A CASE-BASED STUDY ON PUBLIC-PRIVATE-PARTNERSHIP PROJECTS IN THE URBAN WATER SUPPLY SECTOR

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CERTIFICATE OF ORIGINALITY

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it reproduces no material previously published or written, nor material that has been accepted for the award of any other degree or diploma, except where due acknowledgement has been made in the text.

_____(Signed)

(SHENG Nan)

To my parents

ABSTRACT

This thesis points out that public-private partnership (PPP) is an effective procurement method for delivering public infrastructure, and the China government has the motivations to apply it to urban water supply projects to relieve government financial burden on constructing new and rehabilitating existing water supply infrastructure. However, it is noticed that in a partnership, the public sector and the private sector may have different expectations of the project. Therefore, more disputes are associated with PPP projects. To achieve a win-win result, the government has to consider how a regulatory regime will shape and constrain the private sector to provide more reliable service in the meantime promote credibility for attracting private capitals.

Through a comprehensive literature review related to PPP and a deep investigation into the operation of water supply sector in China, the benefits of PPP and the problems faced by water supply companies are identified. The findings indicate that PPP is a favorable choice to rescue water supply companies form the dilemma. Therefore, the objective of this study is to explore how to secure the success of PPP in water supply projects for the economy as a whole. Factors that may influence decision-making in both public and private sectors have been studied. An evaluation scheme is established to reveal the differences and agreements between two sectors on considering these factors. How the interest of different stakeholders can be balanced in the partnership is discussed and concrete and workable policy recommendations are proposed to the public and private sectors.

An integrated checklist of decision-making factors (DMFs) is generated by combining segment studies related to driving and impeding factors of PPP, objectives of different stakeholders, and risk and success factors of promoting PPP. These factors are obtained by means of literature review, content analysis, survey, case study, and interview. Then Delphi survey is conducted to solicit experts' views on these factors. Cronbach's alpha and Kendall's concordance analysis are performed to examine the reliability and validity of data set. Then it followed by Mann Whitney U test to generate the degree of differences between public and private sectors on evaluating the importance of each DMF. These results are employed as parameters to build the Importance-Difference Evaluation Model (IDEM). In the model, K-means algorithm is used to identify the importance boundary. With this model, all the DMFs are divided into four categories: critical DMFs, fundamental DMFs, systematic DMFs, and controversial DMFs. In accordance with the above seven steps, the DMF evaluation scheme is established.

Subsequently, this scheme is applied to a real water supply PPP project as a case-based study. It is verified that this scheme is feasible and reliable. With it, decision-makers can effectively find out the critical factors and take different approaches to deal with different categories of factors. This project gives evidences that PPP is an effective model to provide better service. The private sector has brought in desired investment and advanced management skills, and has also improved operational efficiency and service quality. Nevertheless, issues arising in the implementation of government policies will affect project profitability, and lead to disputes between the public and private sectors. To solve these disputes, a clear demonstration of influences on project profitability due to different policy choices is needed.

Considering all the requirements, a policy recommendation approach is explored to provide inclusive, objective, reliable and practical solutions for both public and private sectors to effectively resolve those disputes. Policies including the adjustment of water selling price, control of groundwater exploration, reliability of water distribution network, and payment of government subsidy are all defined as adjustable parameters and input into a profit calculator developed in this study. By adjusting these parameters, the calculator will produce different net present values (NPVs). Unfeasible policy choices and unacceptable NPVs will be filtered out. Finally, the matrix of feasible policy choices and correspond NPVs will be provided to both public and private sectors to assist their decision-makings.

In summary, the following original contributions of this thesis are achieved:

- Integrate segment studies on DMFs and identify new DMFs related to applying PPP in the water supply projects.
- Establish a seven-step DMF evaluation scheme and validate it through a real project as an effective decision-making platform for identifying critical DMFs and categorizing DMFs.
- Derive feasible policy recommendations to both public and private sectors for sustaining healthy cooperation in the partnership.

