factors for bankability assessment was identified through interviews with experts from major PPP financial institutions. A questionnaire survey to experts in PPP financing was utilized to identify the major risk factors to be taken into account while calculating a project's risk premium. The weights of these risk factors were then calculated using TOPSIS analysis. A scenario analysis was developed to evaluate projects' worst, best, and base cases according to their financial and risk factors. Projects are then able to be ranked based on four metrics according to the sum of their accumulated scores.

Chapter 4: Data Collection and Case Studies

4.1 General

This chapter presents two questionnaires designed to capture experts' opinion with respect to the important criteria for selecting private partners for PPP projects and the important risk factors to be considered assessing the bankability of PPP projects. This chapter also provides a detailed description of the case studies utilized to test the performance of the developed models. Four case studies are utilized to test the private partner selection model and six case studies are used to test the performance of the bankability assessment model.

4.2 Private Partner Questionnaire Survey

A questionnaire was designed according to the criteria identified in the literature for selecting private partners in PPP projects. The questionnaire was sent to practitioners and professionals in the area of PPP infrastructure projects in each project's country. For case study II, 35 individuals were contacted and 30 responses were received, 8 from public clients, 16 from private companies and 6 from academia. For case study III, of the 35 people contacted 26 sent their responses. Of the 20 experts contacted in case study IV, 12 responses were received, in case study IV 25 experts were contacted and 18 responses received , 20 experts were contacted in case study V and received 11 responses were received. All of the respondents possess a rich practical experience and have conducted meaningful work in PPP projects. The data were analyzed using a spread sheet application designed to calculate the criteria's weights according to the questionnaire's responses.

The questionnaire was designed to determine the degree of importance (weight) of the selection criteria (as presented in chapter 3) in selecting private partners in PPP projects. A sample of the data collection and the questionnaire's input is depicted in Figure 4-1. This example illustrates the instructions for completion of a single question / comparison, including the Saaty's pairwise criteria comparison scale, which is utilized in this questionnaire. A pairwise comparison table is provided for each criteria, and the users / experts can click on the preferred importance scale that best describes their judgment towards the relative importance of the criteria. Briefly, for example: If the expert considers that "Equity/Debt" is more important than "Government control on tolls/tariffs" and the degree of this importance is "strong" then he checks (✓) box 5; if he considers that both "Equity/Debt" and Foreign Financing" have "Equal" importance then he check (✓) box 1; and if he considers that "Foreign Financing" has more importance then "Equity/Debt" and the degree of importance is "Absolute", then he checks (✓) box 9, as shown in Figure 4-1. A detailed description of the survey is included in Appendix-A.

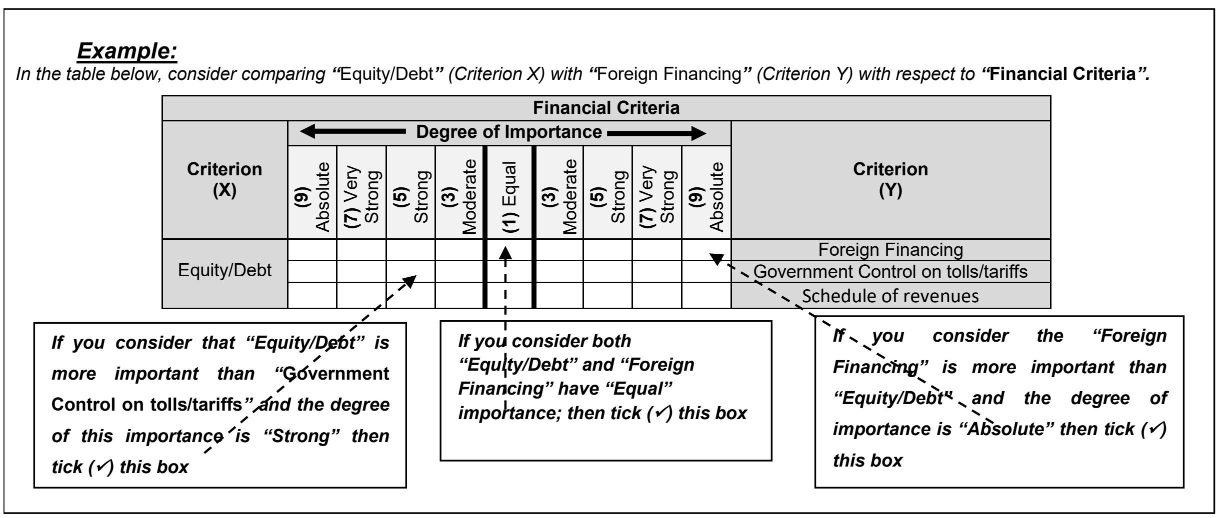


Figure 4-1: Guidelines including quick descriptions as an example

Experts' opinions are used to attain pairwise comparison matrices. Question sets (A, B and C) were posed in order to achieve those comparisons. Question set A provides comparison data for five criteria (financial, technical, safety & environment, managerial and political policy contribution) considered in the private partner selection process. Question B consists of five questions that compare all the alternatives against the others, based on the criteria stated in A.

Question C includes twelve questions where each individual question compares the five selection criteria with the three private partners being considered.

Question A – To select an appropriate partner for public private partnership projects, we have identified five main criteria: Financial, Technical, Safety & Environmental, Managerial, and Political Policy. It is essential to understand which of these five criteria is of greater importance (priority) in private partner selection and to what extent.

Question B-1 – Considering the financing criterial: Which of the three partners offers the greatest financial support and to what extent.

Question B2– Considering the technical criteria. Which of the three partners offers the greatest technical expertise and to what extent.

Question B3– Considering the safety & environment criteria. Which of the three partners offers the greatest support in these areas and to what extent?

Question B4 – Considering the managerial criteria. Which of the three partners offers the greatest managerial experience and to what extent?

Question B5 – Considering political policy. Which of the three partners offers the greatest political policy support and to what extent.

Finally a version of Question C is distributed as a means to rank each of the available partners.

Question C1 – Consider private partner A. Based on the financial strength of this partner with regards to their technical, safety & environment, managerial and political policy contributions how satisfied are you with this partner's ability to carry out the project?

Question C2–Consider private partner A. Based on this partner's technical attributes with regards to their safety & environment, managerial and political policy contributions, how satisfied are you with this partner's ability complete the project?

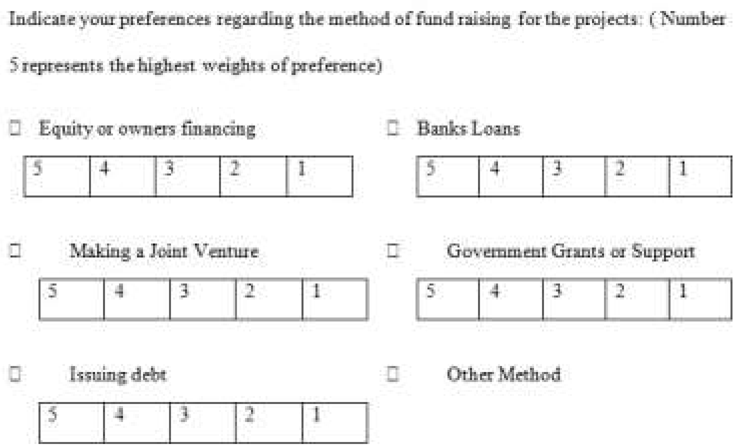
Question C3 –Consider private partner A. Based on this partner's safety & environment abilities with regards to their managerial and political policy contributions, how satisfied are you with this partner's ability to carry out the project?

Question C4 –Consider private partner A. Based on the managerial attributes of this partner with regard to the political policy contributions, how satisfied are you with this partner's ability to complete the project?

To complete the C set of questions, questions similar to those asked about partner A were then posed for partners B and C, for a total of 12 questions in set C. For questions A and B the experts were asked to select an answer from a pre-defined list: (Equal, Moderate, Strong, Very strong, Absolute). For the questions in set C the experts were asked to select an answer from a different pre-defined list: (Not at all satisfied, Satisfied to some extent, fairley satisfied, Satisfied, More than satisfied, extremely satisfied, absolutely satisfied). The experts were thus able to provide answers with a qualitative value based on their knowledge and experience to help create the pairwise comparison matrices required for our analysis.

4.3 Bankability Assessment Questionnaire survey

This questionnaire consists of two types of questions -- multiple choice and open-ended questions. In the multiple choice questions, five choices of scaled responses are used, corresponding to the template most generally accepted in the financial literature. Figure 4.2 presents an example of the multiple choice questions included in the survey. This example represents the capital structure preferred by credit experts, in which a multiple choice question is utilized to identify the preference of a credit analyst regarding a partners' capital structure; a structure designed so as to secure the optimum capital cost for the private partner. It is worth noting that the results of these questions are averaged to obtain the final score for each question.


Indicate your preferences regarding the method of fund raising for the projects: (Number 5 represents the highest weights of preference)

☐ Equity or owners financing

5	4	3	2	1

☐ Banks Loans

5	4	3	2	1

☐ Making a Joint Venture

5	4	3	2	1

☐ Government Grants or Support

5	4	3	2	1

☐ Issuing debt

5	4	3	2	1

☐ Other Method

Figure 4-2: Financial Survey sample question

The experts were asked to evaluate two types of attribute weights:

- General Attribute Weights: This represents each attribute's weight (risk factor) in comparison to the others in the general investment context. It does not take into account any specific project's profile and is mainly derived by the general level of uncertainty in the infrastructure business environment. These relative weights are functions of business cycles, business expectations, and economic trends.
- Attribute’s Weights in each project: This part of the questionnaire targeted each project's specific risk profile from the experts’ perspective. The more deviation a specific attribute has from that general attribute’s weight, the more susceptible it is to uncertainty.

Open-ended structured questions were also utilized to allow respondents to list any factors not included in the survey. All respondents agreed that the questionnaire included most of the important factors. A few examples of the open ended questions are presented here, as follows:

- Considering six predefined risk factors, please rank them from the most to the least important.
- Choose your capital funding preference for each of the following methods.

- Considering the following political and legal factors, please choose the most relevant level of alignment in your country.
- As a financial institution, do you have any in-house credit rating system?
- Have you ever dealt with a default or request for an extension of payment schedules?
- Do you use any derivative product to hedge your default risk?
- Please choose from the following list the covenant(s) that you impose on a borrower (if any).
- What is the source of your economic and operational forecasts? (Internal analysis or third party consultant)
- What is the normal budgetary system in your investment portfolio?

4.4 Private Partner Selection Case Studies

Four projects from different countries to utilize and test the private partner selection model as shown in Table 4.1, which lists the four case studies and four of their parameters: project type, cost in millions, concession period in years. These projects vary in terms of their location, type, cost and concession period. This variability is utilized in measuring the developed model performance and verify its efficiency in selecting the best private partner in each project.

Table 4-1: Private Partner Selection Case Studies

Case Study	Project Type	Cost (Millions)	Concession Period (Years)
I	Bridge	$282	30
II	Highway	€2,033	40
III	Highway Extension	€58.1	30
IV	Highway + Bridge	€64	25

4.4.1 Case Study I -

The bridges and infrastructure have been under severe strain following, and the city's acute traffic problems have threatened to hinder recovery, which will have two three-lane carriageways and cuts the journey time between two major districts of one hour to 15 minutes, was designed to put the path to prosperity and ease citizens' lives. The bridge will span 1.5 kilometers and is part of a new 6.7 kilometer road that includes an interchange, two stretches of motorway, and a 21-lane toll plaza. One hundred thousand vehicles a day will use the bridge, which will cost approximately $282 million to build. The project details are summarized in Table 4.2. The project consists of the design, construction, and operation of a toll bridge. The total length of the full road connection will be around 6.6 kilometers, with the bridge itself spanning 1.5 kilometers. To the north, construction will consist of a 2x2 lane dual carriageway that will connect with the junction of the Boulevard Mitterrand and Est-Ouest roads and on which will be the toll plaza. To the south, construction will consist of a 2x3 lane dual carriageway with lateral access roads that will connect to Boulevard Giscard d'Estaing, the main road that joins Abidjan airport. There will be a separate interchange that will connect the access road to the bridge with the main road that connects to the airport. Initial work on the project, started in October 2011.

The project is being funded by a group of Development Finance Institutions. The project is structured as a public-private partnership (PPP) and will be implemented under a 30-year Build-Operate-Transfer (BOT) concession agreement. Four partners (partnerP_1, partnerP_2 , partner $P_3$and partnerP_3) competed for this project.

Table 4-2: Details of Case Study I

Description of Elements	Value
Concession period	30 years BOT
Cost	$282 Millions
Construction Start	2011
Construction Completion	16 December 2013
Length	1.5-km
Width	Two three-lane carriageways
Benefits	the bridge cuts the journey time between two major districts of one hour to 15 minutes

4.4.2 Case Study II -

This project involves the construction of a highway, which will cover the 1 700-km. The project will be the biggest of its kind in Africa. It will consist of two lanes and a relief lane in each direction, with bridges, junctions and crossings as well as safety facilities as summarized in Table 4-3. Construction will be split in three phases, and will be awarded to three separate consortiums. Three partners (partnerP_1, partnerP_2 , and partnerP_3) have competed for this project.

Table 4-3: Details of Case Study II

Description of Elements	Value
Length	1700 KM
Total number of bridges	263
Intersection (unit collection + intersection Reverse	52
Unit Collection	18
Small Service areas and restrooms	13
Large Service areas and restrooms	17
Tunnels in different sizes	1471

4.4.3 Case Study III

This construction project is part of a renewal of the highway between two cities. The project will be developed on a design, build, finance, operation and maintenance basis with an availability payment structure. Construction is scheduled to start before the end of 2015and the road is expected to be operational by 2018. The concession period is to be 30 years. The tender process was launched in December 2010.The project will be financed by the financial institution. Three partners (partnerP_1, partner P_2 and partnerP_3) have competed for this project.

4.4.4 Case Study IV

In July 2010 the financial institution approved a €12-million senior loan with a 15-year tenor, including a 5-year grace period, to finance the toll. The project includes construction of the 20.4-km section. The motorway will be built as a dual carriageway with three lanes in each direction. The project's main beneficiaries are the road users who will save significant amounts of time and vehicle operating expenditures. It will also help stimulate local economic activity and facilitate the movement of goods and services through this regional hub, thereby strengthening intra and inter-regional trade. The toll road forms part of infrastructure development program, which includes the extension of the port, a new airport as well as a number of other transportation projects. This new infrastructure will stimulate economic activity in the manufacturing, industrial and tourism sector, as well as more generally support trade and mobility. The country will benefit from these projects in terms of increased competitiveness via the reduced costs of doing business. The project is one of the first public-private partnership (PPP) projects in the road sub-sector. Six partners (partnerP_1, partnerP_2, partnerP_3, partnerP_4, partner P_5 and partnerP_6) have competed for this project.

4.5 Bankability Assessment Case Studies

Six projects from different countries: they were used to test the bankability assessment model, as shown in Table 4.4, which lists the project type, cost in millions, concession period in years. These projects vary in terms of their location, type, cost and concession period. This variability is utilized to assess the developed model's performance and verify its efficiency in assessing the bankability of a range of projects.

Table 4-4: Bankability Assessment Case Studies

Case Study	Project Type	Cost (Millions)	Concession Period (Years)
I	Airport	€561	30
II	Highway	€2,033	40
III	20 Bridges	€508	40
IV	Highway Extension	€58.1	30
V	Highway + Bridge	€64	25
VI	Bridge	€270	30

4.5.1 Case Study I -

This is a project to build an airport. Airport operations were expected to start in 2009 and the expected cost of the project is 561,000,000 Euro. It is now planned to be finished in 27 months. Local senior debt will be 62.7 percent of its capital structure and local equity holders will hold 23 percent of that. Local subordinated debt, sponsors, and government grants will contribute of 5.3, 7 and 2 percent of the capital structure, respectively. This project is distinguished by its high level of debt raised through local senior holders, which is a harbinger of a potentially very heavy burden of net income due to high interest payments, as senior debt holders require a high level of interest or coupon payment as compensation for their investment.

4.5.2 Case Study II –

This project is to build a new 1700 KM highway on a Build-Operate-Transfer (BOT) basis. This project is under the supervision of the Ministry of Transportation - Department of Roads and Bridges. It is expected to be built within 36 months and its projected cost is about 2,033,000,000 Euro, financed through 20 percent local equity, 30 percent local senior debt, 30 percent foreign senior debt and the remaining 20 percent by subordinate debt.

4.5.3 Case Study III -

The project comprises constructing 20 Bridges. This project is expected to be completed in 36 months with a projected cost of close to 508,357,000 Euro, financed through 20 percent local equity, 30 percent local senior debt, 30 percent foreign senior debt and the remaining 20 percent through subordinate debt.

4.5.4 Case Study IV -

This is project will expand an ongoing business and therefore the accuracy of its assumptions is relatively high compared to the other projects. The expected cost of the project is 58,100,000 Euro which is the smallest amount among all other five cases, and it was planned to be completed in eighteen months. Local equity holders will provide 20 percent of the capital and the local senior debt holders will provide 30 percent. The remaining will be covered by a combination of subordinated debt and loan from financial institutions.

4.5.5 Case Study V -

The project will build a toll road on a Build-Own-Operate (BOT) basis and will be implemented in two phases. The first one is to build 20.4 KM of road and the second is to construct the 28.8 km of toll road. This project is expected to be built in 36 months and its forecasted cost is about 64,000,000 Euro. This amount will be financed through 14 percent of local equity, 28 percent local senior debt and 58 percent via government grants.

4.5.6 Case Study VI -

This project consists of building a new toll bridge to drastically improve travel times. It is planned to be built over 36 months with an estimated cost of 270,000,000 Euro. This budget will be financed by 11 percent local equity, 46 percent local senior debt and 29 percent of government grant, with the balance covered by local subordinate local debt.

4.6 Summary

This chapter presented a detailed description of the data collection and case studies utilized for the two models' implementation and testing. Two questionnaires were prepared, sent and analyzed, one for selecting the criteria for private partner selection, the other for selecting the risk factors for funding PPP projects. Four case studies were utilized to test the private partner selection model, and six case studies were utilized to test the bankability assessment model.

Chapter 5: Private Partner Selection Model Implementation

5.1 General

This chapter presents the implementation of the developed partner selection model on four real case studies. The developed partner selection model encompasses two techniques: the FANP and the TOPSIS method. The two techniques are applied to each case study, and the results are compared. The developed model is applied on four projects from different countries. These projects vary in terms of their location, type, cost and concession period. This variability is intended to measure the developed model's performance and verify its efficiency in selecting the best private partner in each project.

5.1 Discussion of Questionnaire Responses

The survey was mainly targeted to experts in PPP infrastructure projects, but it was also sent to some experts globally. The experts are mainly from Transportation domin, the Media Center, Training, Documentation and Studies in Communication Technologies, the General Authority for partnership between the public and private sector, the Ministry of Finance, the Ministry of infrastructure, and the Ministry of Communications, National infrastructure and road safety. As shown in Figure 5-1, the survey was distributed to a hundred experts and eighty six responses were collected and utilized to develop the model for the private partner selection. The response rate was 86%, an acceptable response rate.

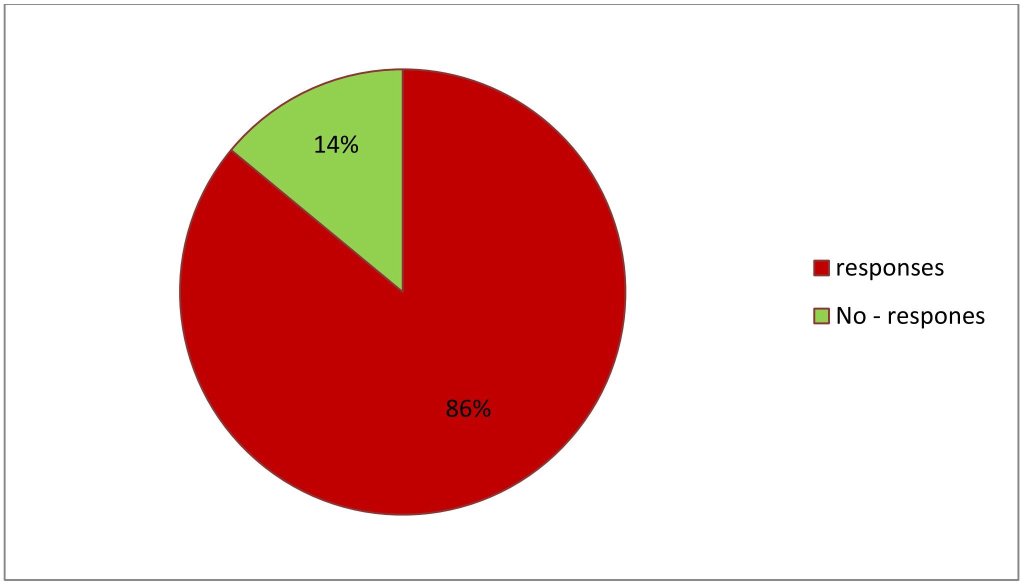


Figure 5-1: Percentage of responses

The respondents were classified based on their position level, as shown in Figure 5-2, where 33% of the respondents were construction managers, 16% were director of infrastructure managers, 41% were project managers, and 10% had other positions within the construction industry.

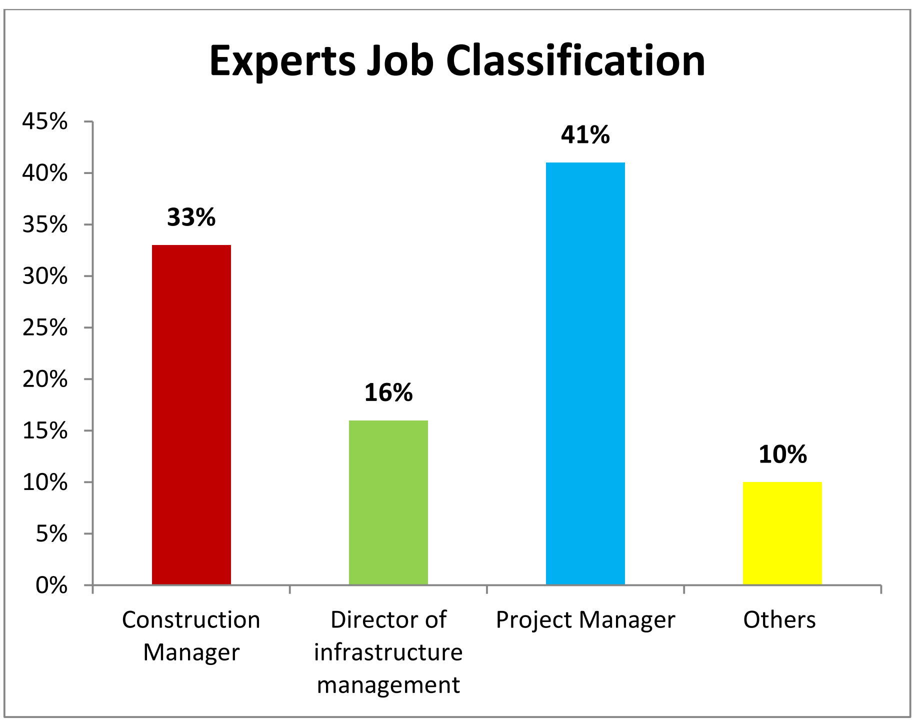


Figure 5-2: Experts' Job Classification

The respondents were also classified by their years of experience in infrastructure projects as shown in Figure 5-3, where 17% had less than 5 years of experience, 32% had 6 to 10 years of experience, 28% had 11 to 15 years of experience, 14% had 16 to 20 years of experience and 9% had more than 20 years of experience.

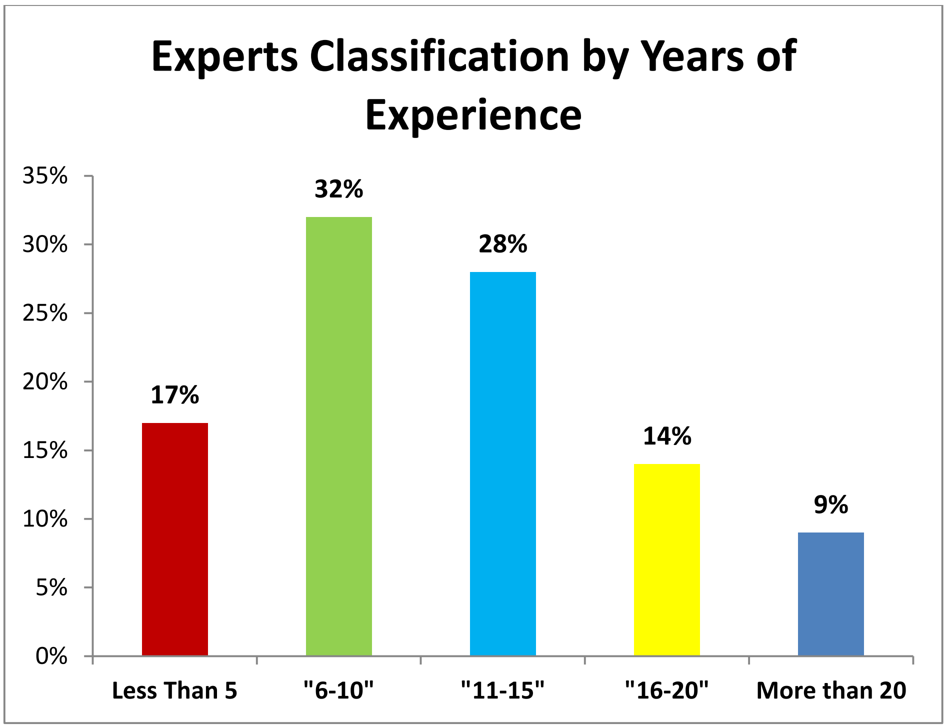


Figure 5-3: Experts' Classification by Years of Experience

5.2 Private Partner Selection Model Implementation using Fuzzy ANP

The developed model is tested on four case studies. The model implementation is performed in four steps, using FANP: main criteria weights' calculation, sub-criteria weights' calculation, priority weights' calculation, and partner ranking.

5.2.1 Main Criteria Weights' Calculation

The first step in the model development is to construct fuzzy comparison matrices. The fuzzy judgment matrix for the five criteria with respect to the overall goal is shown in Table 5-1. The linguistic terms and corresponding fuzzy intervals given in Table 3-3 were used for comparison ratios. The fuzzy numbers are composed in the form of (l, m, u), as explained in chapter 3. For example, in Table 5-1, the comparison between C1 and C1 is represented by fuzzy number (1, 1, 1), and the comparison between C1 and C2 is represented by the fuzzy number (3/2, 2, 5/2), which reflects the importance of C1 with respect to C2.

Table 5-1: Fuzzy judgment matrix for Case Study I

Goal	C1	C2	C3	C4	C5
C1	(1,1,1)	(3/2,2,5/2)	(1/2,1,3/2)	(1,3/2,2)	(1/2,1,3/2)
C2	(2/5,1/2,2/3)	(1,1,1)	(1,3/2,2)	(1,1,1)	(1/2,1,3/2)
C3	(2/3,1,2)	(1/2,2/3,1)	(1,1,1)	(1/2,2/3,1)	(1,1,1)
C4	(1/2,2/3,1)	(1,1,1)	(1,3/2,2)	(1,1,1)	(3/2,2,5/2)
C5	(2/3,1,2)	(2/3,1,2)	(1,1,1)	(2/5,1/2,2/3)	(1,1,1)

Next, Chang's extent analysis is applied to determine the priority weights of the five criteria as shown in Table 5-2, where the fuzzy synthetic extent values are calculated using Equation 3-8. The fuzzy synthetic extent value S_1 for the financial criteria in case study 1 is calculated as:

S_1 = ((1+3/2+1/2+1+1/2); (1+2+1+3/2+1); (1+5/2+3/2+2+3/2)) ⊗

(1/(1+5/2+3/2+2+3/2+2/3+1+2+1+3/2+2+1+1+1+1+1+1+2+1+5/2+2+2+1+2/3+1);

1/(1+2+1+3/2+1+1/2+1+3/2+1+1+1+2/3+1+2/3+1+2/3+1+3/2+1+2+1+1+1+1/2+1);

1/(1+3/2+1/2+1+1/2+2/5+1+1+1+1/2+2/3+1/2+1+1/2+1+1/2+1+1+1+3/2+2/3+2/3+1+2/5+1))

S_1= (4.5; 6.5; 8.5) ⊗ (1/34.8;1/26.5;1/20.8) = (0.129; 0.245; 0.409)

Table 5-2: Fuzzy synthetic extent values of the criteria's

Criteria priority weights	Fuzzy synthetic extent value			
	Case Study I	Case Study II	Case Study III	Case Study IV
$\widetilde{S_1}$	(0.129,0.245,0.409)	(0.277,0.335,0.421)	(0.400,0.298,0.302)	(0.300,0.367,0.333)
$\widetilde{S_2}$	(0.201,0.320,0.587)	(0.252,0.326,0.415)	(0.222,0.381,0.397)	(0.222,0.381,0.397)
$\widetilde{S_3}$	(0.066,0.154,0.287)	(0.366,0.311,0.323)	(0.333,0.367,0.300)	(0.333,0.367,0.300)
$\widetilde{S_4}$	(0.165,0.254,0.278)	(0.233,0.388,0.379)	(0.300,0.355,0.345)	(0.310,0.375,0.320)
$\widetilde{S_5}$	(0.095,0.177,0.289)	(0.250,0.250,0.500)	(0.500,0.500,0.000)	(0.320,0.384,0.296)

From the calculated criteria fuzzy synthetic extent values in Table 5-2, the degree of possibility is calculated using Equations 3.9 to 3.11, and hence the normalized weights of the five criteria are calculated using Equation 3.12 as shown in Table 5-3, which presents the calculated normalized weights for the five main criteria for the four case studies. For example, for case study I the weight for the technical criteria (W_2) is the greatest, while for case studies III and IV the financial criteria weight (W_1) is the highest.