Keywords: Public-private-partnership (PPP), water supply, decision making, project evaluation, project profitability, policy choices

PUBLICATIONS

Journal Articles

Sheng N., Law M.C. and Chua H. (2011). Private Sector Participation towards Improving Performance of Small-Scale Water Supply Projects in China. *International Journal of Arts and Sciences*, Vol. 4, No. 15.

Sheng N., Jia Y. W., Xu Z., Ho S.L., and **Kan C.W.** (2013). A Complex Network Based Model for Detecting Isolated Communities in Water Distribution Networks. *Chaos* 23, 043102 (2013); http://dx.doi.org/10.1063/1.4823803

Conference Papers

Sheng N. and Chua H. (2011). Case study: analysis of public-private partnerships for a small-scale water supply project in China. Proceedings of Small Sustainable Solutions for Water (SSS 4 WATER), Venice, Italy, 18-22 April.

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LIST OF ABBREVIATION

ABM	Agent-Based Model
AHP	Analytic Hierarchy Process
AUR	Active User Ratio
BOOT	Build-Own-Operate-Transfer
BOT	Build-Operate-Transfer
CDMFs	Critical Decision-Making Factors
CSC	China State Council
CSFs	Critical Success Factors
DCF	Discounted Cash Flow
DMFs	Decision-Making Factors
GM	Gray prediction modelling
GWC	Gross Water Consumption
IDEM	Importance-Difference Evaluation Model
IRR	Internal Rate of Return
MFTEC	Ministry of Foreign Trade and Economic Cooperation
MOC	Ministry of Construction
MS	Mean Score
NBS	National Bureau of Statistics
NDRC	National Development and Reform Commission
NETC	National Economic and Trade Commission
NPV	Net Present Value
PFI	Private-Finance-Initiative
PPP	Public-Private-Partnership
PSP	Private Sector Participation
PVs	Present Values
RBS	Risk Breakdown Structure

ROI	Return on Investment
SDPC	State Development and Planning Commission
SPSS	Statistical Package for Social Sciences
TOT	Transfer-Operate-Transfer
UFW	Unaccounted-for Water
UK	United Kingdom
WASH	Water and Sanitation for Health
WBS	Work Breakdown Structure
WSCL	Water Supply Company Limited

CHAPTER 1 INTRODUCTION

1.1 Research Background

There has been an on-going increasing demand for building new water supply infrastructure and renovating existing water supply infrastructure in China. However, due to the insufficiency of government funds, this demand is difficult to be thoroughly fulfilled. Public-Private-Partnership (PPP), as an acquisition method, is a supplementary to compensate for the insufficiency. It has been adopted globally for delivering public infrastructure projects (Regan et al. 2009), and appearing more and more attractive in China.

Nevertheless, PPP thus far has limited applications in the urban water supply sector in China. Two major factors impede its implementation. First, differing from other public services such as transportation, electricity, gas and telecommunication, water supply is irreplaceable. When public sector determines to adopt PPPs in urban water supply projects, extreme attention should be attached to the security and reliability aspects. Second, the number of capable private investors is rather scanty. The gaps between the demand from the public sector and the availability of the private investors make applying PPPs to the urban water supply sector more complex and challenging.

To succeed in a PPP project, decision makers are required to obtain clear understandings of expectations among different stakeholders on the project (Cherns and Bryant 1984). By doing so, they can avoid or at least reduce risks, and achieve multiple goals, such as public satisfaction, investment return, quality, and safety in the implementation process (Shen et al. 2006).

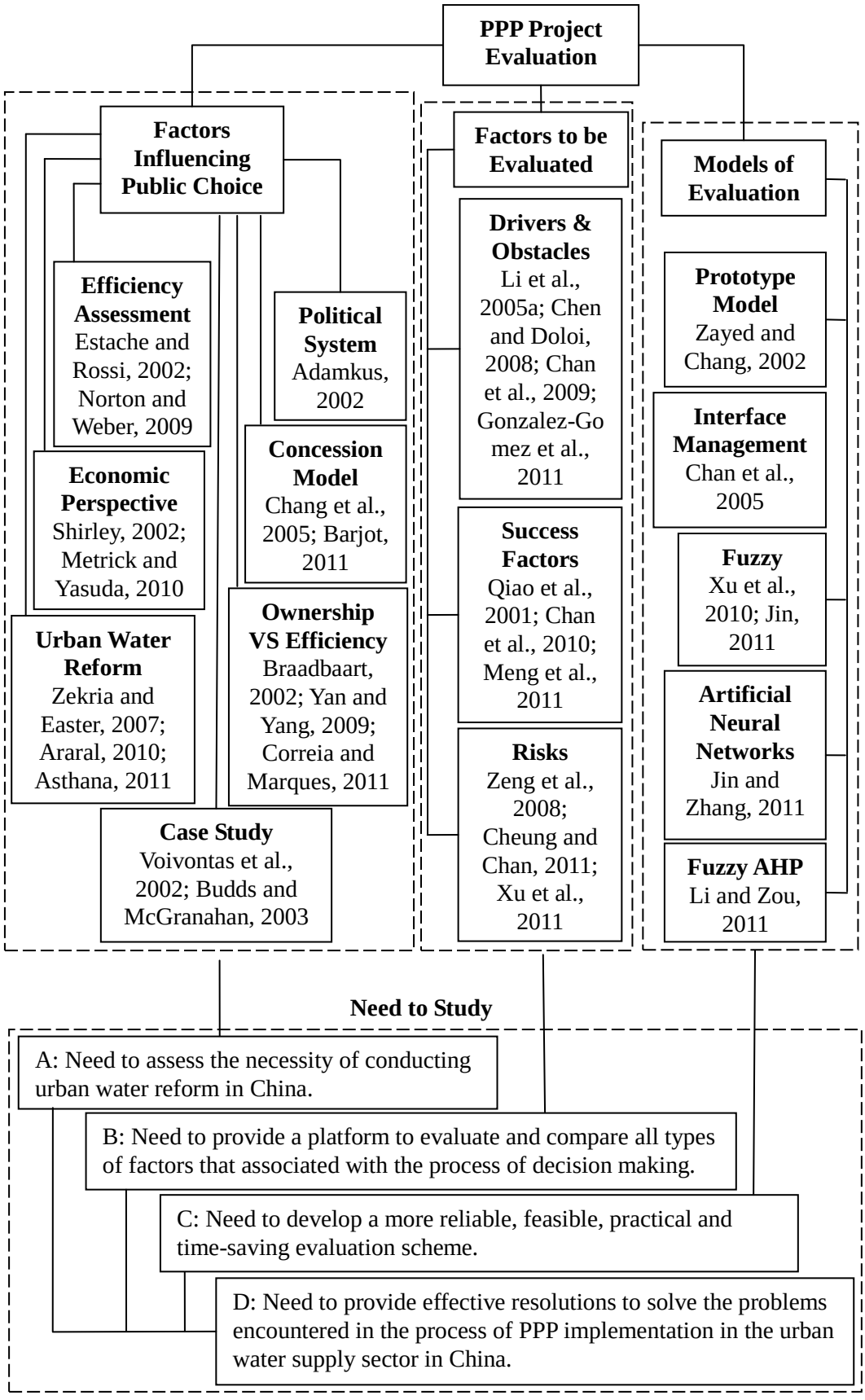

Figure 1.1 Literature map

Prior research substantially reports findings on risk identification and allocation (Jin 2011; Jin and Doloi 2008, 2009; Yuan et al. 2008), as well as project evaluation (Dias and Ioannou 1996; Xu et al. 2010; Yeung et al. 2009; Zayed and Chang 2002; Zhang 2005). Many Decision-Making Factors (DMFs) with respect to general infrastructure PPP projects are generated from these researches; however, very few research efforts are placed on the DMFs regarding PPP projects in the urban water supply sector in China, albeit Cheung and Chan (2011) pointed out that the project evaluation methods should be different for water, power, and transportation sectors.