Table 5-3: Criteria normalized weights

Criteria priority weights	Normalized weights			
	Case Study I	Case Study II	Case Study III	Case Study IV
W_1	0.266	0.275	0.365	0.266
W_2	0.232	0.250	0.209	0.232
W_3	0.109	0.060	0.191	0.109
W_4	0.227	0.100	0.210	0.227
W_5	0.166	0.315	0.025	0.166

5.2.2 Sub-Criteria Weights' Calculation

Sub-criteria are compared using pairwise comparison, and then the related judgment matrices are constructed. Chang's method for calculating the priority weights for sub-criteria is utilized to calculate their weight with respect to the main criteria, calculated as shown in Tables 5.4 and 5.5, which present the sub-criteria priority weights for the first case study.

Table 5-4: Chang's priority weights of sub-criteria against each other (Case Study I).

	Sub-Criteria																	
	C_1				C_2				C_3			C_4				C_5		
	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{31}	C_{32}	C_{33}	C_{41}	C_{42}	C_{43}	C_{44}	C_{51}	C_{52}	C_{53}
C_{11}	0.000	0.000	0.000	0.000	0.488	0.225	0.250	0.125	0.395	0.310	0.295	0.184	0.313	0.177	0.354	0.325	0.328	0.290
C_{12}	0.000	0.000	0.000	0.000	0.488	0.225	0.250	0.125	0.322	0.341	0.263	0.173	0.302	0.164	0.342	0.350	0.364	0.300
C_{13}	0.000	0.000	0.000	0.000	0.500	0.326	0.187	0.188	0.395	0.310	0.295	0.169	0.320	0.160	0.361	0.286	0.340	0.261
C_{14}	0.000	0.000	0.000	0.000	0.551	0.411	0.177	0.079	0.322	0.341	0.263	0.174	0.300	0.188	0.344	0.245	0.317	0.288
C_{21}	0.244	0.225	0.250	0.125	0.000	0.000	0.000	0.000	0.222	0.224	0.371	0.288	0.271	0.233	0.234	0.343	0.350	0.311
C_{22}	0.288	0.271	0.233	0.234	0.000	0.000	0.000	0.000	0.209	0.365	0.323	0.265	0.277	0.211	0.203	0.233	0.277	0.209
C_{23}	0.288	0.271	0.233	0.234	0.000	0.000	0.000	0.000	0.217	0.332	0.315	0.228	0.244	0.209	0.236	0.255	0.226	0.213
C_{24}	0.222	0.224	0.371	0.288	0.000	0.000	0.000	0.000	0.212	0.303	0.366	0.218	0.268	0.200	0.245	0.290	0.215	0.200
C_{31}	0.315	0.228	0.244	0.209	0.236	0.255	0.226	0.213	0.000	0.000	0.000	0.115	0.327	0.221	0.110	0.233	0.219	0.201
C_{32}	0.209	0.365	0.323	0.265	0.322	0.341	0.263	0.174	0.000	0.000	0.000	0.210	0.387	0.235	0.116	0.241	0.212	0.210
C_{33}	0.174	0.300	0.188	0.344	0.173	0.302	0.164	0.342	0.000	0.000	0.000	0.217	0.390	0.239	0.120	0.199	0.117	0.100
C_{41}	0.265	0.277	0.211	0.203	0.263	0.174	0.300	0.188	0.174	0.123	0.146	0.000	0.000	0.000	0.000	0.325	0.387	0.342
C_{42}	0.500	0.326	0.187	0.188	0.395	0.310	0.295	0.188	0.395	0.310	0.295	0.000	0.000	0.000	0.000	0.370	0.344	0.355
C_{43}	0.322	0.310	0.300	0.280	0.317	0.271	0.241	0.196	0.144	0.113	0.122	0.000	0.000	0.000	0.000	0.333	0.361	0.314
C_{44}	0.211	0.203	0.263	0.174	0.263	0.174	0.300	0.300	0.188	0.174	0.123	0.000	0.000	0.000	0.000	0.352	0.343	0.342
C_{51}	0.157	0.144	0.131	0.136	0.118	0.147	0.101	0.128	0.138	0.116	0.241	0.212	0.210	0.124	0.116	0.000	0.000	0.000
C_{52}	0.101	0.113	0.109	0.115	0.110	0.120	0.111	0.129	0.128	0.104	0.111	0.129	0.115	0.110	0.099	0.000	0.000	0.000
C_{53}	0.099	0.120	0.111	0.129	0.128	0.104	0.111	0.129	0.115	0.110	0.115	0.110	0.120	0.111	0.102	0.000	0.000	0.000

Table 5-5 presents the calculated sub-criteria weights for case study I, where sub-criteria W_{23} (Construction program and ability to meet its targeted milestone) has the highest weight of 0.5525, and W_{42} (Acceptance of risk transfer) is second with a weight of 0.4210. It is worth noting that W_{14} (Foreign Financing) has the lowest weight of 0.0155.

Table 5-5: Sub-Criteria Weights (Case Study I).

Sub-Criteria Weights					
	C1	**C2**	**C3**	**C4**	**C5**
Sub1	0.3741	0.1455	0.3333	0.2229	0.4000
Sub2	0.3227	0.1520	0.3579	0.4210	0.3882
Sub3	0.2877	0.5525	0.3088	0.2000	0.2118
Sub4	0.0155	0.1500	-	0.1561	-
Total	1	1	1	1	1

5.2.3 Priority Weights Calculation

The amount of interdependency among sub-criteria, or the degree of sub-criteria's impacts on each other was measured. The priority weights of alternatives with respect to the sub-criteria are calculated as shown in Table 5-6, where partner P_1 has the highest weight with respect to sub-criteria C_{32} (Conformance to laws and regulations) with a weight of 0.375, partner P_2 has the highest weight with respect to sub-criteria C_{33} (Qualification/experience of safety and environmental personal) with a weight of 0.362, partner P_3 has the highest weight with respect to sub-criteria C_{11} (Equity/Debt) with a weight of 0.387, and partner P_4 has the highest weight with respect to sub-criteria C_{53} (Compliance with boycott trade laws) with a weight of 0.32.

Table 5-6: Chang's priority weights of alternatives with respect to sub-criteria (Case Study I)

	C11	C12	C13	C14	C21	C22	C23	C24	C31	C32	C33	C41	C42	C43	C44	C51	C52	C53
P1	0.079	0.216	0.219	0.362	0.302	0.211	0.223	0.361	0.22	0.375	0.133	0.111	0.222	0.225	0.3	0.233	0.299	0.305
P2	0.348	0.227	0.14	0.214	0.222	0.355	0.2	0.09	0.295	0.087	0.362	0.325	0.271	0.227	0.255	0.205	0.271	0.2
P3	0.387	0.277	0.356	0.3	0.213	0.322	0.277	0.366	0.285	0.261	0.322	0.378	0.345	0.223	0.245	0.295	0.288	0.175
P4	0.186	0.28	0.285	0.124	0.263	0.112	0.3	0.183	0.2	0.277	0.183	0.186	0.162	0.225	0.2	0.267	0.142	0.32

5.2.4 Partner Ranking

The priority vectors obtained through paired comparisons are placed in the appropriate columns to form the supermatrix. Table 5-7 represents the supermatrix for case study I, where the zero elements in the supermatrix show the independencies among the variables in the rows and columns. The supermatrix is then transformed into a weighted matrix. The transformation process involves multiplying the supermatrix by the cluster matrix, so that the priorities of the clusters can be taken into account in the decision making process. Finally, the weighted supermatrix is transformed into the limit supermatrix, shown in Table 5-8, to make the distribution of the vector values meaningful to decision makers

In the unweighted supermatrix shown in Table 5-7, the first column and the first row are the cluster of alternatives, the selection criteria and the goal. The priority weight of each element in the cluster is entered in the corresponding cell, and then the goal is calculated.

Table 5-7: (unweighted) super – matrix for the private partner selection (Case Study I).

Cluster Node level			Alternatives				Criteria																		Goal
							C_1				C_2				C_3			C_4				C_5			
			P_1	P_2	P_3	P_4	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{31}	C_{32}	C_{33}	C_{41}	C_{42}	C_{43}	C_{44}	C_{51}	C_{52}	C_{53}	
Alte	P_1		0.000	0.000	0.000	0.000	0.079	0.216	0.219	0.362	0.302	0.211	0.223	0.361	0.220	0.375	0.133	0.111	0.222	0.225	0.300	0.233	0.299	0.305	0.0000
	P_2		0.000	0.000	0.000	0.000	0.348	0.227	0.140	0.214	0.222	0.355	0.200	0.090	0.295	0.087	0.362	0.325	0.271	0.227	0.255	0.205	0.271	0.200	0.0000
	P_3		0.000	0.000	0.000	0.000	0.387	0.277	0.356	0.300	0.213	0.322	0.277	0.366	0.285	0.261	0.322	0.378	0.345	0.223	0.245	0.295	0.288	0.175	0.0000
	P_4		0.000	0.000	0.000	0.000	0.186	0.280	0.285	0.124	0.263	0.112	0.300	0.183	0.200	0.277	0.183	0.186	0.162	0.225	0.200	0.267	0.142	0.320	0.0000
Criteria	C_1																								
		C_{11}	0.300	0.222	0.523	0.333	0.000	0.000	0.000	0.000	0.488	0.225	0.250	0.125	0.395	0.310	0.295	0.184	0.313	0.177	0.354	0.325	0.328	0.290	0.2000
		C_{12}	0.289	0.201	0.213	0.472	0.000	0.000	0.000	0.000	0.488	0.225	0.250	0.125	0.322	0.341	0.263	0.173	0.302	0.164	0.342	0.350	0.364	0.300	0.1500
		C_{13}	0.270	0.277	0.200	0.181	0.000	0.000	0.000	0.000	0.500	0.326	0.187	0.188	0.395	0.310	0.295	0.169	0.320	0.160	0.361	0.286	0.340	0.261	0.0650
		C_{14}	0.140	0.299	0.064	0.013	0.000	0.000	0.000	0.000	0.551	0.411	0.177	0.079	0.322	0.341	0.263	0.174	0.300	0.188	0.344	0.325	0.328	0.290	0.0055
	C_2																								
		C_{21}	0.163	0.142	0.189	0.154	0.244	0.225	0.250	0.125	0.000	0.000	0.000	0.000	0.222	0.224	0.371	0.288	0.271	0.233	0.234	0.343	0.350	0.311	0.0821
		C_{22}	0.311	0.197	0.200	0.487	0.288	0.271	0.233	0.234	0.000	0.000	0.000	0.000	0.209	0.365	0.323	0.265	0.277	0.211	0.203	0.233	0.277	0.209	0.0063
		C_{23}	0.250	0.265	0.388	0.277	0.288	0.271	0.233	0.234	0.000	0.000	0.000	0.000	0.217	0.332	0.315	0.228	0.244	0.209	0.236	0.255	0.226	0.213	0.1179
		C_{24}	0.163	0.394	0.221	0.080	0.222	0.224	0.371	0.288	0.000	0.000	0.000	0.000	0.212	0.303	0.366	0.218	0.268	0.200	0.245	0.343	0.350	0.311	0.0011
	C_3																								
		C_{31}	0.100	0.266	0.250	0.387	0.315	0.228	0.244	0.209	0.236	0.255	0.226	0.213	0.000	0.000	0.000	0.115	0.327	0.221	0.110	0.233	0.219	0.201	0.0033
		C_{32}	0.333	0.400	0.500	0.458	0.209	0.365	0.323	0.265	0.322	0.341	0.263	0.174	0.000	0.000	0.000	0.210	0.387	0.235	0.116	0.241	0.212	0.210	0.0035
		C_{33}	0.566	0.333	0.250	0.154	0.174	0.300	0.188	0.344	0.173	0.302	0.164	0.342	0.000	0.000	0.000	0.217	0.390	0.239	0.120	0.199	0.117	0.100	0.0025
	C_4																								
		C_{41}	0.244	0.181	0.300	0.293	0.265	0.277	0.211	0.203	0.263	0.174	0.300	0.188	0.174	0.123	0.146	0.000	0.000	0.000	0.000	0.325	0.387	0.342	0.0315
		C_{42}	0.222	0.188	0.333	0.184	0.500	0.326	0.187	0.188	0.395	0.310	0.295	0.188	0.395	0.310	0.295	0.000	0.000	0.000	0.000	0.370	0.344	0.355	0.1000
		C_{43}	0.222	0.400	0.250	0.245	0.322	0.310	0.300	0.280	0.317	0.271	0.241	0.196	0.144	0.113	0.122	0.000	0.000	0.000	0.000	0.333	0.361	0.314	0.0045
		C_{44}	0.310	0.230	0.117	0.277	0.211	0.203	0.263	0.174	0.263	0.174	0.300	0.300	0.188	0.174	0.123	0.000	0.000	0.000	0.000	0.352	0.343	0.342	0.0043
	C_5																								
		C_{51}	0.344	0.333	0.400	0.156	0.157	0.144	0.131	0.136	0.118	0.147	0.101	0.118	0.138	0.116	0.241	0.212	0.210	0.124	0.116	0.000	0.000	0.000	0.0800
		C_{52}	0.355	0.333	0.400	0.232	0.101	0.113	0.109	0.115	0.110	0.120	0.111	0.110	0.128	0.104	0.111	0.129	0.115	0.110	0.099	0.000	0.000	0.000	0.0650
		C_{53}	0.299	0.334	0.200	0.611	0.099	0.120	0.111	0.129	0.128	0.104	0.111	0.128	0.115	0.110	0.115	0.110	0.120	0.111	0.102	0.000	0.000	0.000	0.0838
Goa			0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000

The limit supermatrix for case study I is shown in Table 5-8, where the first column and row are the cluster of alternatives, the selection criteria and the goal. The limit supermatrix shows the weight of each element in the cluster after the matrix reaches stability.

Table 5-8: Limit super – matrix for the private partner selection (Case Study I)

Cluster Node level			Alternatives				Criteria																		Goal
							C_1				C_2				C_3			C_4				C_5			
			P_1	P_2	P_3	P_4	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{31}	C_{32}	C_{33}	C_{41}	C_{42}	C_{43}	C_{44}	C_{51}	C_{52}	C_{53}	
Alte	P_1		0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068
	P_2		0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118
	P_3		0.159	0.159	0.159	0.159	0.159	0.159	0.159	0.159	0.159	0.159	0.159	0.159	0.159	0.159	0.159	0.159	0.159	0.159	0.159	0.159	0.159	0.159	0.159
	P_4		0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096
Criteria	C_1																								
		C_{11}	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122
		C_{12}	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099
		C_{13}	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
		C_{14}	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
	C_2																								
		C_{21}	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
		C_{22}	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
		C_{23}	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
		C_{24}	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
	C_3																								
		C_{31}	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
		C_{32}	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011
		C_{33}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	C_4																								
		C_{41}	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
		C_{42}	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
		C_{43}	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
		C_{44}	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
	C_5																								
		C_{51}	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
		C_{52}	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036
		C_{53}	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044
Goal			0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000

The final priority of the four private partner alternatives is represented in Table 5-9, where private partner $P_3 = 0.159$ is chosen as the best private partner to deliver this project. While the result selected private partner $P_3 = 0.159$ as the best private partner, the authorities (decision makers) selected private partner P_4 = 0.096, with a value rating less than the both private partners P_2 and P_3. The decision makers based their selection on unjustifiable and subjective political factors. On the other hand, the developed model provides flexibility in expressing the decision makers' preferences in the form of fuzzy intervals rather than in the form of single numeric values. Also, the developed model is able to deal with possible interdependencies among the selection criteria.

Table 5-9: The priorities of the four private partners (Case Study I).

Private Partner	**Priority of the Alternatives**	**Rank**
Private Partner P1	0.068	4
Private Partner P2	0.118	2
Private Partner P3	0.159	1
Private Partner P4	0.096	3

A similar approach is applied for the three other cases, and the summary of the results is presented in Table 5-10, where the private partners are ranked based on their priority weighting. For case number one, private partner P3 was ranked the highest with a priority weight of 0.159. For case number two, private partner P2 was the highest-ranked with a priority weight of 0.223. As for case number three, private partner P1 was selected with the highest priority weight of 0.238. Finally for case number four, private partner P3 was the highest ranking partner with a priority weight of 0.123.

Table 5-10: Partner Ranking Summary of four case studies.

Private Partner	Priority of the Alternatives			
Private Partner P1	0.068	0.112	0.238	0.058
Private Partner P2	0.118	0.223	0.148	0.045
Private Partner P3	0.159	0.122	0.105	0.123
Private Partner P4	0.096			0.060
Private Partner P5				0.039
Private Partner P6				0.054

5.3 Private Partner Selection Model Implementation using TOPSIS

The developed model is tested on four case studies. The model implementation using the TOPSIS approach is performed in four steps: general criteria weights calculation, decision matrix calculation, separation calculation, and partner ranking.

5.3.1 General Criteria Weights Calculation

In the TOPSIS technique, the general criteria weights are customized for each project. As explained in the methodology section, the sum of the weights should add to 100%, wherein each of the risk factors is assigned a weight by credit exports. For example, in the case study I, the political risk is twice as important as the safety and environmental risk, therefore it was assigned a higher weight as shown in Table 5-11. This political risk is largely due to prolonged political instability and civil war in the country which makes investors twice as worried as they would be in case study IV.

Table 5-11: General Criteria Weights (Case Study I).

General Criteria Weights				
Financial	**Technical**	**Safety & Environmental**	**Managerial**	**Political**
35.0%	35.0%	7.5%	7.5%	15.0%

5.3.2 Decision Matrix Calculation

Each partner was assessed by experts on each of the five criteria, as shown in Table 5-12, according to their ability to fulfill the best practices of the selection criteria. Each cell in Tables 5-12 to 5-15 represents the score given by each of ten experts for each of the four partners (A – D) for case study I. These scores are also averaged to represent each partner's mean score for each criteria. For example, the average score of the ten experts for partner A's Financial capability is 2.6.

Table 5-12: Experts opinions for partner A (Case Study I).

Experts opinions for partner A											
	1	2	3	4	5	6	7	8	9	10	Average
Financial	1	2	4	3	1	3	5	3	3	1	2.60
Technical	3	4	4	1	3	4	5	3	2	1	3.00
Safety & Environmental	3	4	3	1	2	3	1	5	2	1	2.50
Managerial	2	3	4	2	4	3	2	3	2	4	2.90
Political	3	2	4	3	1	2	3	4	2	5	2.90

Table 5-13: Experts opinions for partner B (Case Study I).

Experts opinions for partner B											
	1	2	3	4	5	6	7	8	9	10	Average
Financial	3	4	3	3	5	4	3	3	2	3	3.3
Technical	4	3	4	3	3	2	3	4	4	3	3.3
Safety & Environmental	2	3	4	2	1	5	3	2	4	5	3.1
Managerial	3	4	3	3	2	4	3	4	3	2	3.1
Political	3	4	4	3	2	3	4	2	3	2	3

Table 5-14: Experts opinions for partner C (Case Study I).

Experts opinions for partner C											
	1	2	3	4	5	6	7	8	9	10	Average
Financial	4	3	5	4	4	3	4	5	3	4	3.9
Technical	3	4	5	4	4	5	3	4	5	3	4
Safety & Environmental	4	3	5	5	2	3	4	3	4	5	3.8
Managerial	4	5	3	4	4	5	4	4	3	5	4.1
Political	5	5	3	4	2	3	3	4	5	4	3.8

Table 5-15: Experts opinions for partner D (Case Study I).

Experts opinions for partner D											
	1	2	3	4	5	6	7	8	9	10	Average
Financial	3	3	3	2	3	5	4	4	3	4	3.4
Technical	2	3	4	4	3	3	3	5	3	4	3.4
Safety & Environmental	3	2	4	5	2	3	2	3	3	3	3
Managerial	4	3	4	5	4	2	4	2	4	5	3.7
Political	4	3	4	5	2	3	2	3	2	5	3.3

Table 5-16 summarizes the expert's assessment for the four partners in case study I. The total value for each criteria is calculated as the square root of the sum of squares (for each cell). For example, the total value for the financial criteria is calculated as:

$$\sqrt{2.6^2 + 3.3^2 + 3.9^2 + 3.4^2} = 6.664$$

Table 5-16: Decision Matrix (Case Study I).

	Decision Matrix				
	Partner A	Partner B	Partner C	Partner D	Total
Financial	2.60	3.30	3.90	3.40	6.6648330
Technical	3.00	3.30	4.00	3.40	6.8883960
Safety & Environmental	2.50	3.10	3.80	3.00	6.2689712
Managerial	2.90	3.10	4.10	3.70	6.9656299
Political	2.90	3.00	3.80	3.30	6.5375836

The next step is to normalize the scores. This provides a better comparison tool, especially when partners are very different in scale or in the nature of their business. TOPSIS applies the de-unitization concept to normalize the scores. This step transforms various attribute dimensions into non-dimensional attributes as shown in Table 5-17, which then allows for comparison across criteria. Each cell in Table 5-17 is calculated by dividing the corresponding value in Table 5-16 by the total in its last column. For example, the financial normalized weight for partner A is calculated as $\frac{2.6}{6.6648} = 0.39$, the same approach is applied to the rest of the cells.

Table 5-17: Standard Decision Matrix (Case Study I).

	Standard Decision Matrix			
	Partner A	Partner B	Partner C	Partner D
Financial	0.39	0.50	0.59	0.51
Technical	0.44	0.48	0.58	0.49
Safety & Environmental	0.40	0.49	0.61	0.48
Managerial	0.42	0.45	0.59	0.53
Political	0.44	0.46	0.58	0.50

The weighted standard decision matrix takes into account the general weights by multiplying the standard decision matrix (Table 5-17) by the general criterial weights (Table 5-11). The calculated weighted standard decision matrix for case study I is presented in Table 5-18, where the first column lists the criteria, the next four columns present the weighted standard decision matrix, and the last two columns represent the most-favorable and the least-favorable alternative for each criteria. For example, the financial criteria weighted standard decision is calculated as:

0.39*0.35 = 0.1365.

Table 5-18: Weighted Standard Decision Matrix (Case Study I).

	Weighted Standard Decision Matrix				**Positive Ideal**	**Negative Ideal**
	Partner A	Partner B	Partner C	Partner D		
Financial	0.13654	0.17330	0.20481	0.17855	0.2048	0.1365
Technical	0.15243	0.16767	0.20324	0.17275	0.2032	0.1524
Safety & Environmental	0.02991	0.03709	0.04546	0.03589	0.0455	0.0299
Managerial	0.03122	0.03338	0.04415	0.03984	0.0441	0.0312
Political	0.06654	0.06883	0.08719	0.07572	0.0872	0.0665

5.3.3 Separation Calculation

The separation of the positive ideal solution and the negative ideal solution is utilized to measure the distance between the alternative and the extreme solutions. Table 5-19 presents the separation from the positive ideal solutions in each of the five criteria for case study I. For example, the separation from the weighted positive ideal financial criteria rating for partner A in case study I is calculated from Table 5-18 as: $(0.13654-0.2048)^2 = 0.0047$. The shorter the distance a partner's values are from the ideal, the better the overall situation of that partner relative to the others.

Table 5-19: Separation from Positive Ideal Solution (Case Study I).

	Separation from Positive Ideal Solution			
	Partner A	Partner B	Partner C	Partner D
Financial	0.0047	0.0010	0.0000	0.0007
Technical	0.0026	0.0013	0.0000	0.0009
Safety & Environmental	0.0002	0.0001	0.0000	0.0001
Managerial	0.0002	0.0001	0.0000	0.0000
Political	0.0004	0.0003	0.0000	0.0001
Separation(S+)	0.0899	0.0527	0.0000	0.0431

Similarly, the separations from the negative ideal solutions are calculated for case study I as shown in Table 5-20. For example the financial negative separation for partner B is calculated from Table 5-18 as: $(0.17330-0.1365)^2 = 0.0014$.

Table 5-20: Separation from Negative Ideal Solution (Case Study I).

	Separation from Negative Ideal Solution			
	Partner A	Partner B	Partner C	Partner D
Financial	0.0000	0.0014	0.0047	0.0018
Technical	0.0000	0.0002	0.0026	0.0004
Safety & Environmental	0.0000	0.0001	0.0002	0.0000
Managerial	0.0010	0.0011	0.0019	0.0016
Political	0.0000	0.0000	0.0004	0.0001
Separation(S-)	0.03122	0.05248	0.09929	0.06233

5.3.4 Partner Ranking

The final partner ranking is performed based on the separations calculated in the previous step. The calculated positive and negative separations are used to find the relative separation value as shown in Table 5-21. For example, for partner A, the relative separation value is calculated as: 0.03122/ (0.0899+0.03122) = 0.2578. Higher values mean more distance from the negative solution and less from the ideal positive one. The last row in Table 5-21 shows the final partner ranking based on the calculated relative separations. The result for case study I shows that private partner C the best private partner to deliver this project; however, the authorities (decisions makers) selected private partner D.

Table 5-21: Relative Separation and Partner Ranking (Case Study I).

	Relative Separation			
	Partner A	Partner B	Partner C	Partner D
Separation(S+)	0.0899	0.052733272	0	0.043134706
Separation(S-)	0.03122	0.05248	0.09929	0.06233
(S+) +(S-)	0.12112	0.10522	0.09929	0.10547
S-/((S+) + (S-))	0.2578	0.4988	1	0.5910
Rank of Partners	**4**	**3**	**1**	**2**

The same approach is applied on all four case studies and the results are summarized in Table 5-22, where partner P3 was the best alternative for case study I, partner P2 was the best alternative for case study II, partner P1 was the best alternative for case study III, and partner P3 was the best alternative for case study IV.

Table 5-22: Partner ranking using a TOPSIS summary of four case studies.

Private Partner	**Priority of the Alternatives**			
Private Partner P1	0.2578	0.0823	0.1246	0.6766
Private Partner P2	0.4988	0.9087	0.0859	0.4044
Private Partner P3	1	0.2340	0.0562	1
Private Partner P4	0.5910			0.8198
Private Partner P5				0.1745
Private Partner P6				0.4245

5.4 Model Test and Comparison

The developed model was applied in four case studies to evaluate its performance for selecting the best private partners in PPP projects. These case studies vary in terms of location, size, type, budget, and concession period. This variability was reflected in the calculated criteria weights, which varied from one project to another. The model was applied using two approaches (developed or modified for this study), the Fuzzy Analytical Network Process (FANP), and the TOPSIS multi-criteria decision making technique. The rationale of using two approaches is to crosscheck the model output and thereby offer the decision maker additional confidence in the results. The two approaches complement each other; the FANP accounts for the interdependencies among the selection criteria and the uncertainty and vagueness in the experts' judgement, and on the other hand, the TOPSIS allows the potential private partners to be ranked based on the general criteria, and thus how well they fit the project objectives. The TOPSIS ranking is based on the separation of the partner's weighted criteria values from the positive ideal and from the negative ideal solutions.

To assess the model's performance, its output is compared to the actual partner selected in each case study. The results of case study I – Toll Bridge in the case study I, are illustrated in Table 5-23, indicating that the FANP and the TOPSIS approaches both selected private partner P3, while the partner selected for this project by the government was partner P4. Both approaches (FANP & TOPSIS) provided the same results, however this result is not in line with the actual case study results, therefore it is important to try to understand why the government committee chose to select a partner that was the third choice of one method and far from the first choice of another method.

Table 5-23: Case Study I- Toll bridge – Results Comparison.

Private Partner	FANP	TOPSIS	Actual
P1	0.068	0.257	
P2	0.118	0.498	
P3	0.159	1	
P4	0.096	0.591	✓

The general criteria weights using both FANP and TOPSIS are presented in Table 5-24, where the actual governmental evaluation on that project was based only on the financial and technical criteria. The similarity in the weights for both the financial and technical criteria is illustrated in Figure 5-4, while there are large differences in the weights of the managerial and the safety & environmental criteria. The evaluating authority only considered the financial and technical criteria, which resulted in the wrong selection of their private partner. This illustrates the importance of considering the whole cluster of criteria in the selection process in order to have a comprehensive assessment of the competitors.

Table 5-24: Case Study I- Toll bridge – General Criteria

Criteria	FANP	TOPSIS	Actual
Financial	0.266	0.350	✓
Technical	0.232	0.350	✓
Safety & Environmental	0.109	0.075	✗
Managerial	0.227	0.075	✗
Political	0.166	0.150	✗

It is also noting that, while the TOPSIS analysis provided the same solution for the selection, it only considered the general criteria. Therefore, it presented a different ranking for the subsequent partners, where it ranked partner P4 second, while FANP ranked the same partner third. This difference in the ranking is due to the detailed assessment provided by the FANP, in which not only the general criteria is considered, but also sub-criteria, while taking into consideration the interdependencies among them. Moreover, the fuzzy representation of the expert's judgements also contributes to the uncertainty in the selection process.