In addition, no matter what evaluation techniques, i.e., Desirability Model (Dias and Ioannou 1996), Prototype Model (Zayed and Chang 2002), Interface Management (Chan et al. 2005), Delphi Survey (Xu et al. 2010; Yeung et al. 2009), Neuro-Fuzzy Techniques (Jin 2011), and Fuzzy Analytic Hierarchy Process (AHP) (Li and Zou 2011), are adopted in the previous studies, they have one feature in common, that is they all employed expert opinions as the bases of assessment. However, except for Jin (2011) who perceived that experts with different backgrounds should be associated with particular weightings, none of them noticed that experts representing different stakeholders may have divergent opinions: public clients usually aim to improve the effectiveness, efficiency, and economics of PPPs (Grimsey and Mervyn 2002), whereas private investors consider profits as their essential objective (Zhang 2006). Neglecting these differences may cover up the bifurcation points and mislead the analysis results, which will lead to ineffective communication, and consequently damp the success of PPP projects from the perspective of long term.

This study focuses on PPP projects in the urban water supply sector in China, aiming at answering the fundamental question that whether experts from different interest groups possess different opinions on PPP project assessment; if so, what differences are critical ones. To this end, a set of DMFs associated with PPP projects in the urban

water supply sector are ascertained in a systematic review process, followed by Delphi survey to evaluate the relative importance of each DMF. An expert panel consisting of experts from both public and private sectors is set up. Through statistical analysis and comparison of expert opinions from two separate sectors and the overall evaluation, a novel evaluation scheme is proposed to identify the critical decision-making factors. It is expected that with the aid of this model, practitioners can better understand the planning and implementation processes of PPP projects and facilitate the public and private sectors to achieve win-win outcomes in the urban water supply sector in China.

1.2 Scope of Research

In worldwide, researchers and practitioners made a lot of efforts to determine whether private ownership is better than public ownership in providing urban water supply services, aiming to seek more effective approaches to provide urban water supply service. Since no final verdict could be reached, the ownership and/or management rights repeatedly shifted between the private sector and the public sector over the past two centuries, which has also brought along various mixed cooperation forms. This has been witnessed in many Europe countries (Bakker, 2003).

Typically, there are mainly three types of privatization models: British Model, Canada Model and French Model. The British Model is a representative example of full privatization in urban water supply industry. The privatization is made in the divestiture of assets to the private sectors from the public sector in the process of transition. In England, water supply companies were owned and operated by private sectors when they newly established in London, but later the ownership of water supply companies were converted to the state (first municipal and then national) in

the twentieth century. However, after a period of years, ownership of English water supply utilities was transferred back to the private sectors again by asset sale in 1989. In Canada, private sectors manage the water supply infrastructure on behalf of municipal owners through contractual arrangements. In France and Spain, it is typical for the private sectors to manage the municipal water supply infrastructure via long-term management contracts commonly referred to as "concessions", which is the most prevalent form of PPPs in urban water supply sector, especially in developing countries.

China is a developing country therefore this research focuses on privatization in the form of PPP in urban water supply sector. PPP is no more a new approach to solve intricate problems associated with public ownership in water supply services. In this research, the term "public" refers to companies that are owned and operated by government, while the term "private" refers to corporation controlled by domestic or foreign investors, for-profit companies. Through a transfer on ownership or management responsibility of the urban water supply infrastructure, the private sector could get the control from the public sector. The specific models of PPP not limited in Build–Operate–Transfer (BOT) and its variants, Cooperative Joint Venture, Equity Joint Venture, Non-official Wholly Foreign Ownership, and Official Wholly Foreign Ownership.

In China, PPP has been barely exercised successfully in the urban water supply sector, due to the intricate political, economic and socio-cultural environments (Zhong *et al.*, 2008). Researchers from multiple disciplines have provided theoretical arguments and empirical evidences in favor of PPP. In Figure 1.2, literatures are categorized into seven areas. Among them, water resources (Lobina, 2005; Tortajada, 2006; Zekria and Easter, 2007; Marques, 2008; Jimenez and Perez-Foguet, 2009; Araral, 2010; Correia and Marques, 2011) and engineering (Shen *et al.*, 1996;

Feuillette *et al*., 2003; Yamout and Jamali, 2007; Bel and Warner, 2008; Gonzalez-Gomez *et al*., 2011; Xu *et al*., 2010; Gialis *et al*., 2011) are the most heat areas, together accounting for approximately a half of the literatures. Besides, researches are also interested in areas include business & economics (Feigenbaum and Teeples, 1983; Bhattacharyya *et al*., 1994; Estache and Rossi, 2002; Guasch and Straub, 2006; Wilder and Lankao, 2006; Diakite *et al*., 2009; Metrick and Yasuda, 2010; Asthana, 2011; Picazo-Tadeo *et al*., 2012), public administration (Edwards, 2002; Kirkpatrick *et al*., 2006; Warner and Bel, 2008; Bel *et al*., 2010; Gonzalez-Gomez *et al*., 2011), government & law (Butler, 1985; Brown, 2000; Abers and Keck, 2009; Craig, 2010; Masten, 2011) and urban studies (Solo, 1999; Loftus and McDonald, 2001; Budds and McGranahan, 2003; Martinez-Espineira *et al*., 2009; Cheung and Chan, 2011).

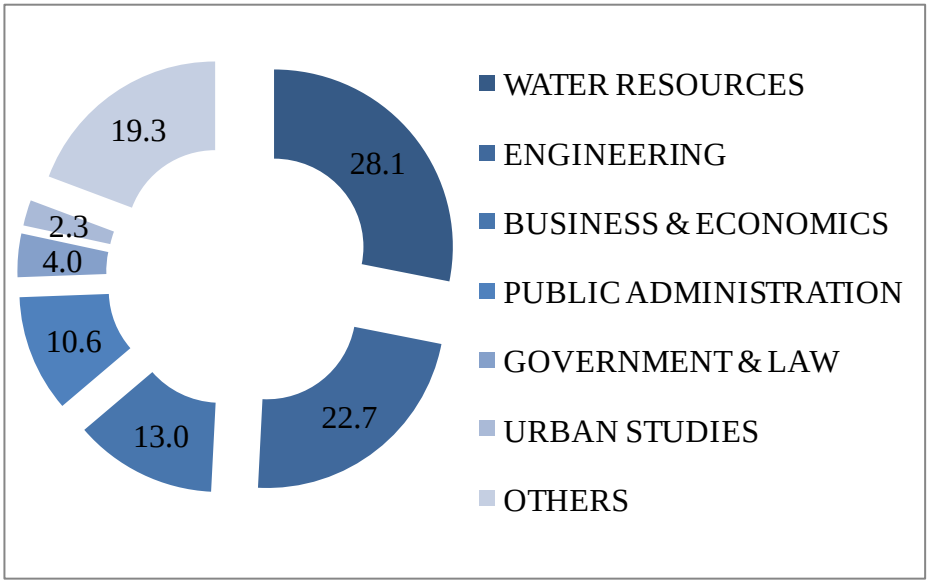

Figure 1.2 Category of research fields

Regardless of tremendous studies on PPP in China, there are four major research gaps could be summarized. First, although previous researches mentioned that the urban water supply sector in China has encountered a lot of problems, no statistical

analysis have been done to identify what problems are the ones most likely to happen, what problems receive the most concerns from the owners of the water supply companies, and what problems the owners expect to solve through PPP. Second, the experiences and lessons learned from empirical studies are drawn from document analysis on countable well-known projects; few, if any, researcher has participated in a project to discover and resolve problems occur in different phases of the project. Third, some researchers dedicated to promote PPP implementation by finding out the impetus and impediments; whereas one important part that they always ignore is that clarifying the bifurcated objectives of public sector and private sector respectively may be more direct and effective in facilitating the negotiation in PPP implementation. Fourth, traditionally, partners of a PPP water supply project are used to determine whether the project is worthy of investment through project evaluation (Antonio and Photios, 1996; Wang *et al*., 1998) and risk assessment (Zayed and Chang, 2002; Zeng *et al*., 2008), which do not have insights into the dynamic decision-making process, thus lacking flexibility. While urban water supply project is a complicated and long-time engaged project, which requires both partners to take full account of possible risks and be able to effectively deal with these risks. However, no model gives a clear prediction about the interest could be guaranteed under different policy scenarios. Therefore, renegotiations timely take place due to invalidation of contracts previously agreed by both parties.