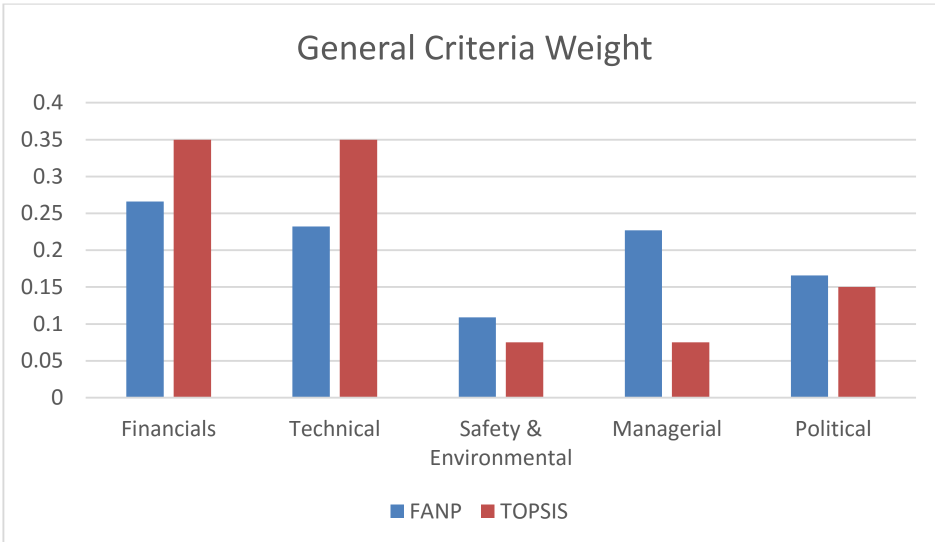


Figure 5-4: Case Study I-General Criteria Weights Comparison

For case study II - Highway, the results of the analysis are presented in Table 5-25, where the developed models using the FANP and the TOPSIS method selected private partner P2, while the authority selected private partner P1. The authority's selection was based on a political decision from a high-level governmental authority to select that specific partner. They did not account for any selection criteria, which resulted in a very subjective selection of their private partner. Such a selection process highlights the importance and the need for the developed selection model, which removes subjectivity (potentially greatly reducing favoritism, graft and unsatisfactory work) and provides a structured method for selecting the private partner.

Table 5-25: Case Study II- Highway Results Comparison

Private Partner	**FANP**	**TOPSIS**	**Actual**
P1	0.112	0.0823	✓
P2	0.223	0.9087	
P3	0.122	0.2340	

The comparison of the general criteria weight presented in Table 5-26 shows a large difference between the criteria weights for the two techniques. This variance in the criteria weight (made more visible in Figure 5-5) can be explained by the different approaches for calculating the weights in each technique. In TOPSIS, criteria weights are calculated using a simple averaging of the expert's scores, while in FANP, a more comprehensive approach is utilized to account for uncertainty and interdependencies.

Table 5-26: Case Study II- Highway Rass Igdaar – Imsaad – General Criteria

Criteria	**FANP**	**TOPSIS**	**Actual**
Financials	0.275	0.400	✘
Technical	0.250	0.300	✘
Safety & Environmental	0.060	0.075	✘
Managerial	0.100	0.150	✘
Political	0.315	0.075	✘

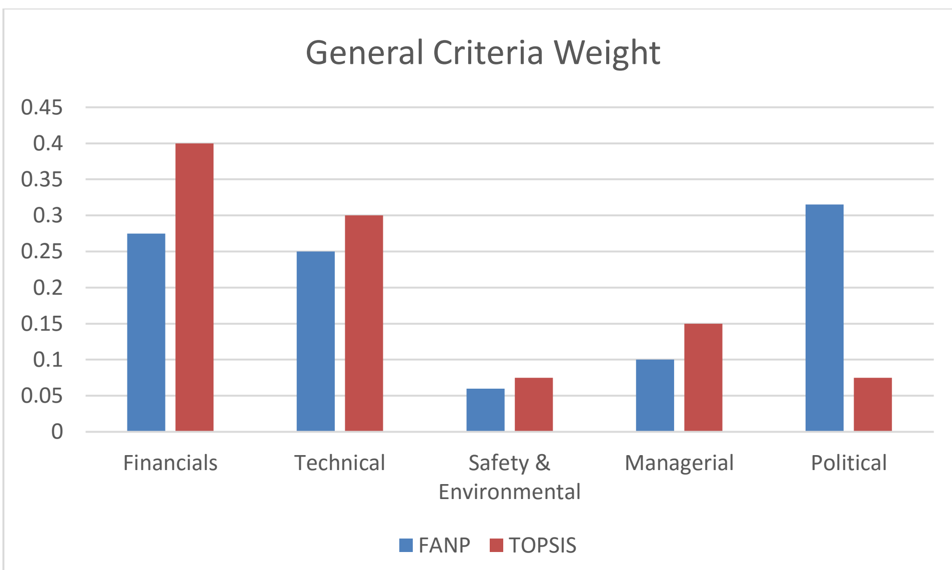


Figure 5-5: Case Study II-General Criteria Weights Comparison

For case study III - Widening a two-lane highway to four lanes, the project was financed by financial institutions. Therefore, the private partner selection process had to account for the five main selection criteria introduced in this research. A complete assessment of the competitors was performed by experts, specifically France. The results obtained from the developed model are compared to the actual selection by the authorities as shown in Table 5-27, where the developed model selected private partner P1, which was also the selection of the authority. Private partner P1 scored 0.238 and 0.124 using the FANP and TOPSIS techniques, respectively.

Table 5-27: Case Study III- Highway Renwal Results Comparison

Private Partner	FANP	TOPSIS	Actual
P1	0.238	0.124	✓
P2	0.148	0.085	
P3	0.105	0.056	

For case study IV- the project was one of the first public-private partnership (PPP) projects in this country and was financed by the financial institution Bank. The results obtained from the developed model are compared to the actual selection by the authorities in Table 5-28. The developed FANP and TOPSIS models ranked private partner P3 the highest, with a priority weight of 0.123, and the authority was also chose partner P3.

Table 5-28: Case Study IV- Results Comparison

Private Partner	FANP	TOPSIS	Actual
P1	0.058	0.764	
P2	0.045	0.177	
P3	0.123	1	✓
P4	0.060	0.577	
P5	0.039	0.273	
P6	0.054	0.268	

5.5 Summary

The developed private partner selection model was applied to four real case studies, and the results revealed the effectiveness of the developed framework in selecting the most suitable private partner for PPP projects. The model was applied using the two developed approaches, the Fuzzy Analytical Network Process (FANP), and the TOPSIS multi-criteria decision making technique. The rationale of using two approaches is to crosscheck the model output and thereby provide the decision maker with more confident results. The two approaches complement each other; the FANP accounts for the interdependency between the selection criteria and the uncertainty and vagueness in the experts' judgement, and the TOPSIS allows for the ranking of potential private partners based on the general criteria, and how well they fit the project objectives. The TOPSIS ranking is based on the separation of the partner from the positive ideal and the negative ideal solution.

The developed model was able to take into account all of the possible dependencies among the selection criteria, as well as those between the alternatives and the selection criteria. Taking into account these interdependencies among decision elements provides more realistic solutions. The use of fuzzy intervals for priority judgments allows decision makers to incorporate both objective and subjective considerations in the evaluation process.

Chapter 6: Bankability Assessment Model Implementation

6.1 General

This chapter presents the implementation of the developed bankability assessment model on six real case studies. These projects were executed in different countries. These projects vary in terms of their location, type, cost and concession period. This variability is intended to measure the developed model's performance and verify its efficiency in assessing the bankability of a range of projects.

6.2 Discussion of the Questionnaire Responses

The respondents of the survey were classified based on their position level as shown in Figure 6-1, where 38% were credit analysts, 21% were investment bankers, 24% were business analysts and 17% were investment finance analysts.

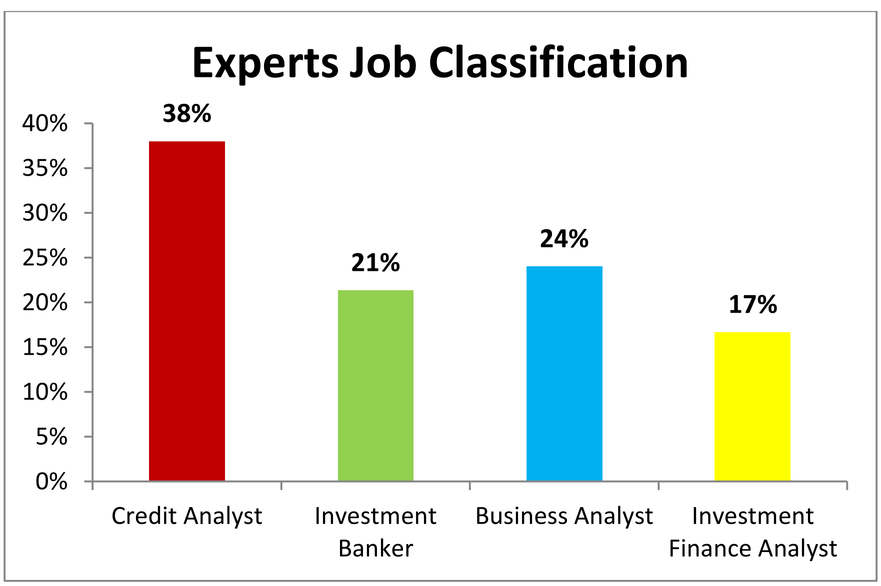


Figure 6-1: Financial Experts by Job Classification

The survey respondents were also classified by their years of experience, as shown in Figure 6-2, where 20% had less than 5 years of experience, 26% had 6 to 10 years, 29% had 11 to 15 years18% had 16 to 20 years and 7% had more than 20 years of experience.

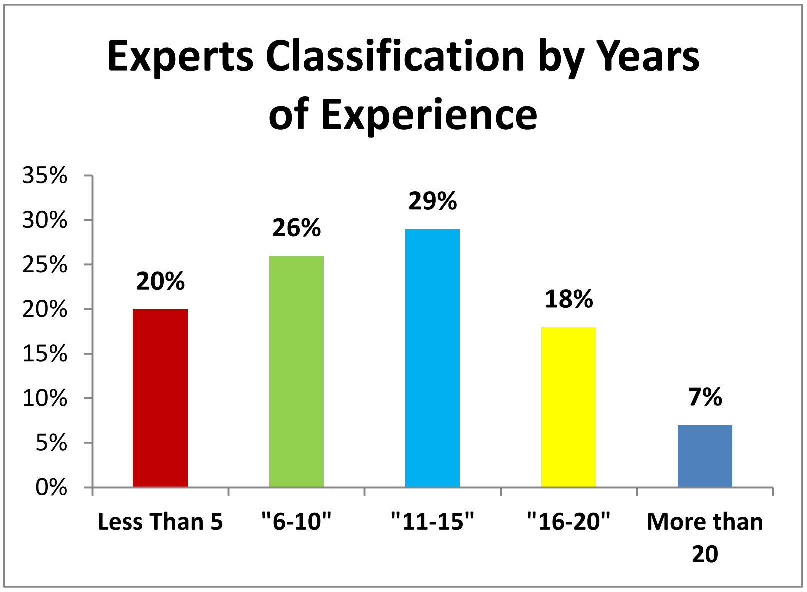


Figure 6-2: Financial Experts Classification by Years of Experience

The surveys were collected from different countries as illustrated in Table 6-1: 47 responses for Project A, 25 responses for Project B, 36 responses for Project C, 30 responses for Project D, and 14 responses for Project E. The average response rate to the questionnaires was 78 % (152 out of 196).

Table 6-1: Survey Distribution Results

Distributed	60	30	41	40	25
Filled & Received	47	25	36	30	14

6.3 Bankability Assessment Model Implementation

The bankability model requires two sets of data. The first set of data consists of the accounting numbers for each project, which represents their revenue and cost forecast for the first year of operation. This data is provided by the project managers when a credit analyst receives their proposal or fund request. The second set of data are the risk factors required for the risk assessment of each project. These numbers were obtained through the questionnaires distributed to the credit experts.

The first model's survey was communication exchange with the projects' managers to acquire their information and data regarding the projects, which is why the ANP model's questionnaire contains questions about the managers' expectation for the first year's financial data, such as income data and its breakdown, cost data and its break down, capital expenditure forecasts, and working capital requirements. The data thus gathered are averaged for each set of data and listed in Table 6-2. These averages are the first year's forecast, used as the starting point of the analysis. A brief description of the data received from each project is presented below. It worth mentioning that our data has been exposed to accounting risks during the process of gathering and presenting the accounting information. This kind of risk arises from different methods of recording transaction, and the potential for accounting rules and regulations to change.

Table 6-2: Brief description of the data received from each project

Case Study	I	II	III	IV	V	VI
Delivery Approach	BOT	BOT	BOT	BOT	BOT	BOT
Construction Period (months)	60	60	54	18	36	26
Period of Analyse (years)	20	20	20	20	20	20
First Year's net revenue (M€)	197	55.6	192	96.7	27	163

The capital structure of the six case studies is presented in Table 6-3. A company's capital structure is a mix of debt and equity that the company uses to finance its business. The goal of a company's capital structure is to determine the financial leverage or capital structure that maximizes the value of the company by minimizing the weighted average cost of capital. We have treated the case studies' capital structure as if each one were a company.

It is worth mentioning that:

- For case study I, its high amount of debt, 86 percent of the project's total capital, means that it is a highly-leveraged project, which makes it more sensitive to any change in risk factors. A large and stable free cash flow is required to mitigate this sensitivity.
- In case study II, the equity and foreign senior debt share the same proportion in the project's capital structure.
- In case study III, senior debt, both foreign and local, comprises 60 percent of its capital structure. Therefore, this is a leveraged project and thus has to keep its cash flow positive and stable.
- In case study IV , sponsors and local equity holders provide 40 percent of the required capital. These two source of capital share the risk with the project and help to reduce the WACC of the total project.
- For case study V (Toll Road - TR), government grants are the main source of the project capital, which mitigates the total WACC.
- For case study VI, local senior debt holders are the main capital providers, followed by the government, and so Cash flow to the firm is the main concern.

Table 6-3: Capital Structure of Six Case Studies

<table>
<tr><th colspan="3">Capital Structure of Each Project</th></tr>
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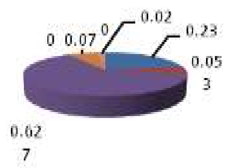

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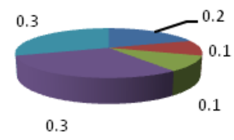

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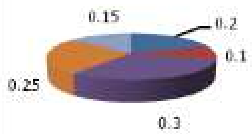

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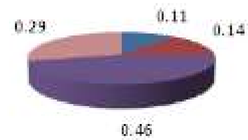


</td>
</tr>
<tr>
<td>Local Equity
Local Subordinate debt
Foreign Subordinate Debt
Local Senior Debt
Foreign Senior debt
Sponsors
Bank Loan
Government Grant</td>
<td colspan="2">BNH = Building a New Highway
BBA = Building 20 Bridges Across Highways
SWOTF = Strengthening and Widening of two lanes to four lanes
TR = Toll Road
TB = Toll Bridge
IA = International Airport</td>
</tr>
</table>

It was assumed that the capital structure of each project was based on the creditors' target capital structure and that it will be stable throughout the life of the project. To discount each future year's free cash flow numbers to the current time, and then analyze the projects, we need a discounting rate. This rate is the function of each project's risk level or risk profile. These profiles are based on the credit experts' opinions regarding each project's uncertainty.

6.3.1 Case Study I -

The steps utilised to obtain the discounting factor for the new International Airport project are listed below:

1. Calculate General Attribute Weights: The first question in the questionnaire sent to the credit experts asks for the relative value of each risk factor. The respondents assigned each risk factor a number on a scale from one to eight. These numbers were then averaged for all the responses and are presented in Table 6-4, where the market risk has a weight of 4, the political risk a weight of 5, the environmental risk a weight of 2, the operation and completion risks a weight of 1.8, and the legal and technical risks have a weight of 1.6.

Table 6-4: General Weights of the Risk Factors according to Credit Experts

General Relative Weights of Risk factors (averaged)	
Risk Factor	**Weight**
Market Risk	4
Environmental Risk	2
Legal Risk	1.6
Political Risk	5
Technical Risk	1.6
Operation Risk	1.8
Completion Risk	1.8
Counter risk	1.9

2. The second step is to assemble the risk profile. The average of the questionnaire's responses, where the project managers were requested to rate the risks on a scale of 1-8 , are presented in Table 6-5, where the three highest risks were technical risk with a value of 3.3, operation risk with a value of 3.11, and completion risk, with a value of 3.02.

Table 6-5: Experts' Responses to questionnaire

Risk Factor	**Average of Responses**
Market Risk	2.76
Environmental Risk	2.92
Legal risk	2.26
Political Risk	2.48
Technical Risk	3.3
Operation Risk	3.11
Completion Risk	3.02
Counter risk	2.62

3. To have a meaningful comparison of the responses, the he averaged results are normalized and presented in Table 6-6. This normalization is calculated using Equation 6.1 below:

$$r_{in} = \frac{x_{in}}{\sqrt{\sum_{i=m}^{Co} x_{in}^2}} \qquad (6.1)$$

For example, the market risk normalized value is calculated as:

$$= \frac{2.76}{\sqrt{2.76^2 + 2.92^2 + 2.26^2 + 2.48^2 + 3.3^2 + 3.11^2 + 3.02^2 + 2.62^2)}} = 0.345$$

Table 6-6: The normalized value for the foregoing project

Risk Factor	Normalized Values
Market Risk	0.345
Environmental Risk	0.365
Legal Risk	0.283
Political Risk	0.310
Technical Risk	0.413
Operational Risk	0.389
Completion Risk	0.378
Counterparty Risk	0.328

4. The fourth step is to multiply the normalized value by the general attributes' weights to calculate the project's risk factors' weights, presented in Table 6-7. For example, the market risk factor weight is calculated as: 4 x 0.345 = 1.38%

Table 6-7: Multiplying normalized value by the general attributes' weights

	General Weights	Normalized Weights	Project Specific Risk Factor
Market Risk	4	0.345	1.38%
Environmental Risk	2	0.365	0.73%
Legal Risk	1.6	0.283	0.45%
Political Risk	5	0.310	1.55%
Technical Risk	1.6	0.413	0.66%
Operational Risk	1.8	0.389	0.70%
Completion Risk	1.8	0.378	0.68%
Counterparty Risk	1.9	0.328	0.62%

5. The factor premiums are summed to find the project's risk premium, which is 6.77%.

6. The risk free rate of the country of operation is added to the risk free rate to obtain the required rate of return for each specific project. This is the discounting factor which will be used to calculate the present value of the free cash flow.

The portion of the interest payments not met by the CFADS will initially be made from the DSRA prefunding reserve account. The unserviceable portion of interest payments may be deferred to later periods. However, lenders do not accept projects that fall short of servicing debt payments under worst case scenarios. Lenders would possibly consider lowering the amount considered by the sponsors for the loan.

For case study I, under the worst-case scenario, the PV CFADS is \$245.33 million. The base-case scenario shows minimally different results with the PVCFADS at \$353.6 million. The best-case scenario shows that the minimum amount lenders would be willing to provide is \$519.81 million. Under the best-case scenario, the data is very attractive to lenders. However, lenders will not risk their capital on a best-case scenario. This concept is best presented by plotting the cash flow available to service the debt in each year throughout the concession period, as shown in Figure 6-3. However, this plot does not account for the time value of money, therefore high cash flows in future years may have little value due to future inflation rates.

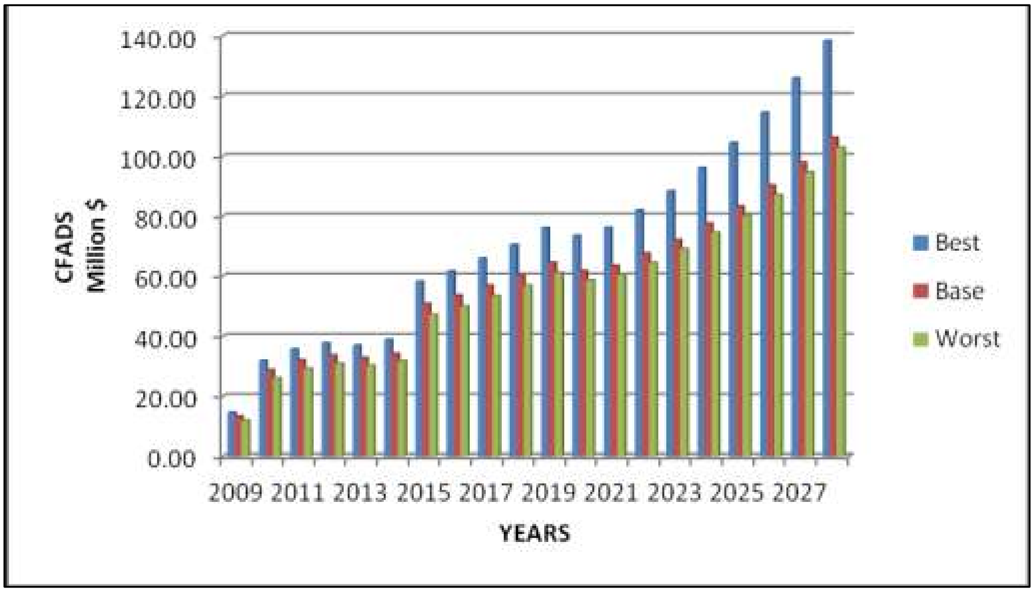


Figure 6-3: Cash Flow Available Debt Service (Case Study I)

In order to account for the time value of money, future cash flows are discounted and their present values are calculated and plotted as shown in Figure 6-4, where a declining trend in the value of future cash flows is observed, which helps to offset the effects of inflation.

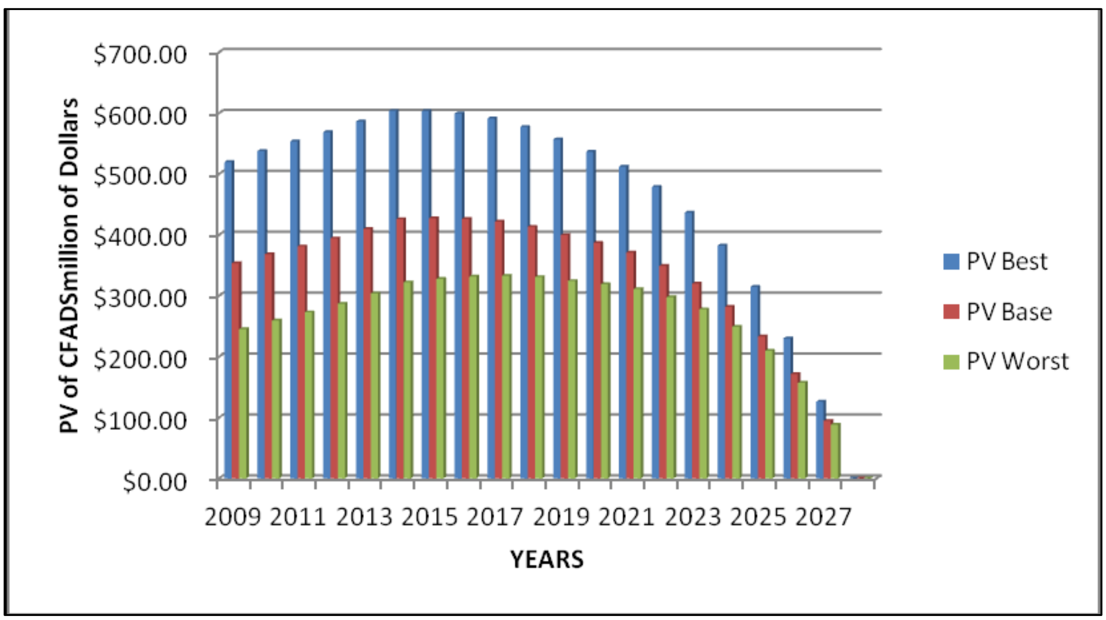


Figure 6-4: Present Value of Cash Flow Available for Debt Service (Case Study I)

The other aspect of the airport project is its high level of uncertainly regarding its risk level. Airport traffic is more sensitive to a country's relationship with other parts of the world. With the political instability in the region, the level of the risk that all kinds of investors will face for this airport infrastructure investment has surged, which is well-reflected in the fluctuating gap between Best case and Base case PVs of the CFADS.

Debt Service Coverage Ratio (DSCR) for case study I is calculated and plotted throughout the concession period as presented in Figure 6-5, where different risk levels are assumed in each scenario, aligned with the effects of high risk levels risk that result in unstable DSCR. Furthermore, the high level of debt deprives the project from having more than one DSCR for the first seven years of operation.

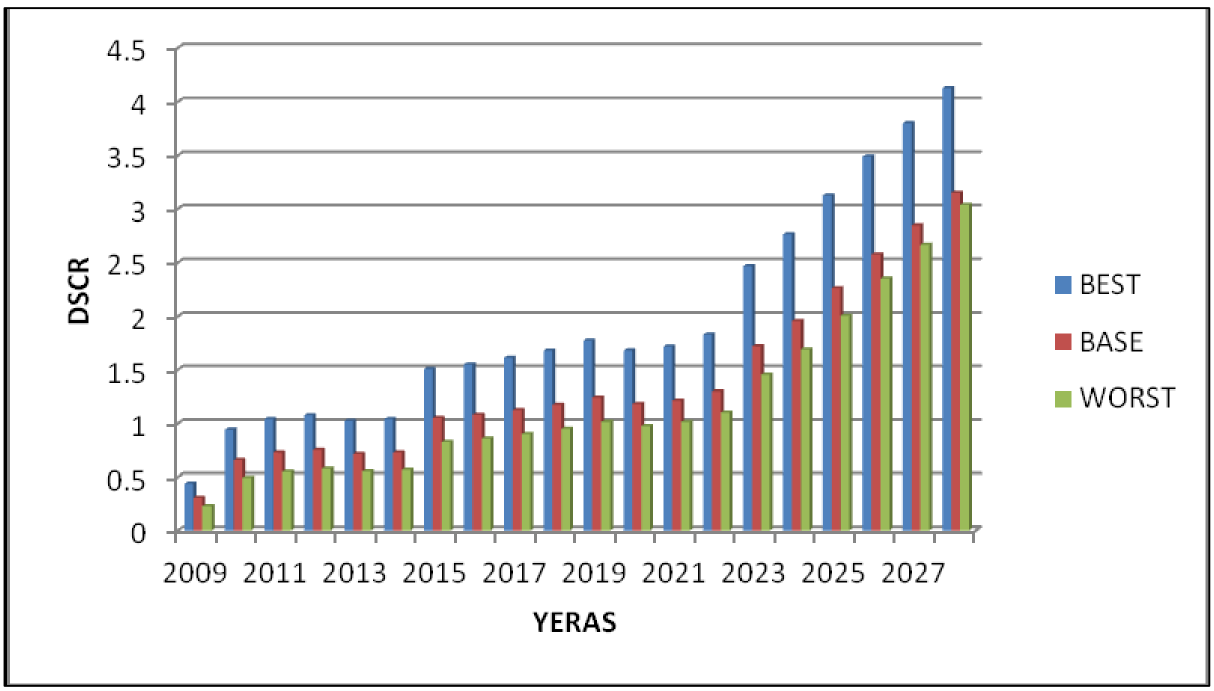


Figure 6-5: Debt Service Coverage Ratio (Case Study I)

Similar to the analysis explained in the first case study, the same steps are applied for the following five case studies. The final results of the analysis are described in detail in the following sections.

6.3.2 Case Study II:

As illustrated in Figure 6-6, the annual free cash flow available for debt service for case study II begins at a low level and rises slowly, because the initial cash flow is limited due to the lower level of revenue and the high level of debt, which is gradually amortized over the life of the project. However, the yearly value of the CFADS cannot be used as a measure of analysis because it does not consider the time value of money.

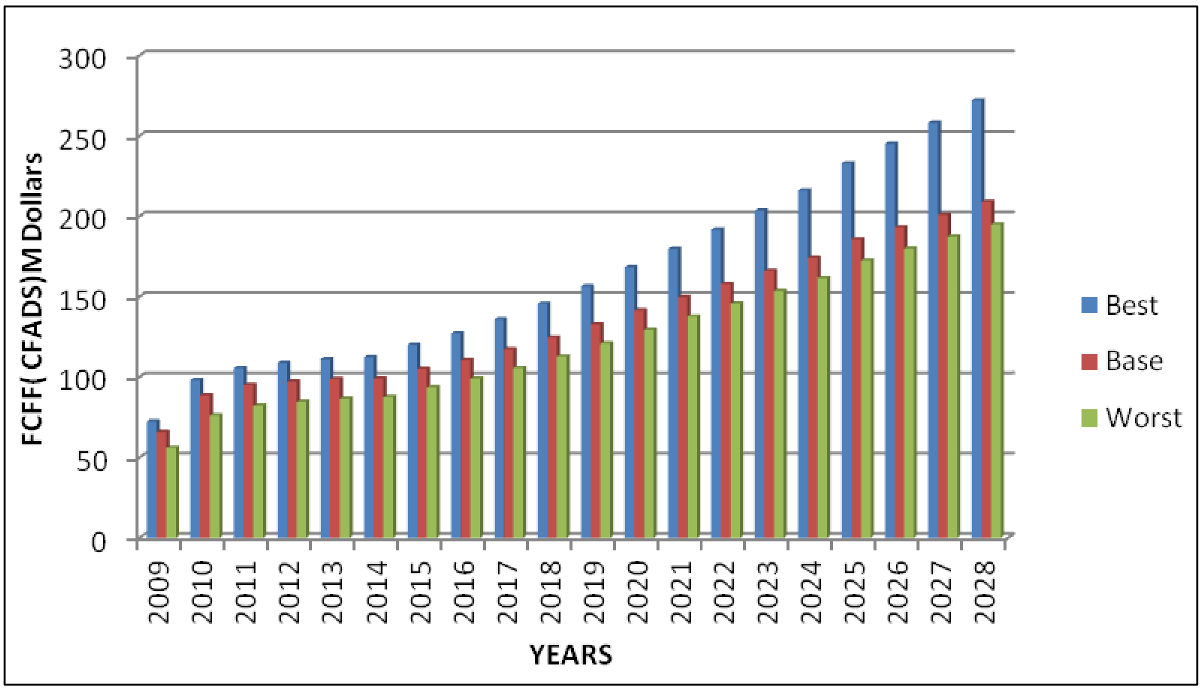


Figure 6-6: Free Cash Flow to the Firm (Case Study II)

Therefore, it is the present value of the CFADS in each year that should be considered, as shown in Figure 6-7. The risk rate is calculated from the TOPSIS model, where the discounting rate for this project is 12.3 percent for the base case. Future cash flows are then discounted to each year at the aforementioned discount rate to calculate the present value of these cash flows, given in Figure 6-7. These discounted cash flows are positive values, which means that after considering the time value of money and the project's annual risk level, there will still be positive value available to meet the project’s obligations.