This study aims to conduct a thorough literature review of problems and PPP applications in the urban water supply sector of China on journal publications, news reports, government reports, and documentations. Then a questionnaire survey will be performed in a typical province of China. All the urban water supply companies in this province will be involved to investigate the actual problems appeared in this industry and the attitude of urban water supply companies toward PPP. Following, by field investigation, case studies representing different situations will be selected

to explore the problems associated with the process of PPP implementation. Further, the author will participate in a county-level PPP project in the implementation phase. Through participation observation, the author will get first-hand information about the causation of problems and make some trials to solve those problems. After that, the author will compare key performance parameters to evaluate the outcomes of PPP. Thereby experiences and lessons are summarized to provide guidelines to PPP implementation. Regarding that one of the most important obstacles is the ineffective communication due to the misunderstanding of bifurcated objectives from public sector and private sector, experts from both public and private sectors will be selected respectively through a stringent process to judge DMFs according to their importance in the Delphi survey. With statistical analysis, the DMF ranking orders for each sector will be established. As a shift of management responsibility from public sectors to private sectors is entailed in the process of PPP, it lead to the reworking of decision-making mechanisms and management mechanisms. In decision-making mechanisms, the public policy allocation based on water rights would be substituted by marketable permits, while in the management mechanisms, laws would be replaced by contracts as regulatory mechanisms, and competition would be regarded as an incentive mechanism. Tradable permits in water rights should also be managed as markets becoming allocation mechanisms. This study will employ the behavior rules concluded from the case studies and Delphi survey and use actual performance data from the participation study to set up an agent-based model (ABM) to simulate the interests could be guaranteed under different policy scenarios. By doing so, various water management responsibilities between the public and private sectors could be allocated reasonably, thereby facilitate the effective communication between public and private sectors.

1.3 Research Objectives

The general objective of this study is to examine whether involving PPP in the urban water supply services could fulfill the expectations of both public and private sectors; if yes, find a way to facilitate the success of PPP implementation in the urban water supply sector of China. To conduct the research systematically, the general objective is split up into specified objectives:

1) Conduct extensive literature review to identify the pros and cons of public ownership and private ownership, find out the impetus and impediments of PPP implementation, review the history of the urban water supply sector in China and draw lessons from empirical studies.
2) Explore the problems encountered by the urban water supply sector in China; investigate the public sectors' willingness to transfer the management responsibility to private sector; and analysis the need of PPP involvement by performing a survey in the urban water supply industry.
3) Through field studies, discover the obstacles of PPP implementation, thereby set reasonable objectives to be achieved by involving PPP into the urban water supply sector in China.
4) Evaluate the outcomes of PPP involvement in the urban water supply sector of China with a participated study by comparing the key performance indicators before and after PPP implementation.
5) Identify the key decision-making factors concerned by public sector and private sector respectively, and disclose the bifurcated expectations between both sectors.
6) Set up a policy simulation model to give clear prediction on the future operational portrait of the project under different policy choices, and give feasible recommendations on how to facilitate the success of PPP implementation in the urban water supply sector of China.

1.4 Potential Contributions

Differing from other public services such as transportation, electricity, gas, and telecommunication, water supply is irreplaceable because of its natural monopoly characteristic. For example, if imbalance of water supply or water allocation happens due to ineffective management under public ownership or the failure of market mechanism, no immediate remedies would be made to solve the problem. Concerning the security and reliability of urban water supply service, it should be discreet to make a decision on how to transfer the management responsibility from the public sector to the private sector. Therefore, this research has practical and far-reaching significances.

1.4.1 Theoretical Contributions

With participated field studies, this research discovers the differences between applying PPP in the urban water supply sector in China and applying it in other countries. Further, this research also aims to provide an operation choice decision-making theory on natural monopoly public goods services based on economics and public management theory. It is expected to set up a reasonable and conductive regulation system of the urban water supply industry to guide its reform in China. This system could also be taken as a reference for the other countries in transition economy.

1.4.2 Practical Contributions

PPP have been carrying out long-term practices in England, the United States, France and other developed countries. However their applications in the urban water supply

sector in China are still in embryo that only countable successful cases of PPP could be found. This research will make practical contributions in four aspects. Firstly, this research has conducted a survey to explore the problems in the urban water supply companies. It has provided statistic evidence which has not been reported by other studies. Secondly, there are only a few successful PPP projects in China, and most of them are municipal projects. This research provides success experiences of implementing county level PPP projects. Compared with municipal projects, these projects have less capital requirement; therefore it is more practical to practise PPP in these projects. This case provides sound evidence for performance evaluation and is a good benchmark for PPP application. Thirdly, this study reveals critical factors that will influence decision-making from the views of the public sector and the private sector respectively, which is worthwhile in promoting the understanding between partners and thus lead to efficient communications. Fourthly, the policy recommendations proposed in this study are practical for the entire water supply sector, and can be used to facilitate the completion of regulatory system toward PPP.

1.5 Thesis Structure

This thesis contains seven chapters. Figure 1.3 shows the flow of this research. Chapter one upholds the necessity to reform the urban water supply sector in China. Two-side attitudes toward PPP are reviewed, and gaps of previous research are addressed. Chapter two introduces the methodology and strategies of this study.

Chapter three aims to find out the factors to be considered in the decision-making process during the whole life-circle of PPP implementation. In this chapter, driving factors, impeding factors, success factors, and risk are all reviewed. Experiences and lessons of worldwide PPP applications as well as the history of the urban water

supply sector reform in China are summarised. Through extensive literature review, the research assumptions are made and the research questions to be examined are ascertained. In addition, this chapter also reports a survey conducted in the urban water supply sector to explore the problems encountered by the urban water supply companies, and to investigate their willingness to adopt PPP to solve those problems.

Chapter four illustrates a novel seven-step evaluation approach proposed by this research to evaluate factors that may influence decision-making. This approach remedies the insufficiency of existing model in that it is a two dimension model which can consider two parameters at the same time. One parameter is the overall importance of a factor evaluated by all experts. This parameter is commonly used in various evaluation models. The other parameter is the degree of agreement/difference on evaluating a particular factor. This parameter is proposed by this research. This chapter introduces the rationale and criteria for conducting each step of this approach in details.

Chapter five presents a real case study of PPP project. Firstly, the necessity of involving PPP is justified. Then the performances before and after PPP are compared. Following that, to validate the novel evaluation approach proposed in the previous sector, it has been applied to this case to solve disputes. Disputes reflect divergent views between partners. Through this approach, it is expected to find out these different considerations in their decision-making process. Finally, suggestions are given on how to build a cultivate environment for PPP.

Chapter six provides feasible policy choices for the partners of PPP projects. The behaviour rules of agents are obtained from the experience in the previous chapter. All the parameters will be input into a Net Present Value (NPV) calculator developed in this study. Adjusting these parameters will produce different output of NPVs. Each

NPV reflects a policy choice. Comparing all the policy choices and filtering out ones which cannot meet the investors' expectation or ones which cannot be implemented in reality will reach to workable and acceptable policy choices for both partners.

Chapter seven concludes the findings of this research and summarizes the limitations of this study. Suggestions are made on the future research.