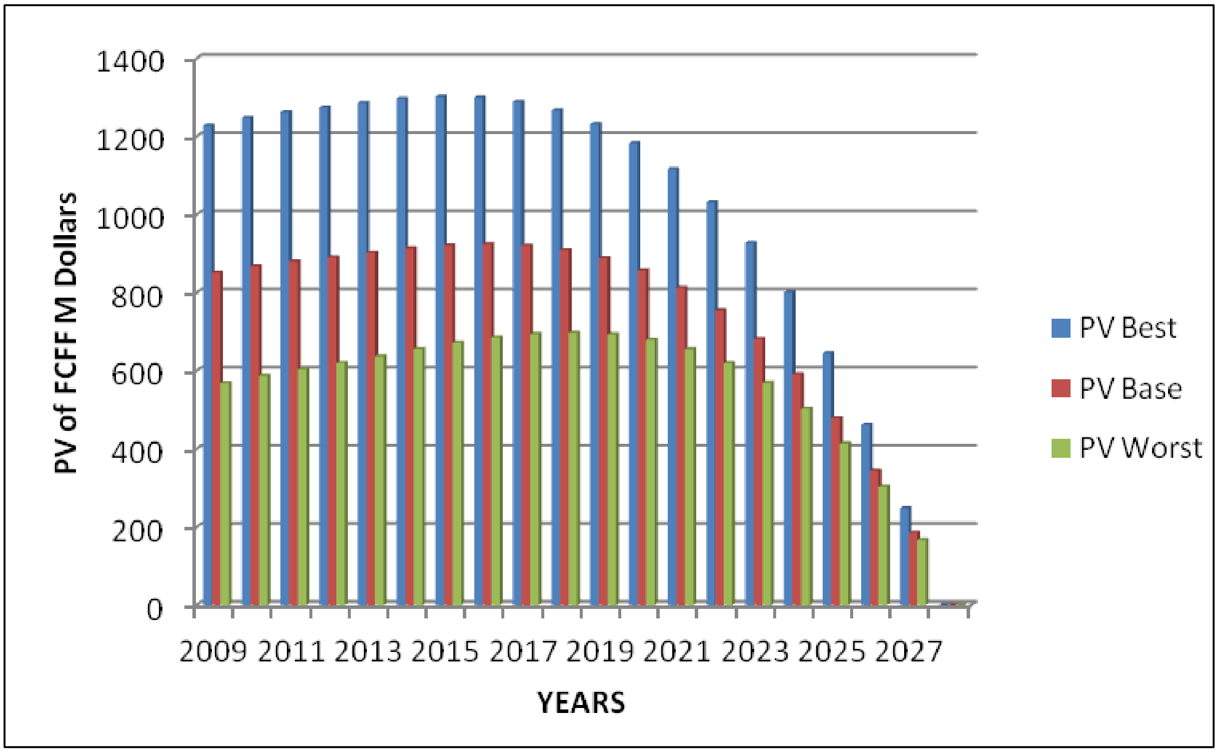


Figure 6-7: Present Value of Free Cash Flow to the Firm (Case Study II)

A positive discounted cash flow only indicates that some amount of money remains after paying all operational costs. It does not say anything about the relative level of available cash in terms of the project's obligations. In other words, it is not sufficient to have a positive cash flow, there must be a surplus after meeting both operational costs and debt payments. This concept can be analysed using the concept of Debt Service Coverage Ratio (DSCR).

A DSCR with a value equal to or greater than one means that the current available free cash flow of a project is equal to its level of obligations, as illustrated in Figure 6-8. In a more amiable business environment, illustrated by the best case scenario, the project has more revenue, which leads to a higher cash flow and lower interest rates charged by the debt holders, and therefore the project is less risky. These favorable conditions combine for a DSCR that is much higher for the best case scenario than those of the two other scenarios. As clearly shown in Figure 6-

8, the first year that the project's cash flow is at least equal to its obligations is in the twelfth year of operation for the base case and in the third year for the best case.

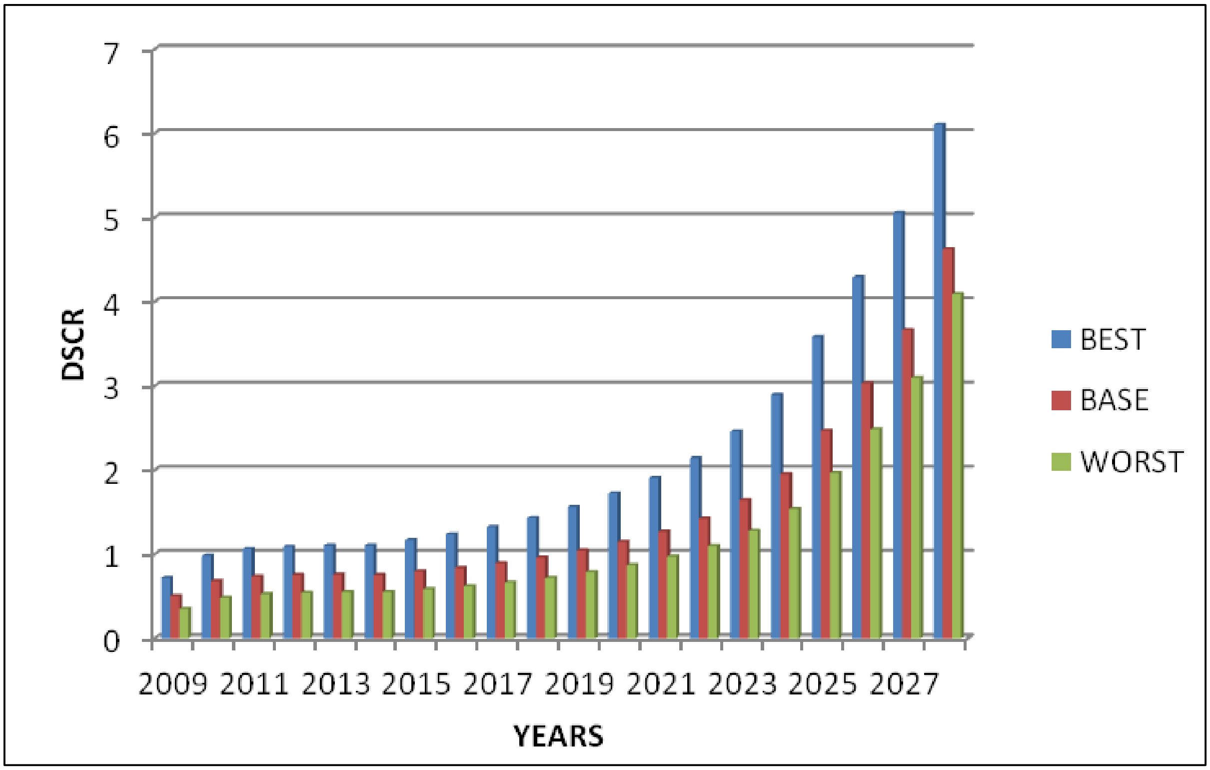


Figure 6-8: Debt Service Coverage Ratio (Case Study II)

6.3.3 Case Study III -

The unique revenue schedule of this project made its CFADS pattern different from the other ones, as shown in Figure 6-9, where the Capital Expenditure peaked in the first year of the project, which is a burden on the free cash flow and caused a lag. The payment mechanism to transfer funds to suppliers and the government contract for receiving the receivables resulted in increasing the working capital, which had a negative effect on the CFADS for years 2011 to 2013. The trend started to change in 2014, and is expected to continue to be positive thanks to the stable CAPEX schedule and better earnings.

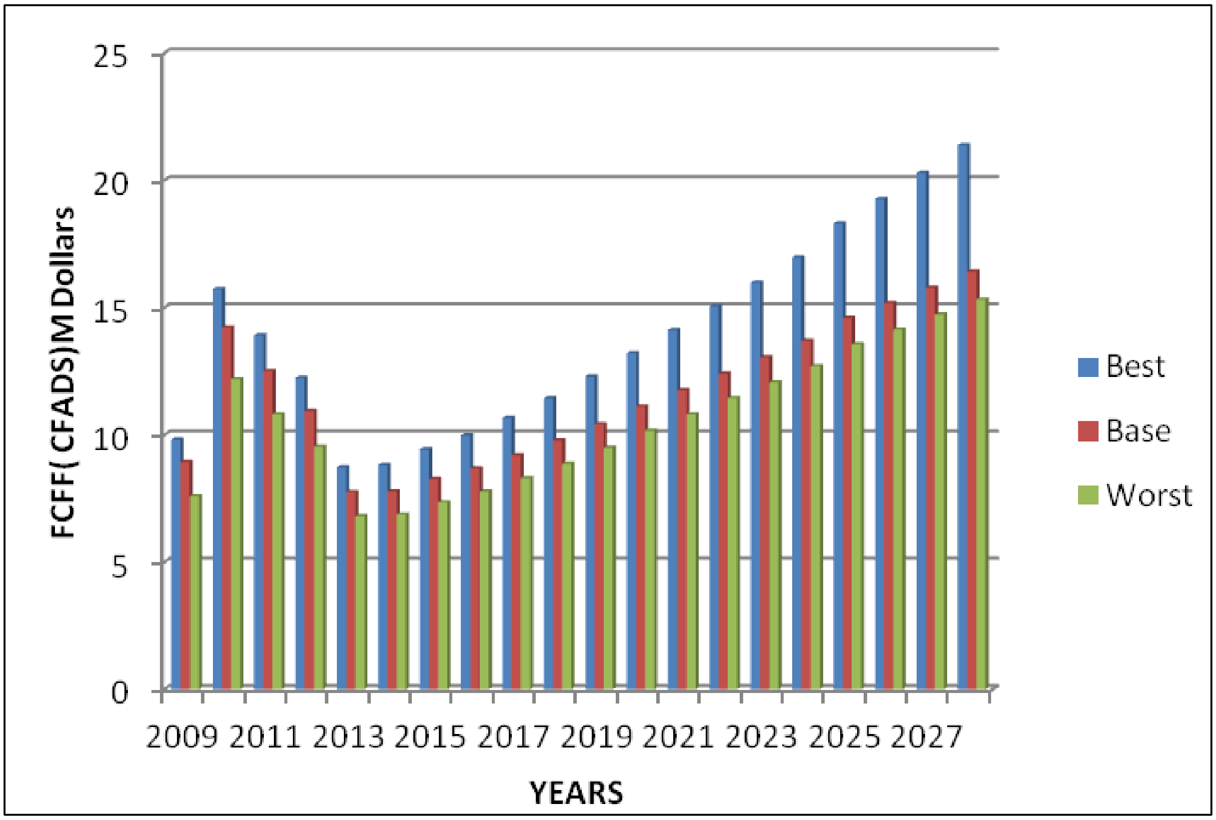


Figure 6-9: Free Cash Flow to the Firm (Case Study III)

The project's risk level can be added to our analysis by discounting the numbers in Figure 6-9 at each year of operation. The discount factor for this project calculated according to our model is 12.6 percent. The aforesaid effect of the CAPEX and changing working capital can be seen in the present value of the cash flow illustrated in Figure 6-10, where there is a wave pattern shape instead of the regular convex shape of the cash flow's present value. This wave pattern shape shows that difference between the worst and the best case is the largest among the six projects, a difference attributed to the project's fluctuating cash flow, which makes it more volatile and therefore risky.

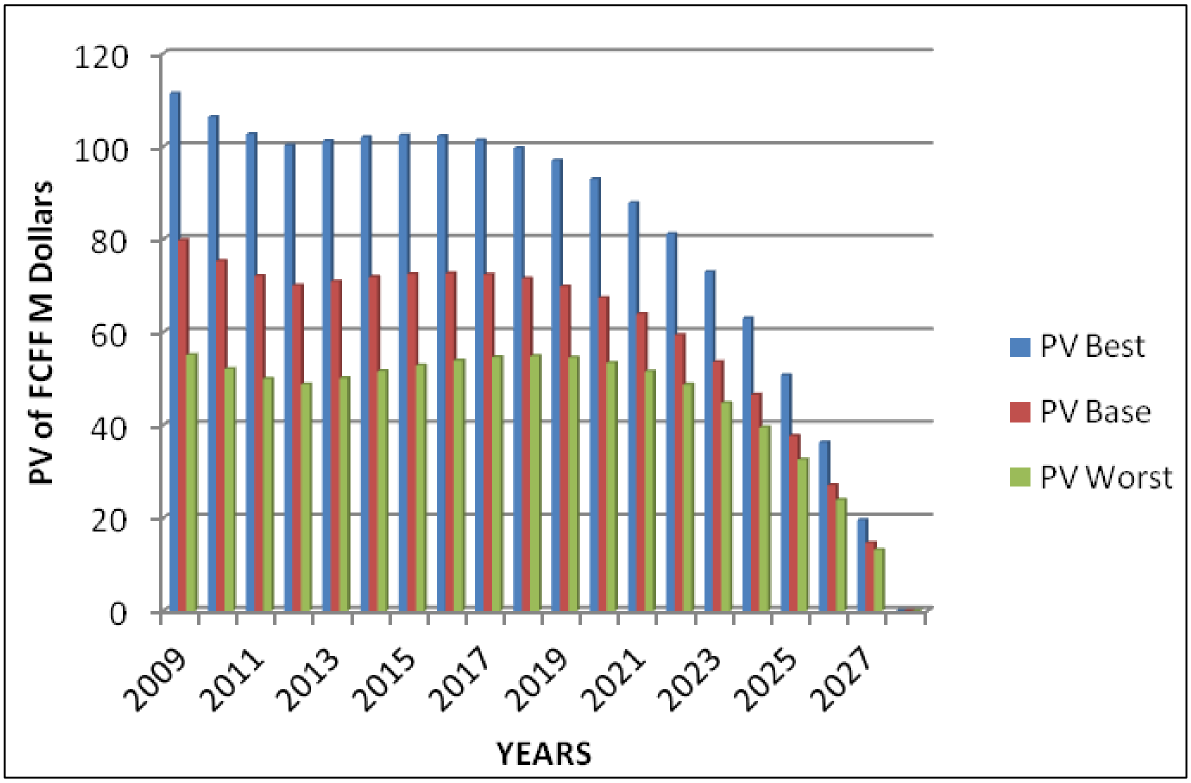


Figure 6-10: Present Value of the Free Cash Flow to the Firm (Case Study III)

The last tools of assessment for BBAH project is its Debt Service Coverage Ratio (DSCR). The DSCR ratio should be at least greater than one to satisfy the lenders' requirements. This is illustrated in Figure 6-11, where the first year that the DSCR stays at a level greater than 1.0 in the base case is 2021, which is 13 years after the initiation of the project. These observations show that the project volatility in the initial years of the BBAH project is among the highest of our case studies.

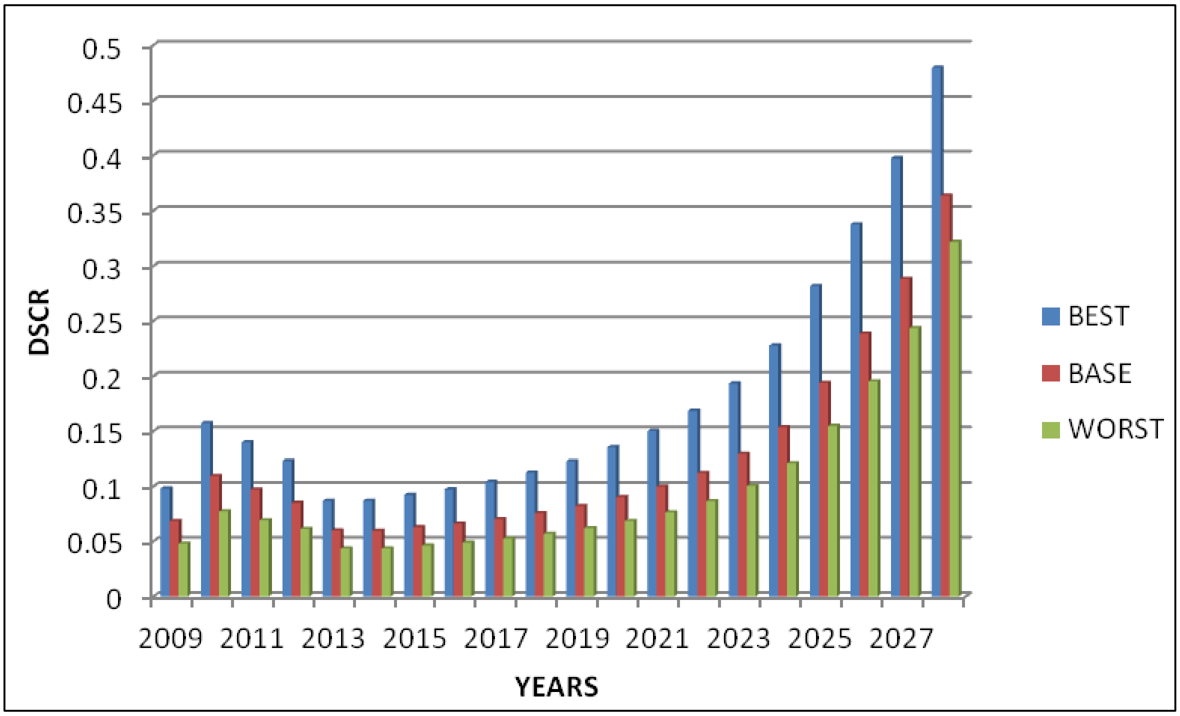


Figure 6-11: Debt Service Coverage Ratio (Case Study III)

6.3.4 Case Study IV - Strengthening and widening of two lanes to four lanes (SWOTF)

The robust normal Cash Flow of this expansion project, presented in Figure 6-12, is the result of the low level of debt required for the project. Such a low level of debt offers the project a more stable level of risks during the life of the project. Moreover, the revenue, as the most important factor that indirectly affects free cash flow available for debt through the net income, is more stable during the eighteen-year construction period than among all the other case study projects. This stability can be attributed to the nature of the project, the expansion of a currently operating highway.

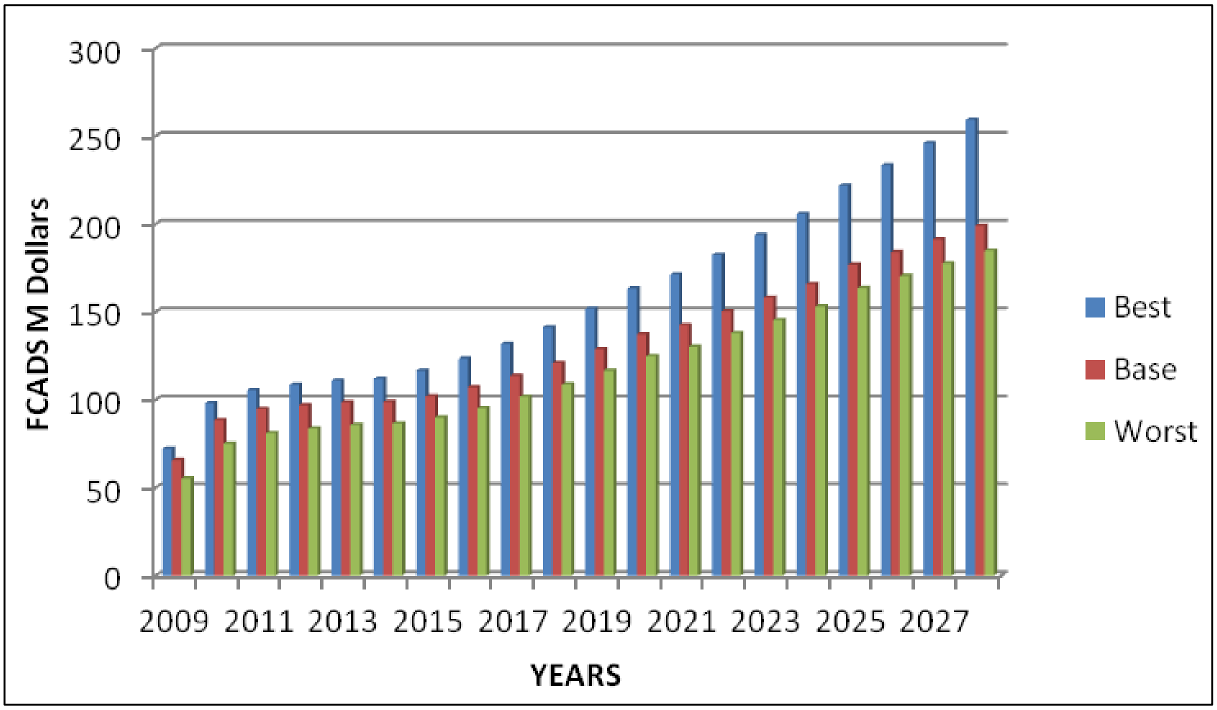


Figure 6-12: Free Cash Flow Available for Debt Service (Case Study IV)

This preference for stability is also reflected in the Present value of the cash flows presented in Figure 6-13, where the gap between the worst cases' and the best case's PV of the cash flows increases whenever the risk is accelerated. These larger gaps are mostly Hi found in the initial years of projects, and gradually, over the life of the project, the technical and operational risks are mitigated and this gap starts to follow a declining pattern. It is obvious that this project reassures its fund providers (both equity and debt holders) with positive cash flows. The nature of an expansion project is usually associated with two important factors:

- Low level of debt; and
- Low level of capital expenditure and required working capital.

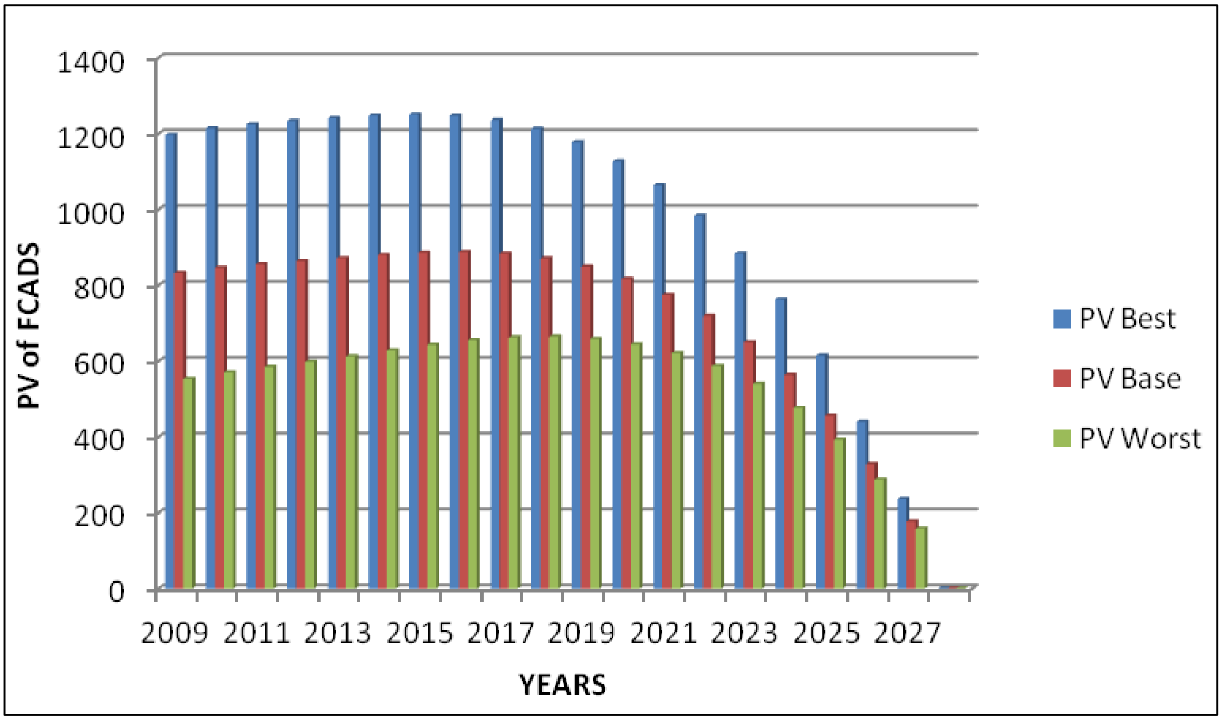


Figure 6-13: Present Value of Free Cash Flow Available for Debt Service (Case Study IV)

Both of the above mentioned factors imply a reduction in cash flow consumption. Therefore, to measure whether the positive cash flow amounts are sufficient for the project's obligations regarding the debt holders and the bank's loan, we have to calculate the DSCR for each year, as shown in Figure 6-14, where it is clear that even in the worst-case scenario, the DSCR is already greater than one in the initial years, which pave the wat for the project manager to take on further expansion or a similar undertaking.

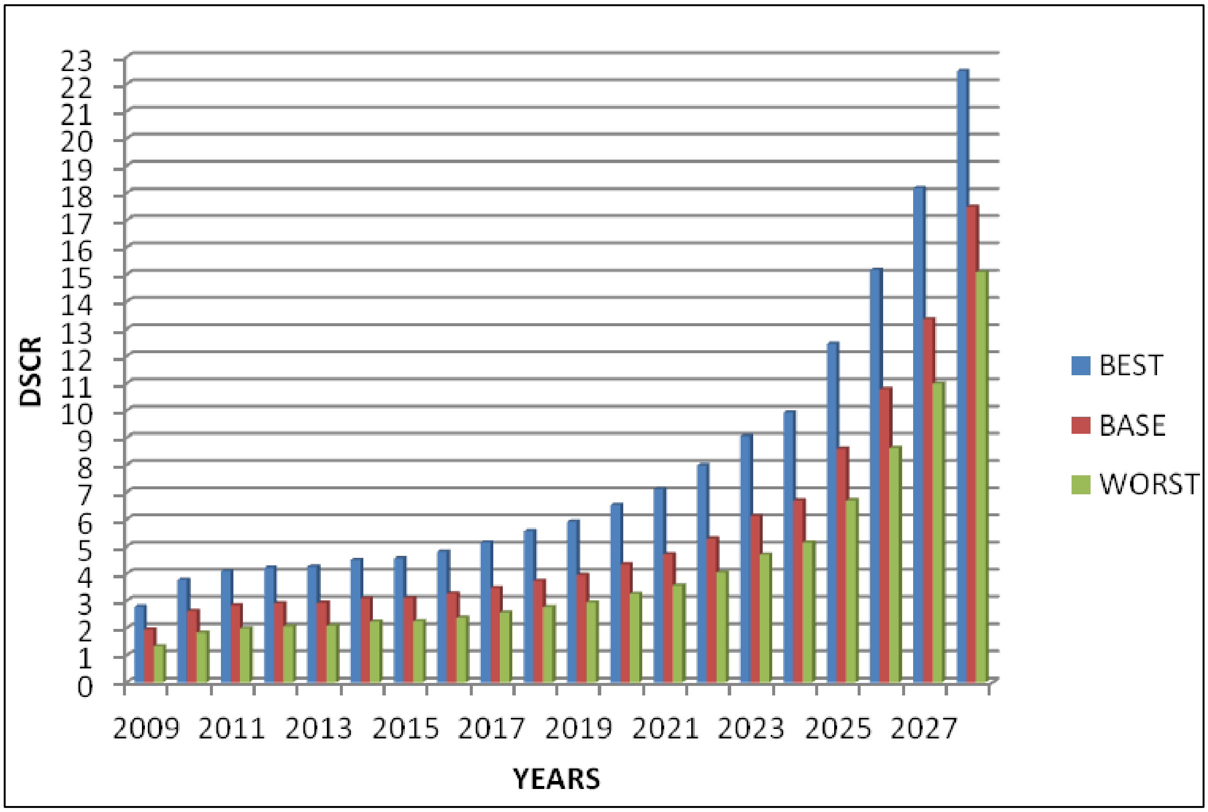


Figure 6-14: Debt Service Coverage Ratio (Case Study IV)

6.3.5 Case Study V -

The very large capital expenditure in this project is a burden for the free cash flow, as shown in Figure 6-15; during the initial four years the cash flow is utilized for the construction, afterwards the required amounts of investment for capital maintenance and expenditure are stabilized and then the revenue begins to increase slowly, as indicated in the upward trend from 2015 onwards.

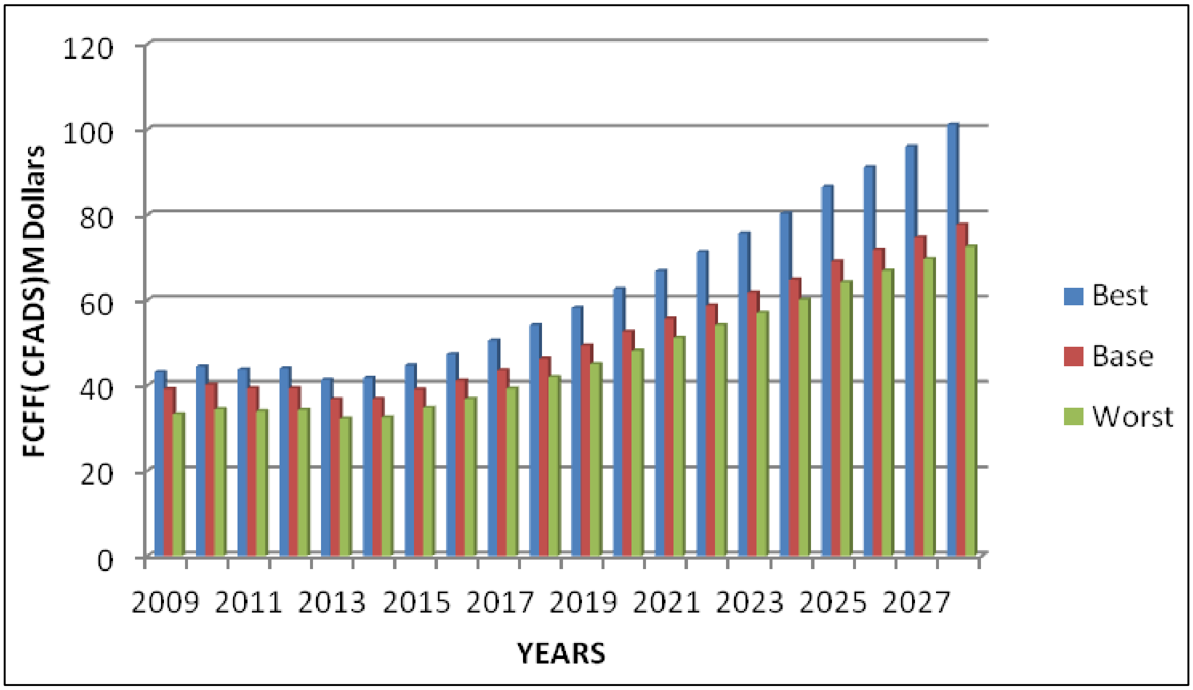


Figure 6-15: Free Cash Flow to the Firm (Case Study V)

The high Present Value of Free Cash Flow to the Firm illustrated in Figure 6-16 reflects the positive elements of this project. The high level of government support (58% of the project funds) makes the government a long term partner in this project. The income statement's predictions for the revenue and traffic growth rates and for the inflation path through the interest rate are all favourable to the free cash flow, which leave the TR project with robust liquidity. The other unique feature of this project compared to the other five is the risk exposure level of the interest rate. With such a low interest rate risk, this project requires a much lower amount of debt raising on the open market or through financial institutions. Open market or regular bank loans, especially variable floating loans, are very exposed to interest rate risks. As the interest rate goes up the cost of borrowing to the borrower also goes up and therefore the free cash flow in the company goes down.

The high level of government funding provides project managers with more latitude to negotiate the interest rate(s) and term of the grants, especially in the prevailing financial environment where market participants are expecting an increase in the interest rate from its historically low level.

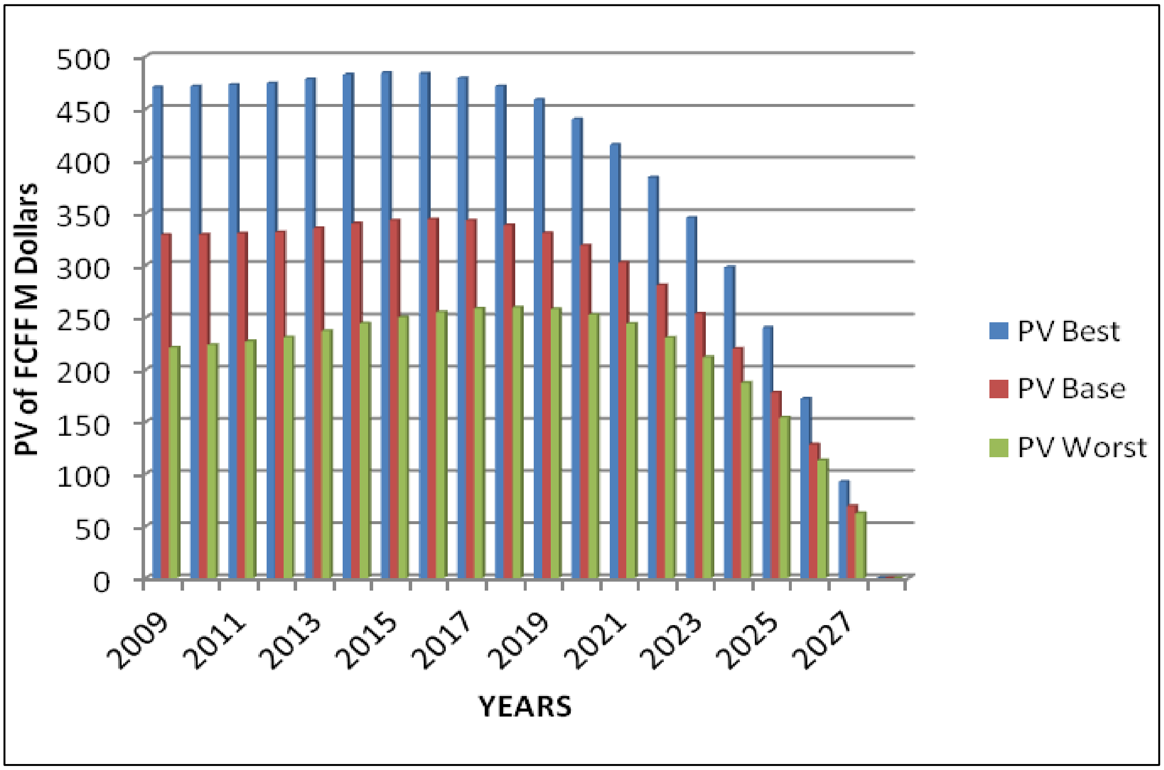


Figure 6-16: Present Value of Free Cash Flow to the Firm (Case Study V)

A sufficient amount of net income, a low level of debt and therefore small interest payments and a lower risk profile, all contribute to position this project in a solvent situation where it can support its obligations through its free cash flows. As depicted in Figure 6-17, it is obvious that these facts put the project in a situation where it can have a DSCR of more than one from the third year of initiation in its base case, and from the first year at its best case, even though it has a large amount of capital expenditure and working capital investment.

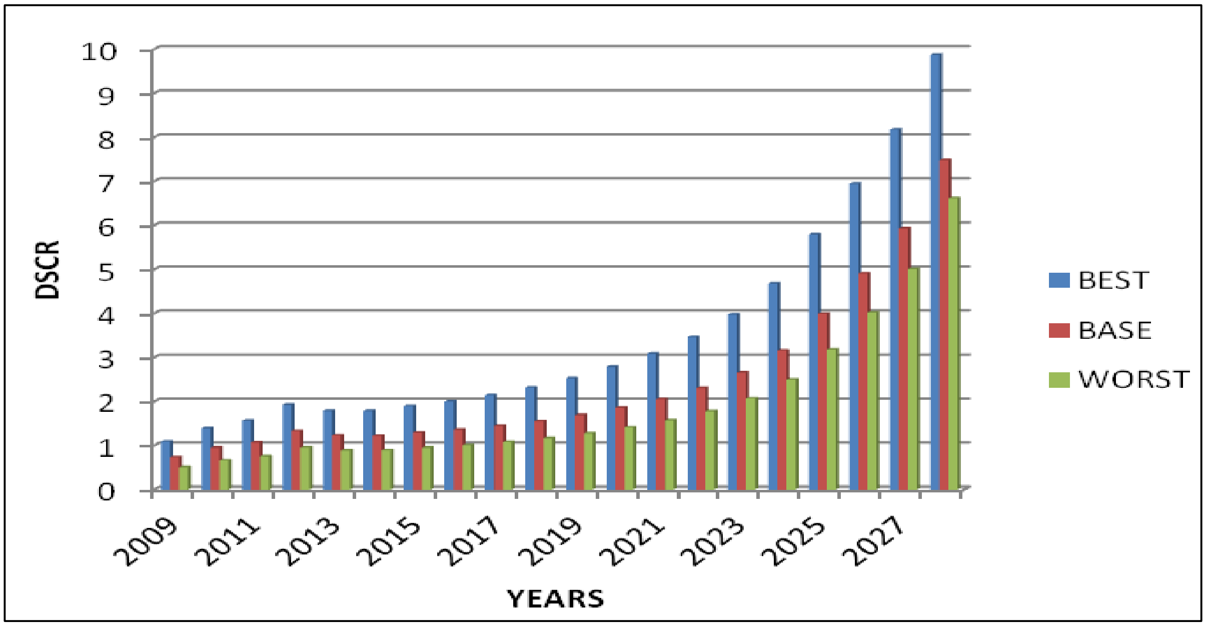


Figure 6-17: Debt Service Coverage Ratio (Case Study V)

6.3.6 Case Study VI -

As illustrated in Figure 6-18, in case study VI's TR project, the free cash flow available for debt service reflects the need for huge capital expenditures in two phases, in the first year of the project and then in its sixth year.

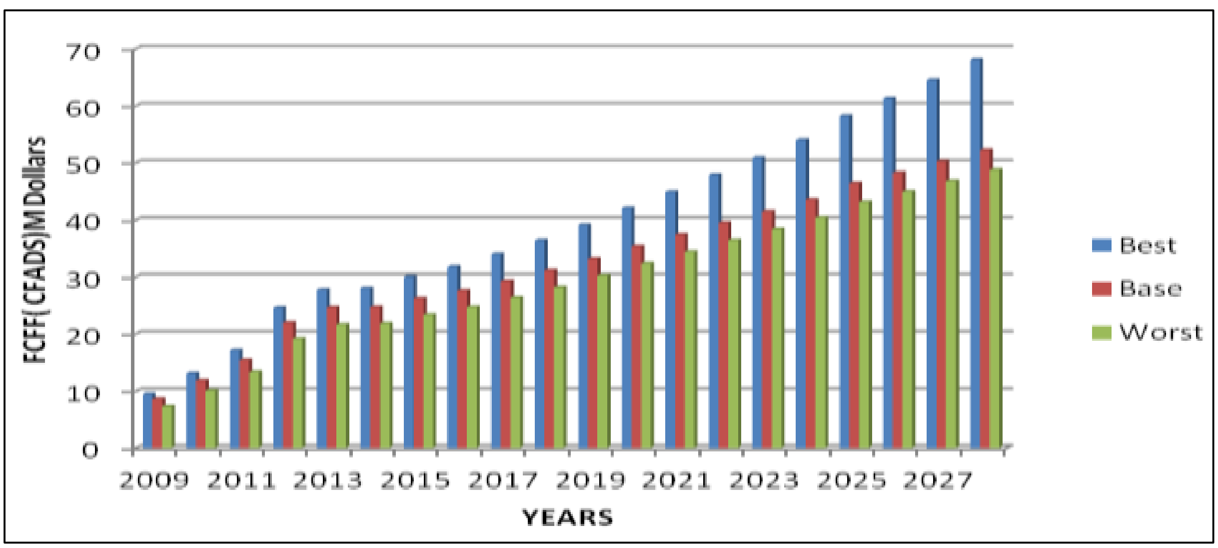


Figure 6-18: Free Cash Flow to the Firm (Case Study VI)

However, the second CAPEX burden is expected to be mitigated in 2015, due to the expected growing revenue trend. The present value of cash flow illustrated in Figure 6-19 indicates the principle difference between this project and the other cases. The case study I, at the time of writing this study, has the highest political instability among all the other countries where our case studies are located, and therefore the required rate of return from both equity holders and debt holders' is high and subject to further increases, which drags down the present value of the project. The average effect of this burden is a 4.6 percent reduction in each year's cash flow value.

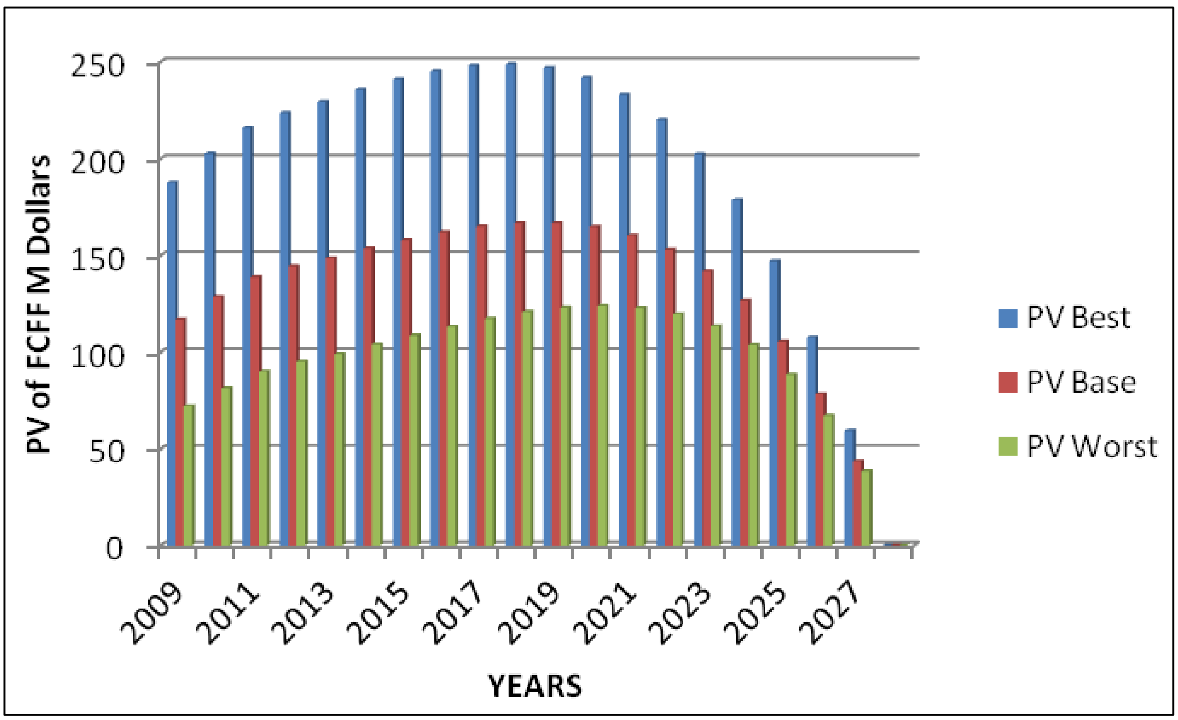


Figure 6-19: Present Value of Free Cash Flow to the Firm (Case Study VI)

As explained chapter two, the Debt Service Coverage Ratio is a function of two factors, the free cash flow available in each year and the interest payment for that year. Increasing the risk profile of a project thus affects both sides of this ratio. Conducting a project in a political risky environment puts pressure on the net income of a company due to the higher costs, which also decreases the free cash flow available for debt services.

In such instable situations debt holders demand a higher interest rate as their compensation for taking on additional risk. Therefore, in this project, we can see in Figure 6-20 that the average value of the DSCR is the second-lowest among all the other projects, and it stays at a breakeven level for most of the life of the project. Moreover, the difference between the best- and the worst-case scenarios' ratios does not follow a predictable pattern, which is a sign of higher level of error in forecasting the data.

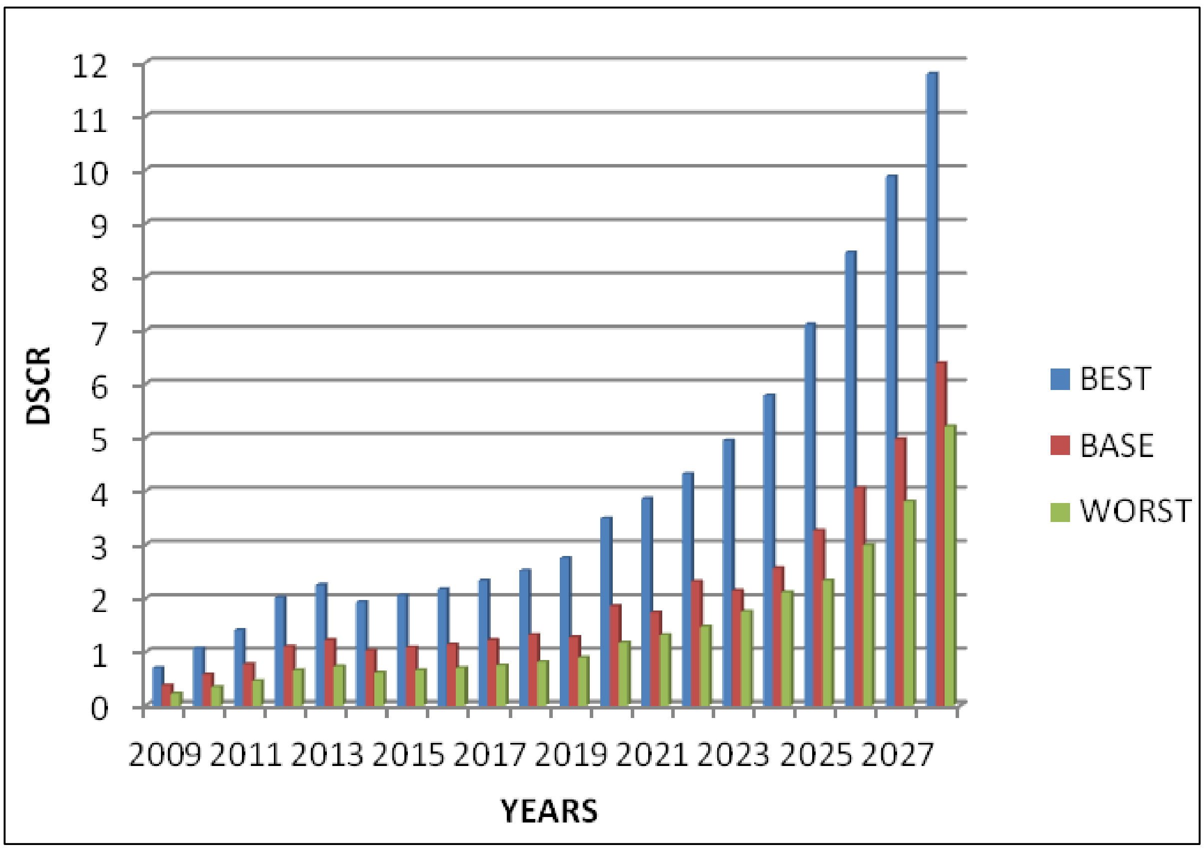


Figure 6-20: Debt Service Coverage Ratio (Case Study VI)

6.4 Summary

The developed bankability assessment model was applied to six real case studies, and the results revealed the effectiveness of the developed model in identifying lenders' debt financing limits. The developed model takes into account two sets of data, accounting and risk sets. The accounting data help us to initiate our financial statement forecasting, and the risk sets allow us to more accurately discount each year's free cash flow to the present time. Accounting data was gathered from the project managers, as they are best source of information about the every-day activities, revenues and cost of the company. The risk numbers, however, should be scrutinized by the individuals who are going to lend capital to the projects. These numbers were gathered by distributing questionnaires to the credit analysts in each project's country.

The model produced three possible scenarios based on factors: inflation, traffic growth, inflation pass through rate and the risk. Since lenders will only consider the worst case scenario to allocate their risk, sponsors must provide adequate risk mitigation methods, with a realistic risk management plan, in order to move forward on a project. The application of the developed model provides private partners with a tool to self-asses their financial bankability for PPP projects. Such assessments not only reduce the time and effort expended to acquire capital finance, but also enables private partners to increase their chances of securing the required funds by enhancing their identified weak points.

This chapter presented the application of the bankability assessment model on six real case studies. For each of the six projects the Free Cash flow for Debt Services, the PV of Free Cash Flow for Debt Services, and Debt service Coverage Ratio were calculated based on three scenarios: the base, the worst and the best. Each scenario changed the value of the accounting data, which changes the income statement and balance sheet numbers for each project.

Changing these two financial statements directly affected the projects' cash flow statements of the projects. The calculated results are illustrated using graphs. The projects mostly follow the same pattern, however the magnitude of their variations during the life of the projects is very important.

Chapter 7: Automated Tool

7.1 Introduction

This chapter describes the development of an automated tool to assist decision makers in selecting private partners on PPP projects, summarizing the developed models described in chapter 3. The automated tool was developed using the Microsoft Visual Studio 2012 C # environment. To start the design process, a listing of the system requirements was assembled, including all the features and capabilities that this software should offer.

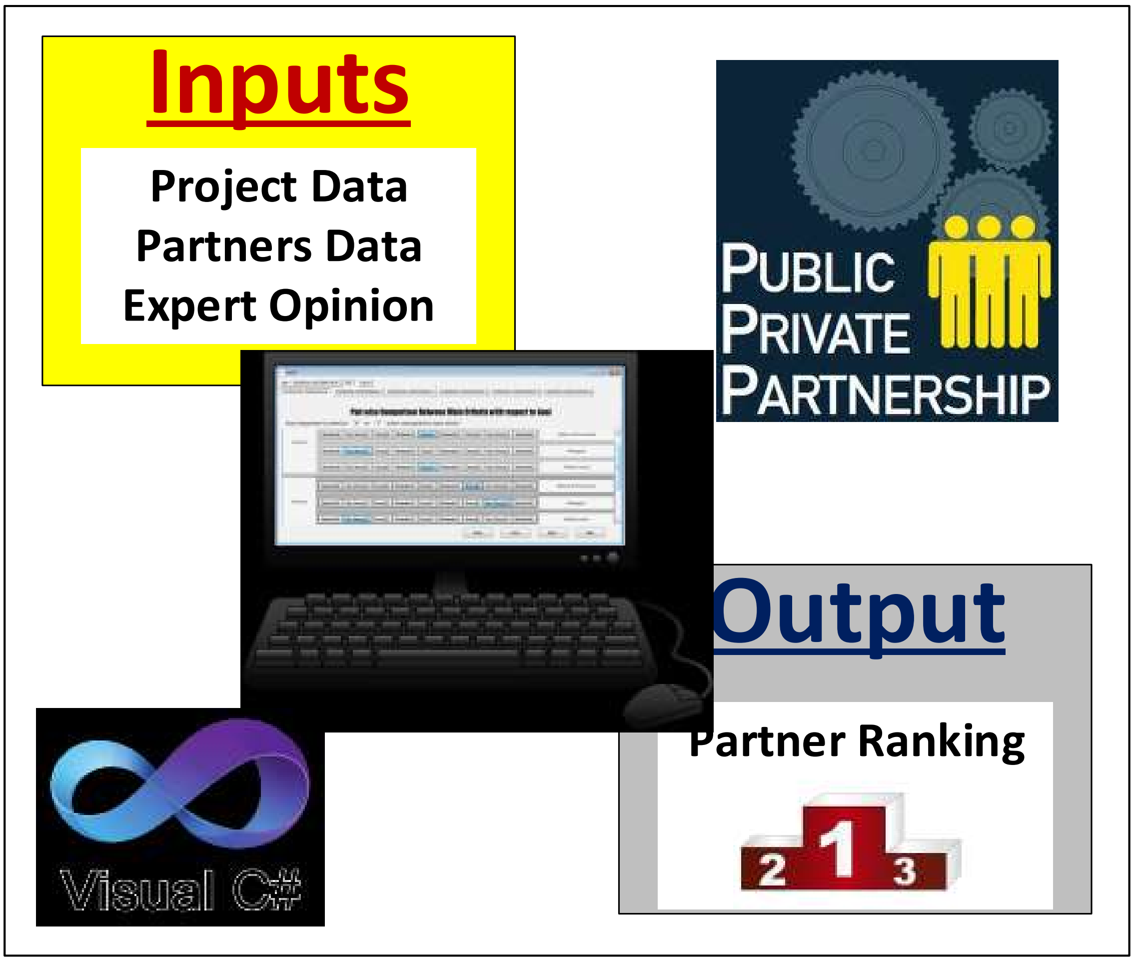


Figure 7-1: Software Input and Output Overview

The next step was to develop the use cases. A use cases describes a software system's functionality from the point of view of an external user; it shows the different possible interactions between the software and other entities. It also lists the necessary preconditions and post conditions of each case. After the use cases are developed they are changed into sequence diagrams, which document the sequence of the interactions of the model classes.

An overview of the input and output of the software prototype is illustrated in Figure 7.1, where the developed tool has three main inputs: the project data, the partner's data and the experts' opinions. The tool's output is the partners' ranking. The developed procedure was modelled using three main classes: a Questionnaire class, an Analysis Class and a Results class.

The interaction with the software is conducted via a user-friendly interface with two input screens and one output screen. The first input screen contains two options as shown in Figure 7.2: new questionnaire and analysis. The new questionnaire option is for a new questionnaire entry, which is used to calculate the selection criteria weights. The analysis option performs the questionnaire's analysis, using the FANP and TOPSIS calculations to obtain the results. After the user selects either to enter a new questionnaire or to conduct the analysis, the second input screen is launched based on the selection.

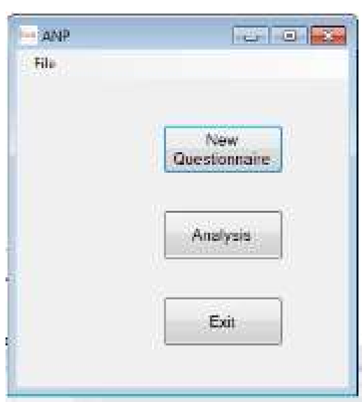


Figure 7-2: Main Windows application.

7.2 New Questionnaire

When a new questionnaire is selected, the screen shown in Figure 7.3 is launched, wherein the details of the questionnaire are entered by comparing and selecting the main criteria, sub-criteria and alternatives. The questionnaire contains three parts:

- General information, as shown in Figure 7.3, which collects the expert's basic information such as their occupation and number of years of experience. This data is used later to generate some of the survey's statistics.

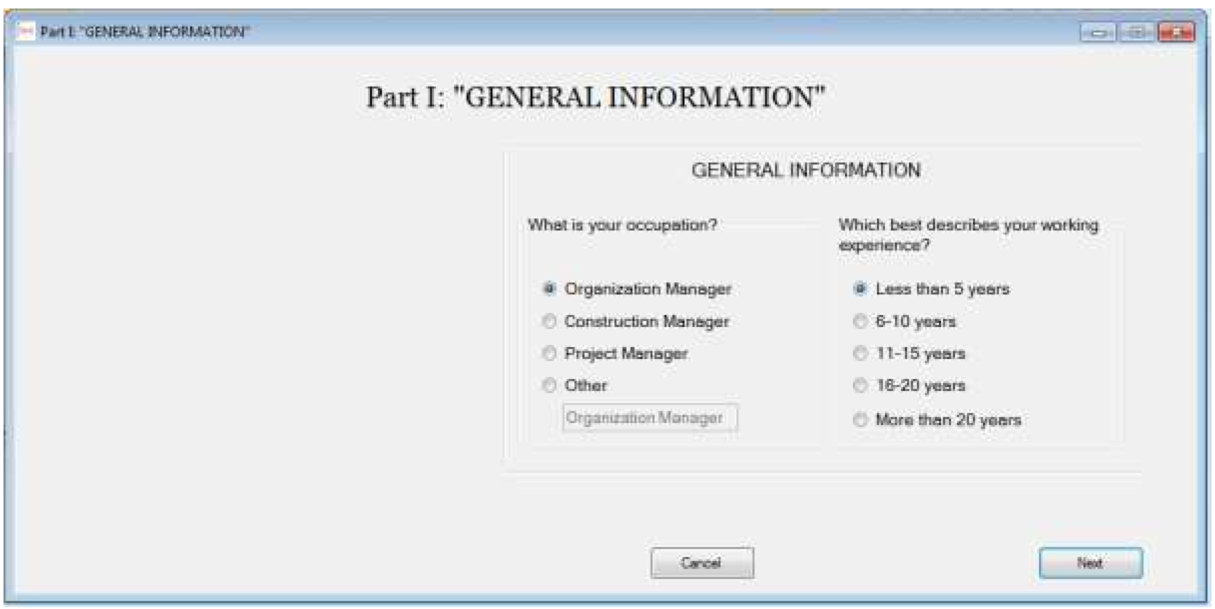


Figure 7-3: Questionnaire Part I.

- The pairwise comparisons between the main criteria and the pairwise comparisons between sub-criteria as shown in Figure 7.4. In this format, the user selects the relative importance among the main criteria, for example and as shown in Figure 7.4, the user indicated equal importance between the financial criterion and the safety and environmental criterion.

Figure 7-4: Questionnaire Part II.

- The pairwise comparison between alternatives is shown in Figure 7.5, where the user compares the partners with respect to the main criteria. For example and as shown in Figure 7.5, the user indicated that partner A has very strong importance compared to partner B with respect to the political policy criteria.

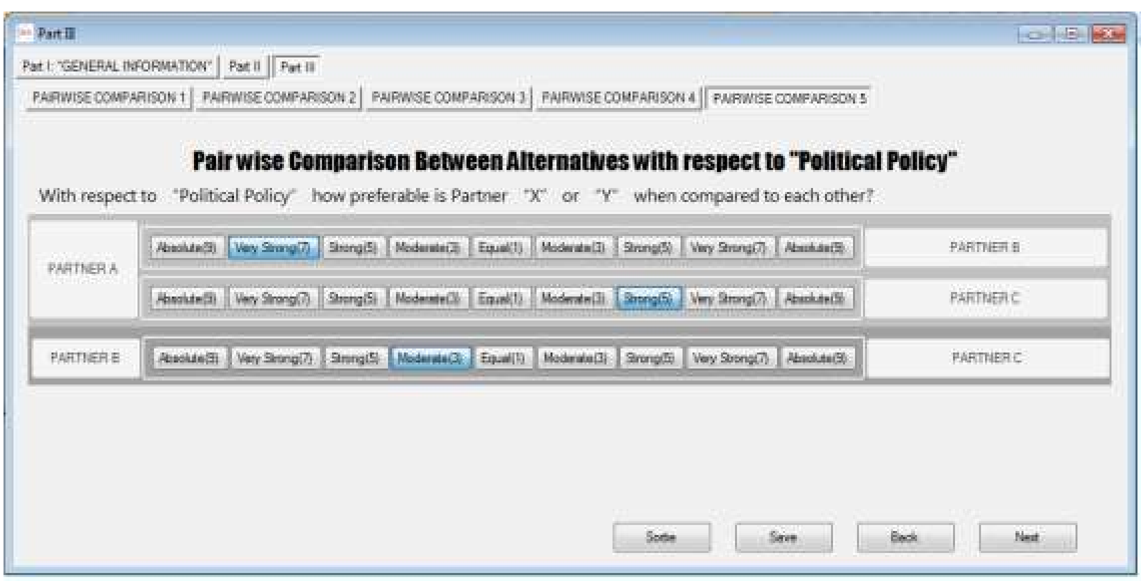
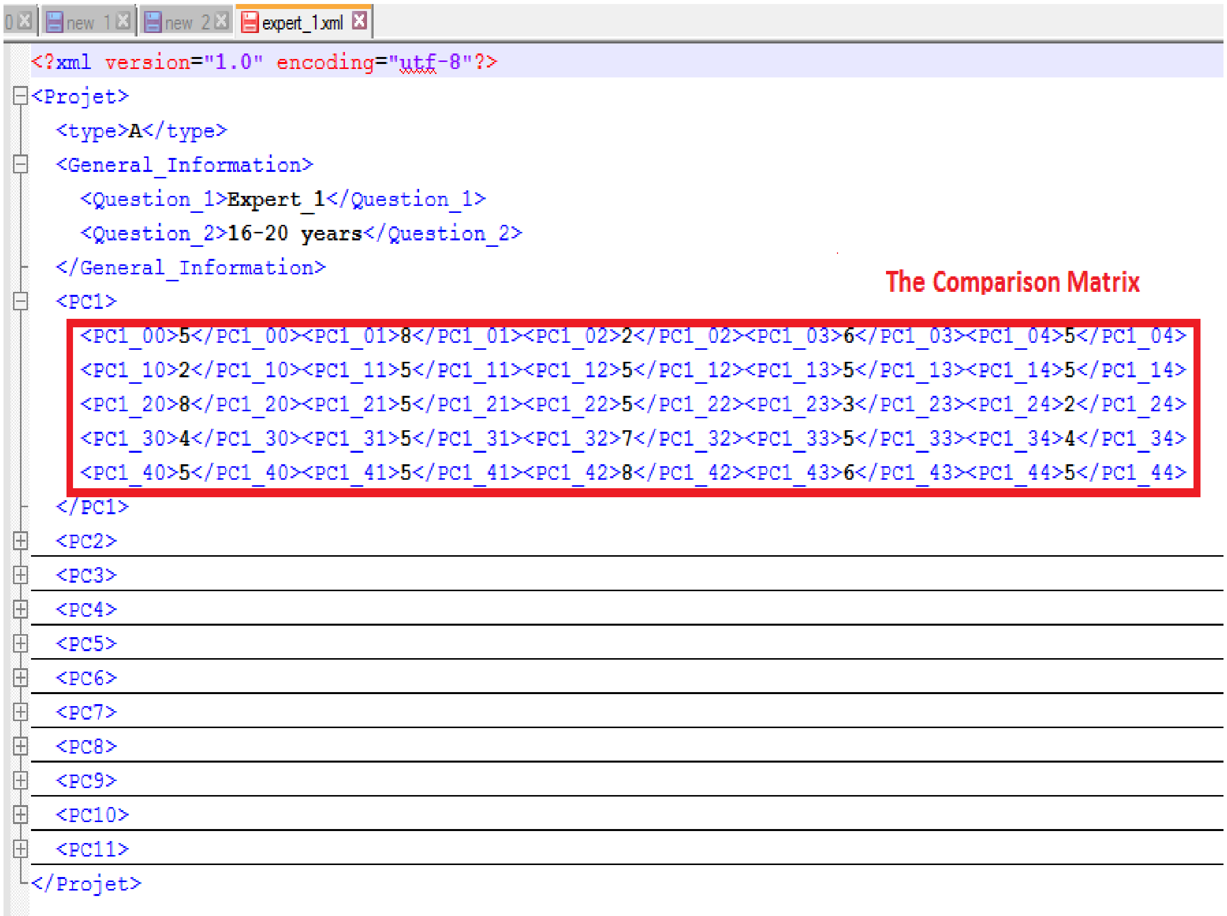


Figure 7-5: Questionnaire Part II.

Data is saved in XML format to facilitate data storage and management, as shown in Figure 7.6, where the user selects whether to continue the analysis or to save the file for later analysis.

Figure 7-6: Questionnaire Save the data

This file format allows for quick and easy access to stored data, as shown in Figure 7.7, and makes it simple to modify the data as needed. The comparison matrix elements are labelled in blue with a format of <PC1_rc>, where r is the row number and c is the column number; the user is thus able to change these values easily to reflect modifications in the expert’s questionnaires.



```xml
<?xml version="1.0" encoding="utf-8"?>
<Projet>
  <type>A</type>
  <General_Information>
    <Question_1>Expert_1</Question_1>
    <Question_2>16-20 years</Question_2>
  </General_Information>
  <PC1>
    <PC1_00>5</PC1_00><PC1_01>8</PC1_01><PC1_02>2</PC1_02><PC1_03>6</PC1_03><PC1_04>5</PC1_04>
    <PC1_10>2</PC1_10><PC1_11>5</PC1_11><PC1_12>5</PC1_12><PC1_13>5</PC1_13><PC1_14>5</PC1_14>
    <PC1_20>8</PC1_20><PC1_21>5</PC1_21><PC1_22>5</PC1_22><PC1_23>3</PC1_23><PC1_24>2</PC1_24>
    <PC1_30>4</PC1_30><PC1_31>5</PC1_31><PC1_32>7</PC1_32><PC1_33>5</PC1_33><PC1_34>4</PC1_34>
    <PC1_40>5</PC1_40><PC1_41>5</PC1_41><PC1_42>8</PC1_42><PC1_43>6</PC1_43><PC1_44>5</PC1_44>
  </PC1>
  <PC2>
  <PC3>
  <PC4>
  <PC5>
  <PC6>
  <PC7>
  <PC8>
  <PC9>
  <PC10>
  <PC11>
</Projet>
```


Figure 7-7: The structure of the XML backup file.

7.3 Analysis

After completing the questionnaire input, the “Analysis” button on the main screen launches the FANP. The user selects the type of analysis for one project or for multiple projects, as shown in Figure 7.8.

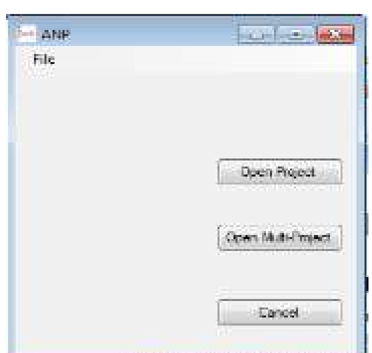


Figure 7-8: Window Analysis

This window has two options. The first option is Open Project, which allows the user to open a single survey or an old project (an incomplete previous record saved for later analysis), as shown in Figure 7.9. The second option, Open Multi-Project, allows you to open and analyze a set of questionnaires as shown in Figure 7.10.

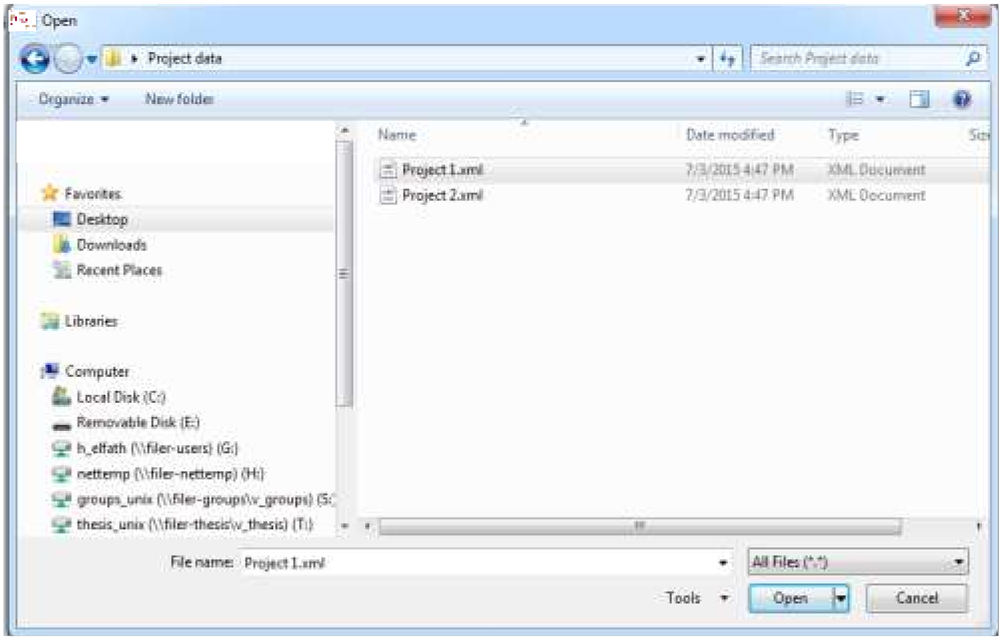


Figure 7-9: Open Project

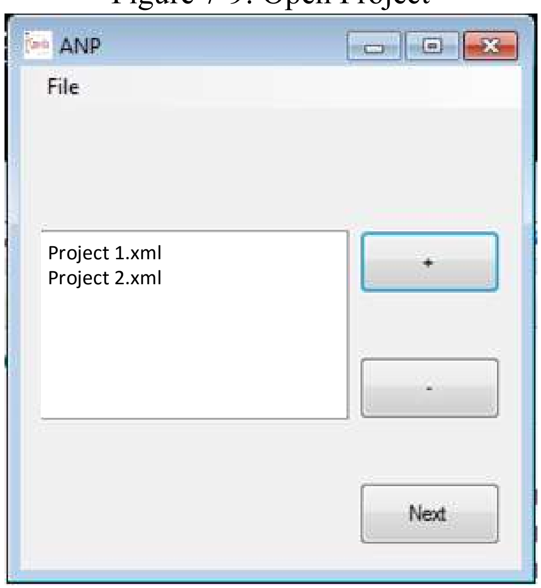


Figure 7-10: Open Multi-Project.

7.4 Results

After the questionnaires and the analyses are completed, the results window is launched, providing the results of the analysis as shown in Figures 7.11, where the partners are ranked based on their priority weight. For example and as shown in Figure 7.11, partner A2 is ranked the highest, with a priority weight of 57.06%. A graphical representation of the results is shown on the right hand side of the form.

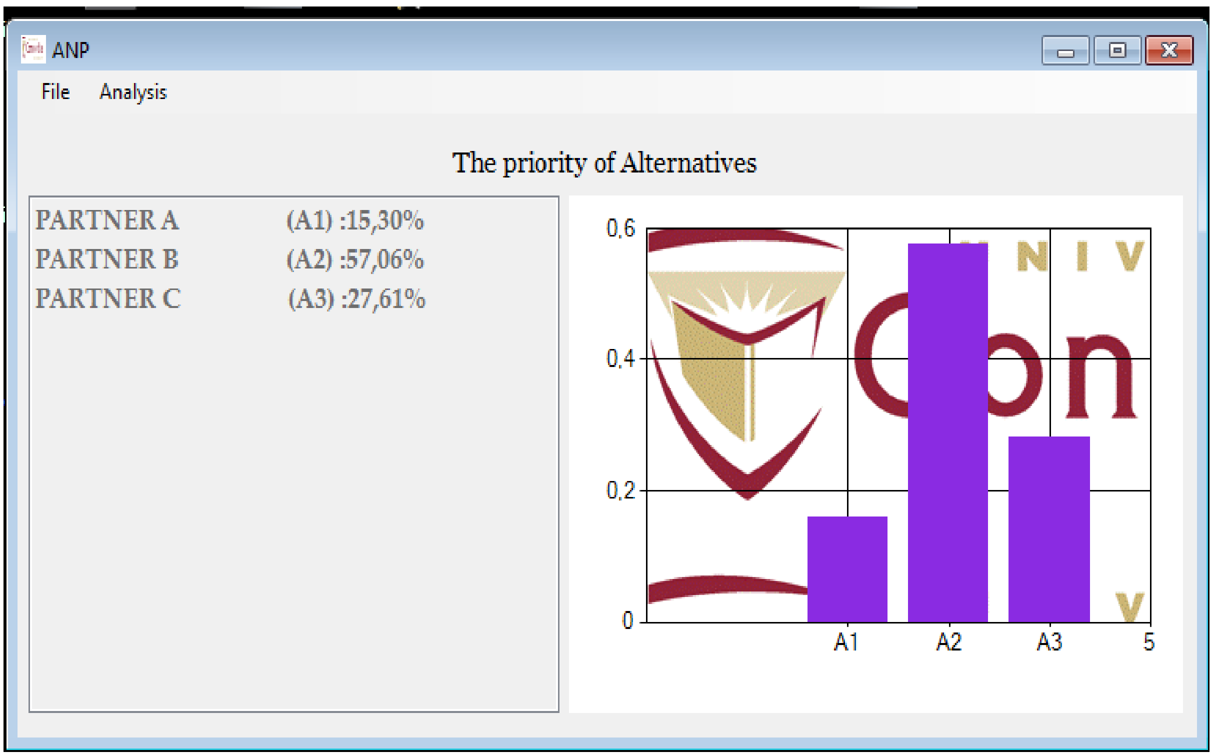


Figure 7-11: The priority of Alternatives

It is important to note that the developed tool can provide reports that present the analysis results as shown in Figure 7.12,including :

- The priority of the main criteria;
- The priority of the sub-criteria;
- The priority of the sub-criteria for the financial aspects;

- The priority of the sub-criteria of the technical aspects;
- The priority of the sub-criteria for safety and the environment concerns;
- The priority of the sub-criteria for the managerial perspective;
- The priority of the sub-criteria for political policy;
- The priority of the alternatives with respect to the financial aspects;
- The priority of the alternatives with respect to the technical aspects;
- The priority of the alternatives with respect to safety and the environment;
- The priority of the alternatives with respect to the managerial perspective; and
- The priority of the alternatives with respect to political policy.

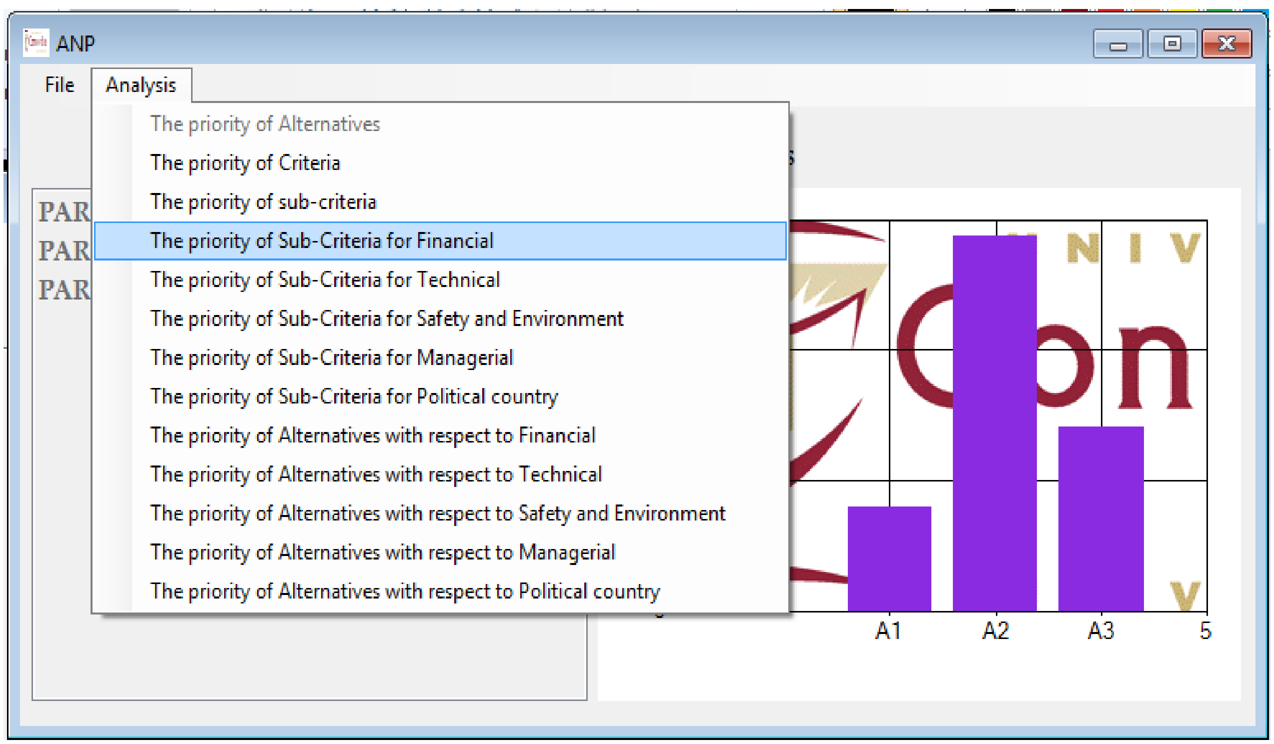


Figure 7-12: Analyzing the other priorities.

An example of one of the above-mentioned analysis reports is shown in Figure 7.13, where the priority of the sub-criteria for the financial aspects are presented. For example, the priority weight for the equity and debt is 39.70%, and the weight of the foreign financing is 33.11%. A graphical representation of the sub-criteria's weights is presented on the right hand side of the report's page.

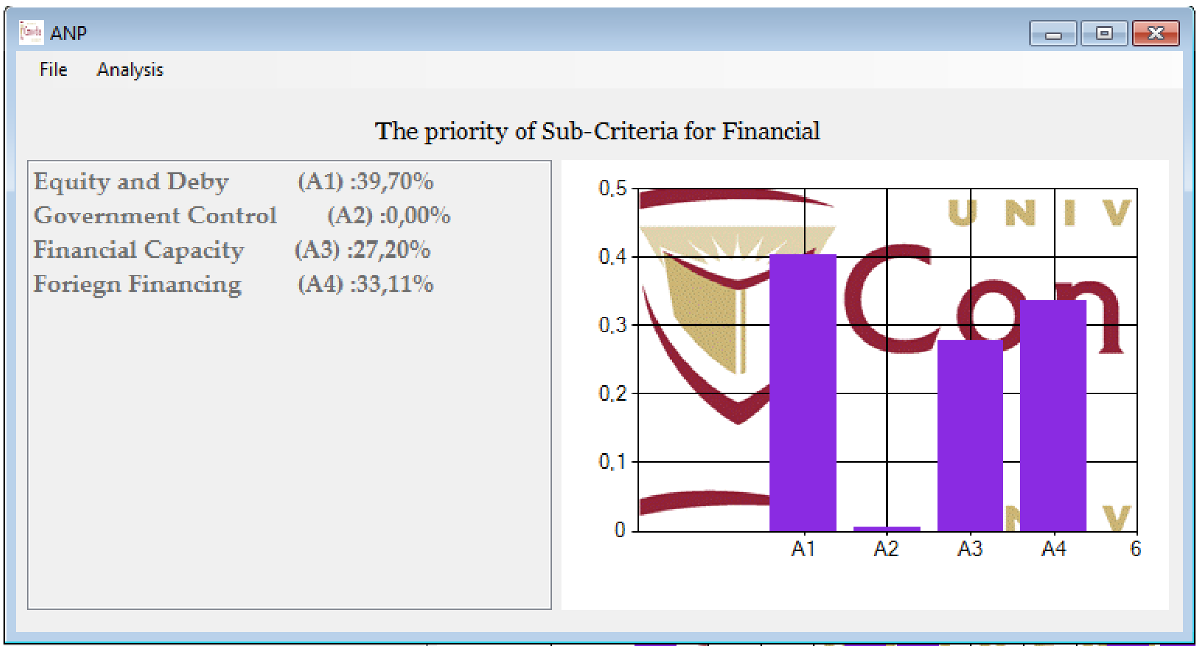


Figure 7-13: The priority of Sub-Criteria for Financial.

7.5 Summary

This chapter described the software tool developed here to select the best private partner for a PPP. The questionnaire distributed to the project managers provided the model with its required input data. The software was developed using C# and based on the developed FANP model. The output of the software tool is to provide a ranking of the private partners based on their individual scores.

Chapter 8: Conclusions, Recommendations and Future Work

8.1 Summary and Conclusions

This research is set out to study, investigate, and develop a new decision-making methodology for selecting the private partner on PPP infrastructure projects, and to prioritize projects based on their bankability. The developed methodology encompasses two newly developed models: the private partner selection and bankability assessment.

The private partner selection model was developed using a fuzzy Analytic Network Process (FANP). This work avoids the hierarchal approach with crisp values for the pairwise decisions used by other methodologies such as AHP and the Goal programming approach. The use of fuzzy intervals for priority judgments addresses the uncertainties involved, and the FANP handles the various relationships between the goal, the criteria and the alternatives.

The developed model was applied to four actual project case studies. The results clearly illustrate the benefits of the structured analysis approach proposed in this study compared to the traditional selection approach. The developed model brings three main advancements to the body of knowledge. Firstly, the utilization of the Fuzzy ANP approach for selecting the private partners in PPP projects. Secondly, it can account for possible dependencies among the selection criteria, as well as between the alternatives and the selection criteria, which in turn provides more realistic solutions. Finally, the use of fuzzy weights for prioritizing alternatives allows decision makers to incorporate both objective and subjective considerations into the evaluation process.

Collecting expert opinion provided an effective approach for identifying the selection criteria and calculating their weight. The fuzzy-based approach accounted for uncertainties in the experts' judgements.

To improve the reliability of the partner selection decision, alongside the fuzzy ANP model, the model incorporates the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) approach. The TOPSIS method is an alternative way of selecting partners that is simple and does not take into account the interrelations between the criteria. This method ranks each partner based on the normalized experts' opinion regarding a predetermined set pf criteria. The rationale of using two approaches is to crosscheck the model's outputs and hence provide the decision maker with more reliable results. The two approaches complement each other; where the FANP accounts for the interdependency between the selection criteria and the uncertainty and vagueness in the experts' judgements, and the TOPSIS method ranks the potential private partners based on the some general criteria and by how well they fit the project objectives.

The developed private partner selection model was applied to four case studies from different countries. These projects vary in terms of their location, type, cost and concession period. This variability is intended to measure the developed model's performance and verify its efficiency in selecting the best private partner in each project. The results of these case studies revealed that the most important aspects for selecting private partners for PPP projects are the financial and the technical criteria.

The bankability assessment model was developed to help creditors to assess the bankability of PPP projects and to calculate the maximum amount of funds to be lent, and to then rank PPP projects according to their financial and risk factors. The developed model incorporates the lenders' perspective in assessing a project's bankability and the sponsor's creditworthiness. The available cash flow for debt service (CFADS) is used as the major metric for the assessment, while accounting for the time value of monetary and risk factors. A list of the most important accounting factors for bankability assessment was identified through interviews with experts from major PPP financial institutions in five African countries. A questionnaire sent to experts in PPP financing was utilized to identify the major risk factors to be taken into account while calculating the project risk premium. The weights of these risk factors was calculated using the TOPSIS analysis. A scenario analysis was developed to evaluate a project's worst, best, and base cases according to their financial and risk factors. Finally, the projects were ranked based on four metrics, and the sum of the accumulated scored of each project was used for prioritize them.

The bankability assessment model was applied on six real case studies. For each of the six projects the Free Cash flow for Debt Services, the PV of Free Cash Flow for Debt Services, and the Debt service Coverage Ratio were calculated based on three scenarios: the base, the worst and the best. Each scenario changed the value of the accounting data, changing the income statement and balance sheet numbers for each project. Changing these two financial statements directly affects the cash flow statement of the projects. The calculated results have been illustrated using graphs. The projects mostly follow the same pattern, however the magnitude of their variation over the life of the projects could be very large indeed. . The results of these case studies indicate that the most important risk factors in the bankability assessment of PPP projects are technical risk, operation risk, completion risk, environmental risk, market risk and counter party risk.

An automated tool using the developed models was developed to assist decision makers in selecting private partners on PPP projects. The automated tool was developed in a Microsoft Visual Studio 2012 C # environment. The output of the software tool ranked of the private partners. The tool was utilized on four projects and the results showed its effectiveness.

8.2 Research Contributions

The contributions of this research are expected to circumvent a number of limitations and challenges associated with current practice in selecting private partners for PPP infrastructure projects. Specifically, the research contributions are:

- The design and development of a decision-support tool to assist public sector and governmental agencies in selecting and evaluating the private partners on certain infrastructure PPP projects;
- The development of a partner selection model utilizing the Fuzzy ANP technique to account for the uncertainties in the experts' judgements and to account for the interdependencies between the goal, the criteria and the alternatives.
- The development of a bankability assessment model to assist creditors in the evaluation and ranking of PPP projects, based on their financial and risk factors.
- The development of an automated tool to support decision-makers in selecting private partners on PPP projects based on the models developed in this research.

8.3 Research Limitations

The limitations of the research are itemized below

- The developed models are limited to applications in African countries, where the survey data were collected from experts in five countries. A new questionnaire survey should be submitted to collect data based on another project locations.
- The Scenario Analysis was limited to three scenarios; however more scenarios can be considered as a way to test the sensitivity of the bankability assessment on PPP projects.
- The capital structure of each project was assumed to remain fixed during the project life, but there are a number of situations when this might change and lead to a change in the FCFADS.
- The comparison between the different projects did not take into account their sizes, therefore the comparison between the absolute value of Cash Flows of building 20 bridges and the strengthening and widening of lanes is irrational. This limitation can be solved via de-unitization of the data.

8.4 Recommendations and Future Work

Based on the research conducted to date, the following is recommended for future work. The recommendations are presented in two categories, enhancements to the presented methodology and extensions to it.

8.4.1 Improving Presented Methodology:

- More data collection could be collected in terms of real PPP projects, such as using the replies to questionnaires received from experts in different countries to increase the reliability of the developed models;

- Other data collection methodologies can be applied to enhance the current research, such as holding workshops to identify the best practices for selecting private partners for n PPP projects;
- The useful utilization and application of the developed methodology can be further validated using data from additional projects. Data from other real projects can thus be used to calibrate the developed models and to incorporate opinions from additional experts;
- Expand the scope of the developed methodology to be applied to other parts of the world by incorporating experts' opinions from other developed and developing countries; and
- Develop a web-based software tool to make the model available for public authorities to use and to collect data, which would improve the model's performance.

8.4.2 Extending the Presented Methodology:

- Expand the bankability assessment model by testing the bankability of PPP projects in various scenarios. Random scenarios can be generated using Monte Carlo simulation and then used to test the project bankability and to gauge the risk associated with each scenario. Monte Carlo simulation tries thousands of scenarios based on input distribution patterns. An analyst can assume different pattern of distribution for all of our assumed input data and then use Monte Carlo to have a broad distribution of results instead of just three scenarios' results. This approach will enable better estimates of project returns, and fit them into distributions from which creditors can estimate their level of confidence in their assessment;

- Improve the bankability assessment model by integrating new features to allow for better comparison between projects of different sizes; and
- Add more factors to expand the bankability criteria for PPP projects, which can be defined by financial and economic analysts.

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Appendix A: Fuzzy judgment matrix

Fuzzy judgment matrix for Case Study II

Goal	C1	C2	C3	C4	C5
C1	(1,1,1)	(2,5/2,3)	(3/2,2,5/2)	(1/2,1,3/2)	(2/5,1/2,2/3)
C2	(1/3,2/5,1/2)	(1,1,1)	(1,3/2,2)	(1,1,1)	(1/2,2/3,1)
C3	(2/5,1/2,2/3)	(1/2,2/3,1)	(1,1,1)	(2/5,1/2,2/3)	(2/5,1/2,2/3)
C4	(2/3,1,2)	(1,1,1)	(3/2,2,5/2)	(1,1,1)	(2/5,1/2,2/3)
C5	(3/2,2,5/2)	(1,3/2,2)	(3/2,2,5/2)	(3/2,2,5/2)	(1,1,1)

Fuzzy judgment matrix for Case Study III

Goal	C1	C2	C3	C4	C5
C1	(1,1,1)	(1/2,1,3/2)	(1,1,1)	(1/3,2/5,1/2)	(3/2,2,5/2)
C2	(1/3,2/5,1/2)	(1,1,1)	(1,1,1)	(1,1,1)	(3/2,2,5/2)
C3	(1,1,1)	(1,1,1)	(1,1,1)	(1,3/2,2)	(3/2,2,5/2)
C4	(2,5/2,3)	(1/2,2/3,1)	(1/2,2/3,1)	(1,1,1)	(3/2,2,5/2)
C5	(2/5,1/2,2/3)	(2/5,1/2,2/3)	(2/5,1/2,2/3)	(2/5,1/2,2/3)	(1,1,1)

Fuzzy judgment matrix for Case Study IV

Goal	C1	C2	C3	C4	C5
C1	(1,1,1)	(1,1,1)	(1/2,1,3/2)	(1,1,1)	(1/2,1,3/2)
C2	(1,1,1)	(1,1,1)	(1,1,1)	(1,3/2,2)	(1,3/2,2)
C3	(2/3,1,2)	(1,1,1)	(1,1,1)	(2/3,1,2)	(1,1,1)
C4	(1,1,1)	(1/2,2/3,1)	(1/2,1,3/2)	(1,1,1)	(1,1,1)
C5	(2/3,1,2)	(1/2,2/3,1)	(1,1,1)	(1,1,1)	(1,1,1)

Appendix B: Chang's priority weights of sub-criteria

Chang's priority weights of sub-criteria against each other (Case Study II).

	Sub-Criteria																	
	C_1				C_2				C_3			C_4				C_5		
	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{31}	C_{32}	C_{33}	C_{41}	C_{42}	C_{43}	C_{44}	C_{51}	C_{52}	C_{53}
C_{11}	0.000	0.000	0.000	0.000	0.421	0.233	0.241	0.121	0.382	0.311	0.287	0.247	0.250	0.199	0.334	0.236	0.316	0.278
C_{12}	0.000	0.000	0.000	0.000	0.500	0.311	0.361	0.402	0.362	0.419	0.388	0.500	0.500	0.201	0.321	0.284	0.261	0.287
C_{13}	0.000	0.000	0.000	0.000	0.300	0.315	0.152	0.174	0.387	0.323	0.295	0.229	0.336	0.171	0.384	0.286	0.333	0.259
C_{14}	0.000	0.000	0.000	0.000	0.188	0.156	0.163	0.217	0.302	0.322	0.264	0.200	0.304	0.213	0.316	0.253	0.224	0.263
C_{21}	0.218	0.229	0.237	0.103	0.000	0.000	0.000	0.000	0.241	0.226	0.322	0.273	0.266	0.210	0.251	0.356	0.374	0.340
C_{22}	0.271	0.264	0.245	0.231	0.000	0.000	0.000	0.000	0.323	0.364	0.346	0.251	0.283	0.219	0.217	0.274	0.269	0.245
C_{23}	0.261	0.256	0.249	0.221	0.000	0.000	0.000	0.000	0.227	0.310	0.298	0.220	0.225	0.202	0.213	0.232	0.211	0.229
C_{24}	0.231	0.201	0.213	0.200	0.000	0.000	0.000	0.000	0.226	0.298	0.331	0.227	0.252	0.206	0.239	0.253	0.238	0.207
C_{31}	0.147	0.132	0.143	0.150	0.219	0.247	0.231	0.214	0.000	0.000	0.000	0.141	0.169	0.147	0.100	0.220	0.249	0.213
C_{32}	0.241	0.218	0.211	0.231	0.291	0.300	0.240	0.197	0.000	0.000	0.000	0.217	0.264	0.254	0.201	0.233	0.240	0.216
C_{33}	0.161	0.213	0.177	0.169	0.150	0.146	0.135	0.139	0.000	0.000	0.000	0.223	0.246	0.251	0.132	0.210	0.176	0.133
C_{41}	0.253	0.269	0.226	0.221	0.251	0.238	0.243	0.169	0.311	0.336	0.345	0.000	0.000	0.000	0.000	0.302	0.366	0.321
C_{42}	0.500	0.500	0.613	0.544	0.523	0.531	0.571	0.527	0.641	0.615	0.600	0.000	0.000	0.000	0.000	0.319	0.337	0.358
C_{43}	0.277	0.269	0.266	0.274	0.265	0.291	0.241	0.211	0.134	0.139	0.141	0.000	0.000	0.000	0.000	0.303	0.370	0.336
C_{44}	0.211	0.203	0.263	0.174	0.263	0.174	0.300	0.300	0.200	0.224	0.221	0.000	0.000	0.000	0.000	0.344	0.321	0.339
C_{51}	0.332	0.311	0.325	0.309	0.312	0.299	0.316	0.319	0.328	0.331	0.324	0.279	0.289	0.261	0.264	0.000	0.000	0.000
C_{52}	0.310	0.317	0.299	0.316	0.319	0.300	0.305	0.301	0.334	0.333	0.333	0.316	0.320	0.312	0.301	0.000	0.000	0.000
C_{53}	0.431	0.345	0.377	0.361	0.364	0.352	0.386	0.389	0.417	0.421	0.410	0.354	0.500	0.432	0.418	0.000	0.000	0.000

Chang's priority weights of sub-criteria against each other (Case Study III).

	Sub-Criteria																	
	C_1				C_2				C_3			C_4				C_5		
	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{31}	C_{32}	C_{33}	C_{41}	C_{42}	C_{43}	C_{44}	C_{51}	C_{52}	C_{53}
C_{11}	0.000	0.000	0.000	0.000	0.421	0.233	0.241	0.121	0.382	0.311	0.287	0.247	0.250	0.199	0.334	0.236	0.316	0.278
C_{12}	0.000	0.000	0.000	0.000	0.500	0.311	0.361	0.402	0.362	0.419	0.388	0.500	0.500	0.201	0.321	0.284	0.261	0.287
C_{13}	0.000	0.000	0.000	0.000	0.300	0.315	0.152	0.174	0.387	0.323	0.295	0.229	0.336	0.171	0.384	0.286	0.333	0.259
C_{14}	0.000	0.000	0.000	0.000	0.188	0.156	0.163	0.217	0.302	0.322	0.264	0.200	0.304	0.213	0.316	0.253	0.224	0.263
C_{21}	0.218	0.229	0.237	0.103	0.000	0.000	0.000	0.000	0.241	0.226	0.322	0.273	0.266	0.210	0.251	0.356	0.374	0.340
C_{22}	0.271	0.264	0.245	0.231	0.000	0.000	0.000	0.000	0.323	0.364	0.346	0.251	0.283	0.219	0.217	0.274	0.269	0.245
C_{23}	0.261	0.256	0.249	0.221	0.000	0.000	0.000	0.000	0.227	0.310	0.298	0.220	0.225	0.202	0.213	0.232	0.211	0.229
C_{24}	0.231	0.201	0.213	0.200	0.000	0.000	0.000	0.000	0.226	0.298	0.331	0.227	0.252	0.206	0.239	0.253	0.238	0.207
C_{31}	0.147	0.132	0.143	0.150	0.219	0.247	0.231	0.214	0.000	0.000	0.000	0.141	0.169	0.147	0.100	0.220	0.249	0.213
C_{32}	0.241	0.218	0.211	0.231	0.291	0.300	0.240	0.197	0.000	0.000	0.000	0.217	0.264	0.254	0.201	0.233	0.240	0.216
C_{33}	0.161	0.213	0.177	0.169	0.150	0.146	0.135	0.139	0.000	0.000	0.000	0.223	0.246	0.251	0.132	0.210	0.176	0.133
C_{41}	0.253	0.269	0.226	0.221	0.251	0.238	0.243	0.169	0.311	0.336	0.345	0.000	0.000	0.000	0.000	0.302	0.366	0.321
C_{42}	0.500	0.500	0.613	0.544	0.523	0.531	0.571	0.527	0.641	0.615	0.600	0.000	0.000	0.000	0.000	0.319	0.337	0.358
C_{43}	0.277	0.269	0.266	0.274	0.265	0.291	0.241	0.211	0.134	0.139	0.141	0.000	0.000	0.000	0.000	0.303	0.370	0.336
C_{44}	0.211	0.203	0.263	0.174	0.263	0.174	0.300	0.300	0.200	0.224	0.221	0.000	0.000	0.000	0.000	0.344	0.321	0.339
C_{51}	0.332	0.311	0.325	0.309	0.312	0.299	0.316	0.319	0.328	0.331	0.324	0.279	0.289	0.261	0.264	0.000	0.000	0.000
C_{52}	0.310	0.317	0.299	0.316	0.319	0.300	0.305	0.301	0.334	0.333	0.333	0.316	0.320	0.312	0.301	0.000	0.000	0.000
C_{53}	0.431	0.345	0.377	0.361	0.364	0.352	0.386	0.389	0.417	0.421	0.410	0.354	0.500	0.432	0.418	0.000	0.000	0.000

Chang’s priority weights of sub-criteria against each other (Case Study IV)

	Sub-Criteria																	
	C_1				C_2				C_3			C_4				C_5		
	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{31}	C_{32}	C_{33}	C_{41}	C_{42}	C_{43}	C_{44}	C_{51}	C_{52}	C_{53}
C_{11}	0.000	0.000	0.000	0.000	0.500	0.311	0.361	0.402	0.362	0.419	0.388	0.200	0.304	0.213	0.316	0.253	0.224	0.263
C_{12}	0.000	0.000	0.000	0.000	0.300	0.315	0.152	0.174	0.387	0.323	0.295	0.273	0.266	0.210	0.251	0.356	0.374	0.340
C_{13}	0.000	0.000	0.000	0.000	0.500	0.500	0.201	0.321	0.284	0.261	0.287	0.247	0.250	0.199	0.334	0.236	0.316	0.278
C_{14}	0.000	0.000	0.000	0.000	0.229	0.336	0.171	0.384	0.286	0.333	0.259	0.174	0.300	0.188	0.344	0.245	0.317	0.288
C_{21}	0.218	0.229	0.237	0.103	0.000	0.000	0.000	0.000	0.219	0.247	0.231	0.288	0.271	0.233	0.234	0.343	0.350	0.311
C_{22}	0.218	0.229	0.237	0.103	0.000	0.000	0.000	0.000	0.291	0.300	0.240	0.251	0.283	0.219	0.217	0.274	0.269	0.245
C_{23}	0.261	0.256	0.249	0.221	0.000	0.000	0.000	0.000	0.150	0.146	0.135	0.220	0.225	0.202	0.213	0.232	0.211	0.229
C_{24}	0.231	0.201	0.213	0.200	0.000	0.000	0.000	0.000	0.219	0.247	0.231	0.227	0.252	0.206	0.239	0.253	0.238	0.207
C_{31}	0.147	0.132	0.143	0.150	0.219	0.247	0.231	0.214	0.000	0.000	0.000	0.115	0.327	0.221	0.110	0.233	0.219	0.201
C_{32}	0.241	0.218	0.211	0.231	0.291	0.300	0.240	0.197	0.000	0.000	0.000	0.210	0.387	0.235	0.116	0.241	0.212	0.210
C_{33}	0.161	0.213	0.177	0.169	0.150	0.146	0.135	0.139	0.000	0.000	0.000	0.217	0.390	0.239	0.120	0.199	0.117	0.100
C_{41}	0.253	0.269	0.226	0.221	0.209	0.236	0.255	0.226	0.213	0.209	0.236	0.000	0.000	0.000	0.000	0.325	0.387	0.342
C_{42}	0.500	0.500	0.613	0.544	0.265	0.322	0.341	0.263	0.174	0.265	0.322	0.000	0.000	0.000	0.000	0.370	0.344	0.355
C_{43}	0.277	0.269	0.266	0.274	0.209	0.236	0.255	0.226	0.213	0.209	0.236	0.000	0.000	0.000	0.000	0.333	0.361	0.314
C_{44}	0.147	0.132	0.143	0.150	0.265	0.322	0.341	0.263	0.174	0.265	0.322	0.000	0.000	0.000	0.000	0.352	0.343	0.342
C_{51}	0.157	0.144	0.131	0.136	0.118	0.147	0.101	0.128	0.138	0.116	0.241	0.212	0.210	0.124	0.116	0.000	0.000	0.000
C_{52}	0.101	0.113	0.109	0.115	0.110	0.120	0.111	0.129	0.128	0.104	0.111	0.129	0.115	0.110	0.099	0.000	0.000	0.000
C_{53}	0.310	0.317	0.299	0.316	0.319	0.300	0.305	0.301	0.334	0.333	0.333	0.316	0.320	0.312	0.301	0.000	0.000	0.000

Appendix C: Sub-Criteria Weights

Sub-Criteria Weights (Case Study II).

Sub-Criteria Weights					
	C1	**C2**	**C3**	**C4**	**C5**
Sub1	0.1937	0.2500	0.3644	0.2500	0.3661
Sub2	0.3000	0.2500	0.3200	0.3899	0.2139
Sub3	0.2411	0.2500	0.3156	0.2000	0.4200
Sub4	0.2652	0.2500	-	0.1601	-
Total	1	1	1	1	1

Sub-Criteria Weights (Case Study III).

Sub-Criteria Weights					
	C1	**C2**	**C3**	**C4**	**C5**
Sub1	0.1937	0.2500	0.3644	0.2500	0.3661
Sub2	0.3000	0.2500	0.3200	0.3899	0.2139
Sub3	0.2411	0.2500	0.3156	0.2000	0.4200
Sub4	0.2652	0.2500	-	0.1601	-
Total	1	1	1	1	1

Sub-Criteria Weights (Case Study IV)

Sub-Criteria Weights					
	C1	**C2**	**C3**	**C4**	**C5**
Sub1	0.2000	0.2500	0.3000	0.2880	0.5000
Sub2	0.0560	0.2000	0.3000	0.3000	0.5000
Sub3	0.3770	0.3000	0.4000	0.2000	0.000
Sub4	0.3670	0.2500	-	0.2120	-
Total	1	1	1	1	1

Appendix D: Chang's priority weights of alternatives

Chang's priority weights of alternatives with respect to sub-criteria (Case Study II)

	C11	C12	C13	C14	C21	C22	C23	C24	C31	C32	C33	C41	C42	C43	C44	C51	C52	C53
P1	0.240	0.231	0.299	0.131	0.191	0.169	0.233	0.166	0.341	0.255	0.297	0.160	0.310	0.214	0.197	0.266	0.244	0.235
P2	0.233	0.198	0.241	0.152	0.183	0.203	0.197	0.178	0.264	0.276	0.271	0.183	0.237	0.179	0.229	0.177	0.161	0.300
P3	0.198	0.288	0.216	0.149	0.224	0.205	0.155	0.139	0.251	0.261	0.309	0.177	0.225	0.227	0.210	0.189	0.173	0.465

Chang's priority weights of alternatives with respect to sub-criteria (Case Study III)

	C11	C12	C13	C14	C21	C22	C23	C24	C31	C32	C33	C41	C42	C43	C44	C51	C52	C53
P1	0.177	0.274	0.171	0.099	0.190	0.148	0.173	0.243	0.244	0.214	0.293	0.158	0.162	0.174	0.146	0.178	0.133	0.150
P2	0.250	0.345	0.281	0.124	0.233	0.216	0.240	0.311	0.333	0.246	0.421	0.247	0.300	0.202	0.251	0.271	0.251	0.227
P3	0.219	0.328	0.200	0.103	0.214	0.200	0.212	0.280	0.289	0.231	0.356	0.201	0.298	0.188	0.210	0.240	0.221	0.198

Chang's priority weights of alternatives with respect to sub-criteria (Case Study IV)

	C11	C12	C13	C14	C21	C22	C23	C24	C31	C32	C33	C41	C42	C43	C44	C51	C52	C53
P1	0.183	0.237	0.179	0.229	0.177	0.161	0.300	0.183	0.299	0.276	0.271	0.183	0.252	0.179	0.200	0.177	0.161	-
P2	0.209	0.200	0.151	0.143	0.224	0.205	0.155	0.139	0.295	0.087	0.362	0.325	0.271	0.227	0.255	0.205	0.271	-
P3	0.378	0.197	0.345	0.312	0.200	0.200	0.309	0.224	0.312	0.375	0.200	0.209	0.387	0.131	0.300	0.266	0.221	-
P4	0.224	0.205	0.179	0.139	0.251	0.261	0.158	0.197	0.220	0.200	0.133	0.201	0.220	0.204	0.210	0.133	0.244	-
P5	0.177	0.225	0.227	0.210	0.233	0.198	0.125	0.125	0.285	0.261	0.322	0.177	0.277	0.356	0.143	0.213	0.322	-
P6	0.183	0.203	0.197	0.178	0.233	0.198	0.201	0.152	0.183	0.203	0.197	0.186	0.280	0.285	0.124	0.263	0.112	-

Appendix E: (unweighted) super – matrix

(unweighted) super – matrix for the private partner selection (Case Study II).

Cluster Node level						Criteria																		Goal
			Alternatives			C_{11}				C_{21}				C_3			C_4				C_5			
			P_1	P_2	P_3	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{31}	C_{32}	C_{33}	C_{41}	C_{42}	C_{43}	C_{44}	C_{51}	C_{52}	C_{53}	
Alternati	P_1		0.000	0.000	0.000	0.197	0.312	0.200	0.200	0.159	0.161	0.221	0.158	0.220	0.375	0.133	0.201	0.177	0.204	0.210	0.266	0.244	0.500	0.000
	P_2		0.000	0.000	0.000	0.233	0.198	0.256	0.152	0.183	0.203	0.197	0.178	0.299	0.276	0.271	0.183	0.252	0.179	0.200	0.177	0.161	0.188	0.000
	P_3		0.000	0.000	0.000	0.220	0.266	0.210	0.155	0.209	0.220	0.151	0.143	0.285	0.261	0.322	0.165	0.200	0.213	0.188	0.134	0.173	0.191	0.000
Criteria	C_1																							
		C_{11}	0.224	0.227	0.523	0.000	0.000	0.000	0.000	0.421	0.233	0.241	0.121	0.382	0.311	0.287	0.247	0.250	0.199	0.334	0.236	0.316	0.278	0.140
		C_{12}	0.402	0.222	0.204	0.000	0.000	0.000	0.000	0.500	0.311	0.361	0.402	0.362	0.419	0.388	0.500	0.500	0.201	0.321	0.284	0.261	0.287	0.210
		C_{13}	0.150	0.303	0.150	0.000	0.000	0.000	0.000	0.300	0.315	0.152	0.174	0.387	0.323	0.295	0.229	0.336	0.171	0.384	0.286	0.333	0.259	0.065
		C_{14}	0.224	0.248	0.113	0.000	0.000	0.000	0.000	0.188	0.156	0.163	0.217	0.302	0.322	0.264	0.200	0.304	0.213	0.316	0.253	0.224	0.263	0.005
	C_2																							
		C_{21}	0.195	0.250	0.450	0.218	0.229	0.237	0.103	0.000	0.000	0.000	0.000	0.241	0.226	0.322	0.273	0.266	0.210	0.251	0.356	0.374	0.340	0.063
		C_{22}	0.213	0.250	0.177	0.271	0.264	0.245	0.231	0.000	0.000	0.000	0.000	0.323	0.364	0.346	0.251	0.283	0.219	0.217	0.274	0.269	0.245	0.025
		C_{23}	0.350	0.250	0.186	0.261	0.256	0.249	0.221	0.000	0.000	0.000	0.000	0.227	0.310	0.298	0.220	0.225	0.202	0.213	0.232	0.211	0.229	0.100
		C_{24}	0.242	0.250	0.187	0.231	0.201	0.213	0.200	0.000	0.000	0.000	0.000	0.226	0.298	0.331	0.227	0.252	0.206	0.239	0.253	0.238	0.207	0.018
	C_3																							
		C_{31}	0.415	0.433	0.250	0.147	0.132	0.143	0.150	0.219	0.247	0.231	0.214	0.000	0.000	0.000	0.141	0.169	0.147	0.100	0.220	0.249	0.213	0.000
		C_{32}	0.169	0.188	0.500	0.241	0.218	0.211	0.231	0.291	0.300	0.240	0.197	0.000	0.000	0.000	0.217	0.264	0.254	0.201	0.233	0.240	0.216	0.000
		C_{33}	0.416	0.379	0.250	0.161	0.213	0.177	0.169	0.150	0.146	0.135	0.139	0.000	0.000	0.000	0.223	0.246	0.251	0.132	0.210	0.176	0.133	0.000
	C_4																							
		C_{41}	0.140	0.181	0.164	0.253	0.269	0.226	0.221	0.251	0.238	0.243	0.169	0.311	0.336	0.345	0.000	0.000	0.000	0.000	0.302	0.366	0.321	0.030
		C_{42}	0.200	0.371	0.261	0.500	0.500	0.613	0.544	0.523	0.531	0.571	0.527	0.641	0.615	0.600	0.000	0.000	0.000	0.000	0.319	0.337	0.358	0.109
		C_{43}	0.250	0.300	0.125	0.277	0.269	0.266	0.274	0.265	0.291	0.241	0.211	0.134	0.139	0.141	0.000	0.000	0.000	0.000	0.303	0.370	0.336	0.004
		C_{44}	0.410	0.148	0.450	0.211	0.203	0.263	0.174	0.263	0.174	0.300	0.300	0.200	0.224	0.221	0.000	0.000	0.000	0.000	0.344	0.321	0.339	0.004
	C_5																							
		C_{51}	0.200	0.333	0.400	0.332	0.311	0.325	0.309	0.312	0.299	0.316	0.319	0.328	0.331	0.324	0.279	0.289	0.261	0.264	0.000	0.000	0.000	0.075
		C_{52}	0.200	0.333	0.431	0.310	0.317	0.299	0.316	0.319	0.300	0.305	0.301	0.334	0.333	0.333	0.316	0.320	0.312	0.301	0.000	0.000	0.000	0.065
		C_{53}	0.600	0.334	0.169	0.431	0.345	0.377	0.361	0.364	0.352	0.386	0.389	0.417	0.421	0.410	0.354	0.500	0.432	0.418	0.000	0.000	0.000	0.088
Goal			0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

(unweighted) super – matrix for the private partner selection (Case Study III).

Cluster						Criteria																			Goal
Node level			Alternatives			C_{11}				C_{21}				C_3			C_4				C_5				
			P_1	P_2	P_3	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{31}	C_{32}	C_{33}	C_{41}	C_{42}	C_{43}	C_{44}	C_{51}	C_{52}	C_{53}		
Alternati	P_1		0.000	0.000	0.000	0.240	0.231	0.299	0.131	0.191	0.169	0.233	0.166	0.341	0.255	0.297	0.160	0.310	0.214	0.197	0.266	0.244	0.235		0.000
	P_2		0.000	0.000	0.000	0.233	0.198	0.241	0.152	0.183	0.203	0.197	0.178	0.264	0.276	0.271	0.183	0.237	0.179	0.229	0.177	0.161	0.300		0.000
	P_3		0.000	0.000	0.000	0.198	0.288	0.216	0.149	0.224	0.205	0.155	0.139	0.251	0.261	0.309	0.177	0.225	0.227	0.210	0.189	0.173	0.465		0.000
Criteria	C_1																								
		C_{11}	0.234	0.500	0.336	0.000	0.000	0.000	0.000	0.421	0.233	0.241	0.121	0.382	0.311	0.287	0.247	0.250	0.199	0.334	0.236	0.316	0.278		0.153
		C_{12}	0.100	0.133	0.391	0.000	0.000	0.000	0.000	0.500	0.311	0.361	0.402	0.362	0.419	0.388	0.500	0.500	0.201	0.321	0.284	0.261	0.287		0.198
		C_{13}	0.366	0.147	0.086	0.000	0.000	0.000	0.000	0.300	0.315	0.152	0.174	0.387	0.323	0.295	0.229	0.336	0.171	0.384	0.286	0.333	0.259		0.036
		C_{14}	0.300	0.220	0.187	0.000	0.000	0.000	0.000	0.188	0.156	0.163	0.217	0.302	0.322	0.264	0.200	0.304	0.213	0.316	0.253	0.224	0.263		0.008
	C_2																								
		C_{21}	0.115	0.346	0.377	0.218	0.229	0.237	0.103	0.000	0.000	0.000	0.000	0.241	0.226	0.322	0.273	0.266	0.210	0.251	0.356	0.374	0.340		0.043
		C_{22}	0.100	0.239	0.397	0.271	0.264	0.245	0.231	0.000	0.000	0.000	0.000	0.323	0.364	0.346	0.251	0.283	0.219	0.217	0.274	0.269	0.245		0.040
		C_{23}	0.399	0.215	0.126	0.261	0.256	0.249	0.221	0.000	0.000	0.000	0.000	0.227	0.310	0.298	0.220	0.225	0.202	0.213	0.232	0.211	0.229		0.120
		C_{24}	0.386	0.200	0.100	0.231	0.201	0.213	0.200	0.000	0.000	0.000	0.000	0.226	0.298	0.331	0.227	0.252	0.206	0.239	0.253	0.238	0.207		0.026
	C_3																								
		C_{31}	0.333	0.235	0.481	0.147	0.132	0.143	0.150	0.219	0.247	0.231	0.214	0.000	0.000	0.000	0.141	0.169	0.147	0.100	0.220	0.249	0.213		0.000
		C_{32}	0.334	0.222	0.260	0.241	0.218	0.211	0.231	0.291	0.300	0.240	0.197	0.000	0.000	0.000	0.217	0.264	0.254	0.201	0.233	0.240	0.216		0.000
		C_{33}	0.333	0.543	0.259	0.161	0.213	0.177	0.169	0.150	0.146	0.135	0.139	0.000	0.000	0.000	0.223	0.246	0.251	0.132	0.210	0.176	0.133		0.000
	C_4																								
		C_{41}	0.400	0.311	0.236	0.253	0.269	0.226	0.221	0.251	0.238	0.243	0.169	0.311	0.336	0.345	0.000	0.000	0.000	0.000	0.302	0.366	0.321		0.041
		C_{42}	0.369	0.186	0.111	0.500	0.500	0.613	0.544	0.523	0.531	0.571	0.527	0.641	0.615	0.600	0.000	0.000	0.000	0.000	0.319	0.337	0.358		0.122
		C_{43}	0.131	0.409	0.153	0.277	0.269	0.266	0.274	0.265	0.291	0.241	0.211	0.134	0.139	0.141	0.000	0.000	0.000	0.000	0.303	0.370	0.336		0.007
		C_{44}	0.100	0.094	0.500	0.211	0.203	0.263	0.174	0.263	0.174	0.300	0.300	0.200	0.224	0.221	0.000	0.000	0.000	0.000	0.344	0.321	0.339		0.006
	C_5																								
		C_{51}	0.500	0.401	0.136	0.332	0.311	0.325	0.309	0.312	0.299	0.316	0.319	0.328	0.331	0.324	0.279	0.289	0.261	0.264	0.000	0.000	0.000		0.060
		C_{52}	0.286	0.198	0.120	0.310	0.317	0.299	0.316	0.319	0.300	0.305	0.301	0.334	0.333	0.333	0.316	0.320	0.312	0.301	0.000	0.000	0.000		0.040
		C_{53}	0.214	0.401	0.744	0.431	0.345	0.377	0.361	0.364	0.352	0.386	0.389	0.417	0.421	0.410	0.354	0.500	0.432	0.418	0.000	0.000	0.000		0.100
Goal			0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000

(un weighted) super – matrix for the private partner selection (Case Study IV).

Cluster Node level			Alternatives						Criteria																		Goal
									C_1				C_2				C_3			C_4				C_5			
			P_1	P_2	P_3	P_4	P_5	P_6	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{31}	C_{32}	C_{33}	C_{41}	C_{42}	C_{43}	C_{44}	C_{51}	C_{52}	C_{53}	
Alte	P_1		0.000	0.000	0.000	0.000	0.000	0.000	0.183	0.237	0.179	0.229	0.177	0.161	0.300	0.183	0.299	0.276	0.271	0.183	0.252	0.179	0.200	0.177	0.161	0.000	0.000
	P_2		0.000	0.000	0.000	0.000	0.000	0.000	0.209	0.200	0.151	0.143	0.224	0.205	0.155	0.139	0.295	0.087	0.362	0.325	0.271	0.227	0.255	0.205	0.271	0.000	0.000
	P_3		0.000	0.000	0.000	0.000	0.000	0.000	0.378	0.197	0.345	0.312	0.200	0.200	0.309	0.224	0.312	0.375	0.200	0.209	0.387	0.131	0.300	0.266	0.221	0.000	0.000
	P_4		0.000	0.000	0.000	0.000	0.000	0.000	0.224	0.205	0.179	0.139	0.251	0.261	0.158	0.197	0.220	0.200	0.133	0.201	0.220	0.204	0.210	0.133	0.244	0.000	0.000
	P_5		0.000	0.000	0.000	0.000	0.000	0.000	0.177	0.225	0.227	0.210	0.233	0.198	0.256	0.125	0.285	0.261	0.322	0.177	0.277	0.356	0.143	0.213	0.322	0.000	0.000
	P_6		0.000	0.000	0.000	0.000	0.000	0.000	0.183	0.203	0.197	0.178	0.233	0.198	0.201	0.152	0.183	0.203	0.197	0.186	0.280	0.285	0.124	0.263	0.112	0.000	0.000
Criteria	C_1																										
		C_{11}	0.533	0.222	0.100	0.333	0.140	0.450	0.000	0.000	0.000	0.000	0.500	0.311	0.361	0.402	0.362	0.419	0.388	0.200	0.304	0.213	0.316	0.253	0.224	0.263	0.051
		C_{12}	0.203	0.201	0.081	0.472	0.200	0.177	0.000	0.000	0.000	0.000	0.300	0.315	0.152	0.174	0.387	0.323	0.295	0.273	0.266	0.210	0.251	0.356	0.374	0.340	0.037
		C_{13}	0.200	0.278	0.399	0.181	0.250	0.186	0.000	0.000	0.000	0.000	0.500	0.500	0.201	0.321	0.284	0.261	0.287	0.247	0.250	0.199	0.334	0.236	0.316	0.278	0.119
		C_{14}	0.063	0.299	0.420	0.013	0.410	0.187	0.000	0.000	0.000	0.000	0.229	0.336	0.171	0.384	0.286	0.333	0.259	0.174	0.300	0.188	0.344	0.245	0.317	0.288	0.102
	C_2																										
		C_{21}	0.250	0.154	0.158	0.154	0.164	0.189	0.218	0.229	0.237	0.103	0.000	0.000	0.000	0.000	0.219	0.247	0.231	0.288	0.271	0.233	0.234	0.343	0.350	0.311	0.059
		C_{22}	0.311	0.487	0.158	0.487	0.261	0.288	0.218	0.229	0.237	0.103	0.000	0.000	0.000	0.000	0.291	0.300	0.240	0.251	0.283	0.219	0.217	0.274	0.269	0.245	0.046
		C_{23}	0.163	0.277	0.316	0.277	0.125	0.281	0.261	0.256	0.249	0.221	0.000	0.000	0.000	0.000	0.150	0.146	0.135	0.220	0.225	0.202	0.213	0.232	0.211	0.229	0.073
		C_{24}	0.275	0.080	0.368	0.080	0.450	0.240	0.231	0.201	0.213	0.200	0.000	0.000	0.000	0.000	0.219	0.247	0.231	0.227	0.252	0.206	0.239	0.253	0.238	0.207	0.064
	C_3																										
		C_{31}	0.166	0.266	0.175	0.387	0.333	0.200	0.147	0.132	0.143	0.150	0.219	0.247	0.231	0.214	0.000	0.000	0.000	0.115	0.327	0.221	0.110	0.233	0.219	0.201	0.015
		C_{32}	0.500	0.400	0.325	0.458	0.333	0.200	0.241	0.218	0.211	0.231	0.291	0.300	0.240	0.197	0.000	0.000	0.000	0.210	0.387	0.235	0.116	0.241	0.212	0.210	0.015
		C_{33}	0.333	0.333	0.500	0.154	0.334	0.600	0.161	0.213	0.177	0.169	0.150	0.146	0.135	0.139	0.000	0.000	0.000	0.217	0.390	0.239	0.120	0.199	0.117	0.100	0.063
	C_4																										
		C_{41}	0.257	0.181	0.279	0.293	0.227	0.190	0.253	0.269	0.226	0.221	0.209	0.236	0.255	0.226	0.213	0.209	0.236	0.000	0.000	0.000	0.000	0.325	0.387	0.342	0.061
		C_{42}	0.293	0.188	0.347	0.184	0.222	0.179	0.500	0.500	0.613	0.544	0.265	0.322	0.341	0.263	0.174	0.265	0.322	0.000	0.000	0.000	0.000	0.370	0.344	0.355	0.073
		C_{43}	0.250	0.400	0.174	0.245	0.303	0.440	0.277	0.269	0.266	0.274	0.209	0.236	0.255	0.226	0.213	0.209	0.236	0.000	0.000	0.000	0.000	0.333	0.361	0.314	0.052
		C_{44}	0.200	0.230	0.200	0.277	0.248	0.190	0.147	0.132	0.143	0.150	0.265	0.322	0.341	0.263	0.174	0.265	0.322	0.000	0.000	0.000	0.000	0.352	0.343	0.342	0.033
	C_5																										
		C_{51}	0.500	0.500	0.500	0.500	0.500	0.500	0.157	0.144	0.131	0.136	0.118	0.147	0.101	0.128	0.138	0.116	0.241	0.212	0.210	0.124	0.116	0.000	0.000	0.000	0.073
		C_{52}	0.500	0.500	0.500	0.500	0.500	0.500	0.101	0.113	0.109	0.115	0.110	0.120	0.111	0.129	0.128	0.104	0.111	0.129	0.115	0.110	0.099	0.000	0.000	0.000	0.073
		C_{53}	0.000	0.000	0.000	0.000	0.000	0.000	0.310	0.317	0.299	0.316	0.319	0.300	0.305	0.301	0.334	0.333	0.333	0.316	0.320	0.312	0.301	0.000	0.000	0.000	0.000
Goal			0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Appendix F: Limit super – matrix

Limit super – matrix for the private partner selection (Case Study II).

Cluster Node level			Alternatives			Criteria																		Goal
						C_1				C_2				C_3			C_4				C_5			
			P_1	P_2	P_3	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{31}	C_{32}	C_{33}	C_{41}	C_{42}	C_{43}	C_{44}	C_{51}	C_{52}	C_{53}	
Alternati	P_1		0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112
	P_2		0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223
	P_3		0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122
Criteria	C_1																							
		C_{11}	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068
		C_{12}	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
		C_{13}	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023
		C_{14}	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
	C_2																							
		C_{21}	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
		C_{22}	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
		C_{23}	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047
		C_{24}	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044
	C_3																							
		C_{31}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		C_{32}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		C_{33}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	C_4																							
		C_{41}	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
		C_{42}	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
		C_{43}	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
		C_{44}	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
	C_5																							
		C_{51}	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
		C_{52}	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
		C_{53}	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080
Goal			0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Limit super – matrix for the private partner selection (Case Study III).

Cluster Node level		Alternatives			Criteria																			Goal
					C_1				C_2				C_3			C_4				C_5				
		P_1	P_2	P_3	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{31}	C_{32}	C_{33}	C_{41}	C_{42}	C_{43}	C_{44}	C_{51}	C_{52}	C_{53}		
Alternati	P_1	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	
	P_2	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	
	P_3	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	
Criteria	C_1																							
	C_{11}	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	
	C_{12}	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	
	C_{13}	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	
	C_{14}	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	
	C_2																							
	C_{21}	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	
	C_{22}	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	
	C_{23}	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	
	C_{24}	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	
	C_3																							
	C_{31}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
	C_{32}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
	C_{33}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
	C_4																							
	C_{41}	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	
	C_{42}	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	
	C_{43}	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	
	C_{44}	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	
	C_5																							
	C_{51}	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	
	C_{52}	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	
	C_{53}	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	
Goal		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	

Limit super – matrix for the private partner selection (Case Study IV).

Cluster Node level			Alternatives						Criteria																		Goal
									C_1				C_2				C_3			C_4				C_5			
			P_1	P_2	P_3	P_4	P_5	P_6	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{31}	C_{32}	C_{33}	C_{41}	C_{42}	C_{43}	C_{44}	C_{51}	C_{52}	C_{53}	
Alte	P_1		0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.058
	P_2		0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
	P_3		0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123
	P_4		0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
	P_5		0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
	P_6		0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.054
Criteria	C_1																										
		C_{11}	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
		C_{12}	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028
		C_{13}	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068
		C_{14}	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047
	C_2																										
		C_{21}	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
		C_{22}	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026
		C_{23}	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051
		C_{24}	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
	C_3																										
		C_{31}	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
		C_{32}	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
		C_{33}	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029
	C_4																										
		C_{41}	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061
		C_{42}	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051
		C_{43}	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022
		C_{44}	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
	C_5																										
		C_{51}	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051
		C_{52}	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051
		C_{53}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Goal			0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Appendix G: Partners Ranking

The priority of the four private partners (Case Study II).

Private Partner	Priority of the Alternatives	Rank
Private Partner P1	0.112	3
Private Partner P2	0.223	1
Private Partner P3	0.122	2

This result shows the private partner $P_2 = 0.223$ is the best private partner to deliver this project; however the authority (decisions makers) select private partner P_1 = 0.112 which has less value then the (Private Partner P_2). The decision makers based their selection on unjustifiable and subjective political factors.

The priority of the four private partners (Case Study III).

Private Partner	Priority of the Alternatives	Rank
Private Partner P1	0.238	1
Private Partner P2	0.148	2
Private Partner P3	0.105	3

As shown, the private partner P_3 is chosen as the best private partner to deliver such a project. This result shows the private partner $P_1 = 0.238$ is the best private partner to deliver this project; the authority (decisions makers) select private partner P_1 = 0.238 which has same value.

The priority of the four private partners (Case Study IV).

Private Partner	Priority of the Alternatives	Rank
Private Partner P1	0.058	3
Private Partner P2	0.045	5
Private Partner P3	0.123	1
Private Partner P4	0.060	2
Private Partner P5	0.039	6
Private Partner P6	0.054	4

As shown, the private partner P_3 is chosen as the best private partner to deliver such a project. This result shows the private partner $P_3 = 0.123$ is the best private partner to deliver this project; the authority (decisions makers) select private partner P_3 = 0.123 which has the same value the (Private Partner P_3).

Appendix H: Private Partner Selection using TOPSIS Technique

Case II:

The General Criteria Weights are customized. This case study was done before the start of the unstable political conditions in the country of operation. Therefor at that time the political weight was assigned a value of 7.5% which is less than the weight assigned for thr case study as shown:

General Criteria Weights (Case Study II).

General Criteria Weights				
Financials	**Technical**	**Safety & Environmental**	**Managerial**	**Political**
40.0%	30.0%	7.5%	15.0%	7.5%

Each partner was assessed by Experts on each of the five criteria as shown in following tables. The Experts' assessment is regarding the partner ability to fulfill the best practice of the selection criteria.

Experts opinions for partner A (Case Study II).

Experts opinions for partner A											
	1	2	3	4	5	6	7	8	9	10	Average
Financials	2	2	2	2	4	3	2	3	3	4	2.70
Technical	2	3	3	4	5	3	2	4	4	3	3.30
Safety & Environmental	4	0	5	4	2	5	3	1	1	3	3.11
Managerial	1	2	3	4	2	1	2	2	2	1	2.00
Political	1	2	3	4	4	3	3	3	3	4	3.00

Experts opinions for partner B (Case Study II).

Experts opinions for partner B											
	1	2	3	4	5	6	7	8	9	10	Average
Financials	1	5	3	4	5	5	5	5	5	5	4.3
Technical	2	5	3	3	3	4	5	1	2	3	3.1
Safety & Environmental	3	4	5	5	4	2	3	4	5	3	3.8
Managerial	4	3	4	5	5	4	5	4	3	1	3.8
Political	5	1	2	3	3	1	2	3	4	5	2.9

Experts opinions for partner C (Case Study II).

Experts opinions for partner C											
	1	2	3	4	5	6	7	8	9	10	Average
Financials	1	2	4	5	5	4	2	1	2	3	2.9
Technical	2	2	2	4	5	4	5	4	1	3	3.2
Safety & Environmental	3	4	3	3	4	5	1	2	3	4	3.2
Managerial	1	2	3	4	5	3	3	3	2	3	2.9
Political	4	5	2	3	1	2	3	5	5	3	3.3

Similarly to the step explained in case study I, the decision matrix, standard decision matrix and weighted standard decision matrix are generated as shown:

Decision Matrix (Case Study II).

	Decision Matrix			
	Partner A	Partner B	Partner C	Total
Financial	2.70	4.30	2.90	5.85
Technical	3.30	3.10	3.20	5.54
Safety & Environmental	3.11	3.80	3.20	5.86
Managerial	2.00	3.80	2.90	5.18
Political	3.00	2.90	3.30	5.32

Standard Decision Matrix (Case Study II).

	Standard Decision matrix		
	Partner A	Partner B	Partner C
Financial	0.46	0.74	0.50
Technical	0.60	0.56	0.58
Safety & Environmental	0.53	0.65	0.55
Managerial	0.39	0.73	0.56
Political	0.56	0.55	0.62

Weighted Standard Decision Matrix (Case Study II).

	Weighted Standard Decision Matrix		
	Partner A	Partner B	Partner C
Financial	0.18	0.29	0.20
Technical	0.18	0.17	0.17
Safety & Environmental	0.04	0.05	0.04
Managerial	0.06	0.11	0.08
Political	0.04	0.04	0.05

The standard decision matrix should take into account the general weights value. Therefore we multiply the first matrix with the Standard decision Matrix to have the Weighted Standard decision Matrix as shown:

Weighted Standard Decision Matrix, with Ideals (Case Study II).

	Weighted Standard Decision Matrix			Ideal Solution	Negative Ideal
	Partner A	Partner B	Partner C		
Financial	0.18	0.29	0.20	0.29	0.18
Technical	0.18	0.17	0.17	0.18	0.17
Safety & Environmental	0.04	0.05	0.04	0.05	0.04
Managerial	0.06	0.11	0.08	0.11	0.06
Political	0.04	0.04	0.05	0.05	0.04

The positive separation and negative separation are calculated as shown in the following tables. The shorter the distance a partner has, the better situation a partner has relative to the other partners.

Separation from Ideal Solution (Case Study II).

	Separation from Ideal Solution		
	Partner A	Partner B	Partner C
Financial	0.0120	0.0000	0.0092
Technical	0.0000	0.0001	0.0000
Safety & Environmental	0.0001	0.0000	0.0001
Managerial	0.0027	0.0000	0.0007
Political	0.0000	0.0000	0.0000
Separation(S+)	**0.1216**	**0.0122**	**0.0997**

Separation from Negative Ideal Solution (Case Study II).

	Separation from Negative Ideal Solution		
	Partner A	Partner B	Partner C
Financial	0.0000	0.0120	0.0002
Technical	0.0001	0.0000	0.0000
Safety & Environmental	0.0000	0.0001	0.0000
Managerial	0.0000	0.0027	0.0007
Political	0.0000	0.0000	0.0000
Separation(S-)	0.01091	0.12154	0.03047

The final partner ranking is the total assessment pertain to positive and negative distance each partner has from the positive Ideal and Negative Ideal points, as shown:

Relative Separation and Partner Ranking (Case Study II).

	Relative Separation		
	Partner A	Partner B	Partner C
Separation(S+)	0.12161734	0.01220301	0.099695827
Separation(S-)	0.01091324	0.12154377	0.030468568
(S+) +(S-)	0.13253058	0.13374678	0.130164395
S-/(S+ + S-)	**0.0823451**	**0.90876037**	**0.234077593**
Rank of Partners	3	1	2

This result shows the private partner B the best private partner to deliver this project; however the authority (decisions makers) selected private partner A.

Case III:

The General Criteria Weights are customized. During the time of our assessment the political stability and the sufficient access to the European financial market, especially France, therefor the political and financial weights were assigned a value of 8% and 26% respectively, as shown:

General Criteria Weights (Case Study II).

General Criteria Weights				
Financials	**Technical**	**Safety & Environmental**	**Managerial**	**Political**
26.0%	35.0%	24.0%	7.0%	8.0%

Each partner was assessed by Experts on each of the five criteria as shown in the following tables. The Experts' assessment is regarding the partner ability to fulfill the best practice of the selection criteria.

Experts opinions for partner A (Case Study III).

Experts opinions for partner A											
	1	2	3	4	5	6	7	8	9	10	Average
Financials	3	3	4	3	4	3	5	3	3	2	3.30
Technical	3	4	4	3	3	4	5	3	2	2	3.30
Safety & Environmental	3	4	3	4	4	3	2	5	3	2	3.30
Managerial	2	3	4	2	4	3	2	3	2	4	2.90
Political	3	5	5	3	5	4	3	4	2	5	3.90

Experts pinions for partner B (Case Study III).

Experts opinions for partner B											
	1	2	3	4	5	6	7	8	9	10	Average
Financials	3	3	3	2	3	5	4	4	3	4	3.4
Technical	5	3	4	4	3	3	3	3	3	4	3.5
Safety & Environmental	3	3	4	5	2	3	2	5	3	3	3.3
Managerial	4	3	4	2	4	2	4	2	4	5	3.4
Political	4	3	4	5	2	3	2	3	2	5	3.3

Experts opinions for partner C (Case Study III).

Experts opinions for partner C											
	1	2	3	4	5	6	7	8	9	10	Average
Financials	1	3	3	4	4	3	4	4	3	4	3.3
Technical	3	4	3	4	2	5	3	4	2	3	3.3
Safety & Environmental	4	3	4	2	2	3	4	3	4	5	3.4
Managerial	4	4	3	2	4	3	4	4	3	5	3.6
Political	3	3	3	1	2	3	3	4	3	4	2.9

Similarly to the step explained in case study I, the decision matrix and standard decision matrix are generated as shown:

Decision Matrix (Case Study III).

	Decision Matrix			
	Partner A	Partner B	Partner C	Total
Financial	3.30	3.40	3.30	5.77
Technical	3.30	3.50	3.30	5.83
Safety & Environmental	3.30	3.30	3.40	5.77
Managerial	2.90	3.40	3.60	5.74
Political	3.90	3.30	2.90	5.87

Standard Decision Matrix (Case Study III).

	Standard Decision Matrix		
	Partner A	Partner B	Partner C
Financial	0.57	0.59	0.57
Technical	0.57	0.60	0.57
Safety & Environmental	0.57	0.57	0.59
Managerial	0.51	0.59	0.63
Political	0.66	0.56	0.49

The standard decision matrix should take into account the general weights value. Therefore we multiply the first matrix with the Standard decision Matrix to have the Weighted Standard decision Matrix as shown:

Weighted Standard Decision Matrix, with Ideals (Case Study III).

	Weighted Standard Decision matrix			Positive Ideal	Negative Ideal
	Partner A	Partner B	Partner C		
Financial	0.15	0.15	0.15	0.15	0.15
Technical	0.20	0.21	0.20	0.21	0.20
Safety & Environmental	0.14	0.14	0.14	0.14	0.14
Managerial	0.04	0.04	0.04	0.04	0.04
Political	0.05	0.04	0.04	0.05	0.04

The positive separation and negative separation are calculated as shown in the following tables. The shorter the distance a partner has, the better situation a partner has relative to the other partners.

Separation from Ideal Solution (Case Study III).

	Separation from Positive Ideal Solution		
	Partner A	Partner B	Partner C
Financial	0.0000	0.0000	0.0000
Technical	0.0000	0.0038	0.0024
Safety & Environmental	0.0000	0.0001	0.0001
Managerial	0.0000	0.0115	0.0110
Political	0.0091	0.0107	0.0119
Separation(S+)	0.0956	0.1617	0.1592

Separation from Negative Ideal Solution (Case Study III).

	Separation from Negative Ideal Solution		
	Partner A	Partner B	Partner C
Financial	0.0000	0.0000	0.0000
Technical	0.0000	0.0001	0.0000
Safety & Environmental	0.0000	0.0000	0.0000
Managerial	0.0000	0.0000	0.0001
Political	0.0002	0.0000	0.0000
Separation(S-)	**0.01362**	**0.01520**	**0.00950**

The final partner ranking is the total assessment pertain to positive and negative distance each partner has from the positive Ideal and Negative Ideal points, as shown:

Relative Separation and Partner Ranking (Case Study III).

	Relative Separation		
	Partner A	Partner B	Partner C
Separation(S+)	0.0956	0.1616783	0.1592312
Separation(S-)	0.01362	0.01520	0.00950
(S+) +(S-)	0.10921	0.17688	0.16873
S-/(S+ + S-)	0.1246983	0.0859516	0.0562845
Rank of Partners	1	2	3

This result shows the private partner A the best private partner to deliver this project, and the authority (decisions makers) selected private partner A.

Case VI:

The General Criteria Weights are customized for case study IV as shown:

General Criteria Weights (Case Study IV).

General Criteria Weights				
Financials	**Technical**	**Safety & Environmental**	**Managerial**	**Political**
50.0%	20.0%	7.5%	15.0%	7.5%

Each partner was assessed by Experts on each of the five criteria as shown in the following tables. The Experts' assessment is regarding the partner ability to fulfill the best practice of the selection criteria.

Experts opinions for partner A (Case Study IV).

Experts opinions for partner A											
	1	2	3	4	5	6	7	8	9	10	Average
Financials	4	2	4	3	4	3	5	3	3	4	3.50
Technical	3	4	4	1	3	4	5	3	2	1	3.00
Safety & Environmental	3	4	3	4	2	3	4	5	2	1	3.10
Managerial	2	3	4	2	4	5	2	3	2	4	3.10
Political	3	2	4	3	4	2	3	4	2	5	3.20

Experts opinions for partner B (Case Study IV).

Experts opinions for partner B											
	1	2	3	4	5	6	7	8	9	10	Average
Financials	3	2	3	2	3	2	4	4	3	4	3
Technical	2	1	2	4	1	3	3	1	3	1	2.1
Safety & Environmental	3	2	4	5	2	1	2	3	3	3	2.8
Managerial	4	3	4	5	4	2	4	2	4	5	3.7
Political	2	3	4	5	2	3	2	3	2	1	2.7

Experts opinions for partner C (Case Study IV).

Experts opinions for partner C											
	1	2	3	4	5	6	7	8	9	10	Average
Financials	4	3	5	4	4	3	4	5	3	4	3.9
Technical	3	4	5	2	4	5	3	4	5	3	3.8
Safety & Environmental	4	3	5	5	2	3	4	3	4	5	3.8
Managerial	4	5	3	4	4	5	4	4	3	5	4.1
Political	5	5	3	4	2	3	3	4	5	4	3.8

Experts opinions for partner D (Case Study IV).

Experts opinions for partner D											
	1	2	3	4	5	6	7	8	9	10	Average
Financials	3	4	5	3	5	4	3	3	2	5	3.7
Technical	4	3	4	5	3	4	3	4	4	3	3.7
Safety & Environmental	2	3	4	2	1	5	3	2	4	5	3.1
Managerial	3	4	5	3	2	4	3	4	3	2	3.3
Political	3	4	4	3	2	3	4	4	3	2	3.2

Experts opinions for partner E (Case Study IV).

Experts opinions for partner E											
	1	2	3	4	5	6	7	8	9	10	Average
Financials	2	3	2	1	2	1	3	4	3	2	2.3
Technical	3	4	3	3	3	3	3	2	3	3	3
Safety & Environmental	3	4	2	3	1	3	3	4	4	2	2.9
Managerial	2	3	4	2	2	2	1	4	2	3	2.5
Political	1	2	1	3	2	4	2	1	2	3	2.1

Similarly to the step explained in case study I, the decision matrix and standard decision matrix are generated as shown:

Decision Matrix (Case Study IV).

	Decision Matrix						
	Partner A	Partner B	Partner C	Partner D	Partner E	Partner F	Total
Financial	3.50	3.00	3.90	3.70	2.3	2.9	7.99
Technical	3.00	2.10	3.80	3.70	3	3.4	7.88
Safety & Environmental	3.10	2.80	3.80	3.10	2.9	2.9	7.63
Managerial	3.10	3.70	4.10	3.30	2.5	2.9	8.10
Political	3.20	2.70	3.80	3.20	2.1	2.6	7.30

Standard Decision Matrix (Case Study IV).

	Standard Decision Matrix					
	Partner A	Partner B	Partner C	Partner D	Partner E	Partner F
Financial	0.44	0.38	0.49	0.46	0.29	0.36
Technical	0.38	0.27	0.48	0.47	0.38	0.43
Safety & Environmental	0.41	0.37	0.50	0.41	0.38	0.38
Managerial	0.38	0.46	0.51	0.41	0.31	0.36
Political	0.44	0.37	0.52	0.44	0.29	0.36

The standard decision matrix should take into account the general weights value. Therefore we multiply the first matrix with the Standard decision Matrix to have the Weighted Standard decision Matrix as shown:

Weighted Standard Decision Matrix, with Ideals (Case Study IV).

	Weighted Standard Decision Matrix						+VE Ideal	-VE Ideal
	Partner A	Partner B	Partner C	Partner D	Partner E	Partner F		
Financial	0.22	0.19	0.24	0.23	0.14	0.18	0.24	0.14
Technical	0.08	0.05	0.10	0.09	0.08	0.09	0.10	0.05
Safety & Environmental	0.03	0.03	0.04	0.03	0.03	0.03	0.04	0.03
Managerial	0.06	0.07	0.08	0.06	0.05	0.05	0.08	0.05
Political	0.03	0.03	0.04	0.03	0.02	0.03	0.04	0.02

The positive separation and negative separation are calculated as shown in the following tables. The shorter the distance a partner has, the better situation a partner has relative to the other partners.

Separation from Ideal Solution (Case Study IV).

	Separation from Positive Ideal Solution					
	Partner A	Partner B	Partner C	Partner D	Partner E	Partner F
Financial	0.0006	0.0032	0.0000	0.0002	0.0100	0.0039
Technical	0.0004	0.0019	0.0000	0.0000	0.0004	0.0001
Safety & Environmental	0.0000	0.0001	0.0000	0.0000	0.0001	0.0001
Managerial	0.0003	0.0001	0.0000	0.0002	0.0009	0.0005
Political	0.0000	0.0001	0.0000	0.0000	0.0003	0.0002
Separation(S+)	**0.0383**	**0.0729**	**0.0000**	**0.0216**	**0.1081**	**0.0689**

Separation from Negative Ideal Solution (Case Study IV).

	Separation from Negative Ideal Solution					
	Partner A	Partner B	Partner C	Partner D	Partner E	Partner F
Financial	0.0056	0.0019	0.0100	0.0077	0.0000	0.0014
Technical	0.0005	0.0000	0.0019	0.0016	0.0005	0.0011
Safety & Environmental	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
Managerial	0.0001	0.0005	0.0009	0.0002	0.0000	0.0001
Political	0.0001	0.0000	0.0003	0.0001	0.0000	0.0000
Separation(S-)	**0.08012**	**0.04950**	**0.11473**	**0.09838**	**0.02286**	**0.05080**

The final partner ranking is the total assessment pertain to positive and negative distance each partner has from the positive Ideal and Negative Ideal points, as shown:

Relative Separation and Partner Ranking (Case Study IV).

	Relative Separation					
	Partner A	Partner B	Partner C	Partner D	Partner E	Partner F
Separation(S+)	0.0383	0.07288	0	0.02162	0.10815	0.06886
Separation(S-)	0.08012	0.04950	0.11473	0.09838	0.02286	0.05080
(S+) +(S-)	0.11842	0.12238	0.11473	0.12000	0.13101	0.11966
S-/(S+ + S-)	0.6766	0.40446	1	0.81981	0.17451	0.42452
Rank of Partners	3	5	1	2	6	4

This result shows the private partner C the best private partner to deliver this project, and the authority (decisions makers) selected private partner C.

Appendix I: Bankability Questionnaire

Department of Building, Civil & Environmental Engineering

Private Partner's Borrowing Eligibility Assessment for PPP Projects

Dear Sir/Madam

In the beginning, I would like to thank you for your valuable participation in this questionnaire survey and sharing your knowledge and expertise. The purpose of this questionnaire is to assess private partner's eligibility to borrow required funds for Public-Private Partnership projects. This questionnaire is a part of my on-going PhD research under supervision of Prof. Osama Moselhi and Prof. Tarek Zayed at the Department of Building, Civil and Environmental Engineering, Concordia University.

The information gathered in this questionnaire will be strictly confidential and will only be used for academic research purposes.

Basic information:

Name of Organization: ....

What is your role in this organization: ....

How many years you are in this role? ....

Country of the project: ....

<u>**Please choose the industry in which you do business: (you can choose more than one):**</u>

- ☐ Food & Health
- ☐ IT & Telecommunication
- ☐ Banking & Finance
- ☐ Machinery & Industrial
- ☐ Material(Chemical & building materials)
- ☐ Utilities & Infrastructure
- ☐ Energy & Oil
- ☐ Real Estate

Risks Factors

- Please read the explanation of risk factors which have been used in this research in the survey guideline and rank them from the most important one assigned number (6) to the least one number (1)

Market Risk	Environmental Risk	Legal & Political Risk	Technical & Operational Risk	Completion Risk	Counterparty Risk

Financial Risk

- Indicate your preferences regarding the method of fund raising for the projects: (Number 5 represents the highest weights of preference)

☐ Equity or owners financing

5	4	3	2	1

☐ Banks Loans

5	4	3	2	1

☐ Making a Joint Venture

5	4	3	2	1

☐ Government Grants or Support

5	4	3	2	1

☐ Issuing debt

5	4	3	2	1

☐ Other Method

Legal & Political Risks

The political & legal profile of each project is mainly affected by the sovereign credit analysis which is available mostly by rating agencies like Standard & Poor. However this can be adjusted by the lenders to fit to the specific project. The following are the positive sign which leads to lower Legal & Political risk levels. Based on your country of operation, please choose the level that you agree with for each parameter. (5 is completely agree)

- **<u>Effectiveness, Stability, and predictability of policy making and institutions:</u>**

Successful management of past political, economic and financial crises	5	4	3	2	1
Ability and willingness to implement reform to address fiscal challenges	5	4	3	2	1
Absence of changes to the political institutions	5	4	3	2	1
Absence of corruptions	5	4	3	2	1
Unbiased law enforcement and respect for rule of law and property rights	5	4	3	2	1
Independent/unfettered media and source of economic data	5	4	3	2	1
Size of Public sector relative to private sector: a smaller public sector is more likely to be able to enact necessary change because it should be less beholden to special interest groups, including public employee unions.	5	4	3	2	1

Completion Risk

The downside risk of the project can be increase by underestimating of the time required for completion of the project. Therefore lengthening the project beyond its forecasted one can be harbinger of a risk.

- **<u>What is the average life of your projects?</u>**

☐ less than 5 years ☐ 5-10 years ☐ 10 -15years ☐ more than 15 years

Counterparty Risk

The lenders are concern about the default of the borrowers. A situation when the borrower cannot pay interest or principal payment of his or her loan. Here is the evaluation of the tools to tackle this risk:

- **<u>Do you have any in-house credit rating system?</u>**

☐ Yes ☐ No, we third party or lenders evaluations

- **<u>Have you ever defaulted or extend the payment time on one of your loan obligations?</u>**

☐ Yes ☐ No

If yes, what was the consequence of that according to the concession agreement?

- **Do you use any of the following tools to hedge against project default risk?**

☐ Buy insurance from the bank or other financial institutions
☐ Make a guarantee contract with the government
☐ Buy financial derivatives like Options, Future, SWAPS, ...

- **What kinds of covenants you have in your Concession Agreements?** (The higher value represents, more covenant on the company which reduce the counterparty risk. The highest value is (7) and the lowest is (0)

☐ On Free Cash Flows
☐ On Dividends Pay-out Policies
☐ On the Reinvestment Policies
☐ On Capital structure of the company

☐ Changes of Control Puts
☐ Limitations on liens & additional indebtedness
☐ Restricted versus unrestricted subsidiaries
☐ Others , Please name:

Please name:

Operational & Technological Risk

Lenders monitor carefully the level of free cash flow available for servicing the lent debt. The main factor which defines the CFADS is the net income, which is the result of collected revenue and expended cost. Operational Risk asses the volatility of these two items:

- **What is the source of traffic estimation for the projects?**

☐ In-house Analyses
☐ Governmental Forecasts
☐ Lenders Forecasts
☐ Third Party Forecasts

- **How the operational contract define the revenue?**

For Example, Is it fixed, or floating based on the traffic volume, please explain

- **How you collect the revenue from the projects after completion?**

☐ Collects by the Operating company ☐ Collects by the Government and then redistribute ☐ Collect by a third party as an outsourced operating company ☐ Others:

Please Explain:

Capital expenditure is of the most important costs during the operation period of infrastructure projects. There should be a clear definition of these costs in the contracts. The responsibility of funding required capital for reinvesting for the capital expenditure is important.

- **What is your preferred budgetary system when you assessing projects' cash flow?** (5 represents the highest weight of preference)

☐ The lump sum year-end budgetary system ☐ Rolling Over budgetary-system ☐ Combination of the both

5	4	3	2	1

5	4	3	2	1

5	4	3	2	1

- **Is there any monitoring mechanism during the life of project?**

☐ Yes ☐ NO

If yes please choose the method of implementation:

☐ Government`s Monitoring ☐ Lender`s Monitoring ☐ Self-reporting ☐ Other Method