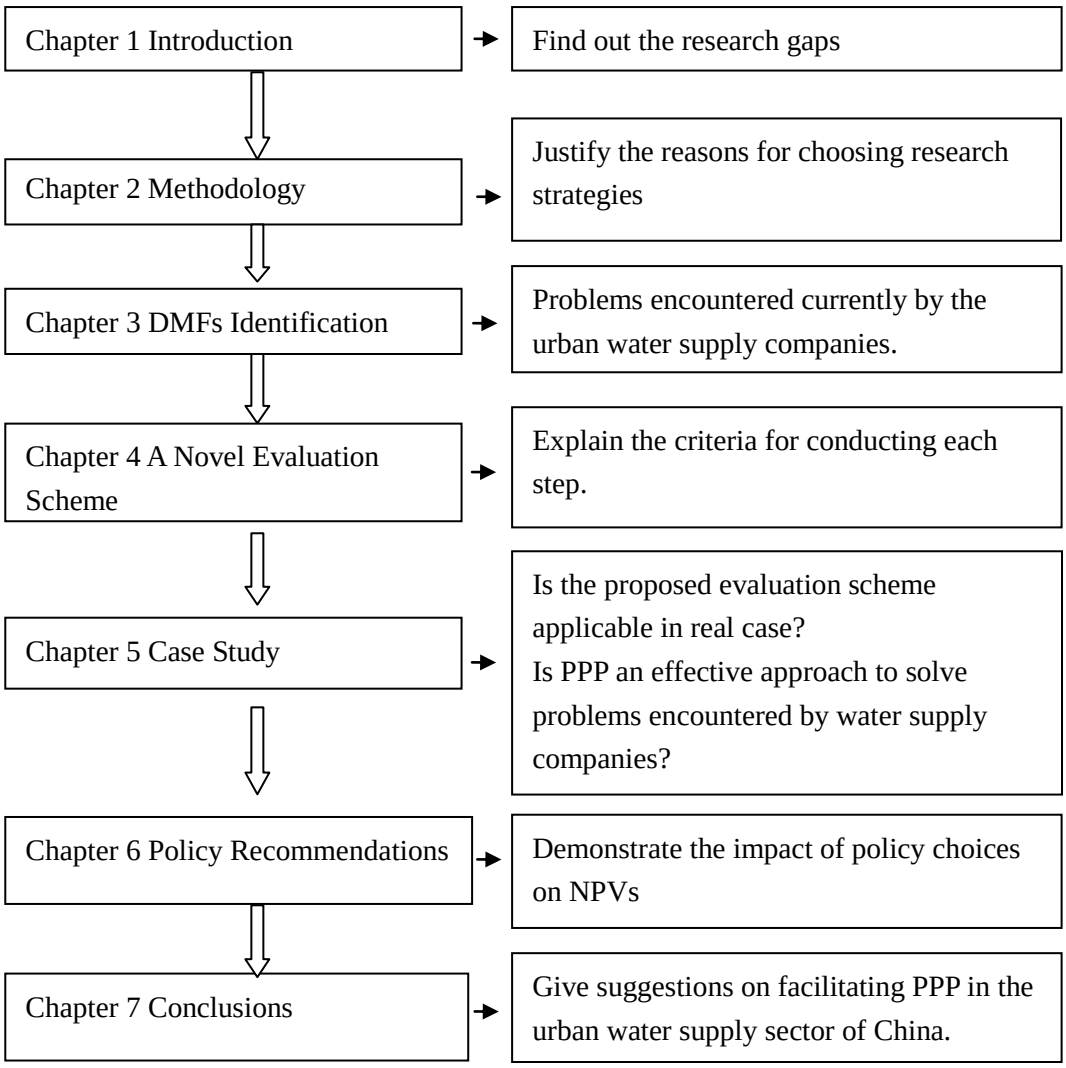

Figure 1.3 Structure of this thesis

CHAPTER 2 RESEARCH METHODOLOGY

2.1 Overview of Research Methodology

Research methodology refers to the principles and procedures of logical thought (Fellows and Liu, 1997). The selection of a suitable research methodology is crucial to the success of a research project, because it provide guidance from assessing the general philosophical ideas to the data collection and analysis procedures, which allows researchers to lodge their studies in ideas well grouped in the literature and recognized by audiences (Creswell, 2008). There are mainly three approaches to conduct research: quantitative, qualitative, and mixed methods approaches.

2.1.1 Quantitative Methods

Quantitative research is the traditional mode of research, according to Given (2008), it refers to the systematic empirical investigation of social phenomena via statistical, mathematical or computational techniques. The objective of quantitative research is to test or verify and refine the laws or theories that govern the world. To be specific, quantitative research may aim to examine the cause and effect relationship, reduce variables, and test hypotheses. There are some characteristics of quantitative research: firstly, the knowledge derived is based on developing numeric measures of observation, thus quantitative data should be in numerical form; secondly, mathematical models, theories, and hypotheses are developed or employed pertaining to phenomena; thirdly, the data should be analysed with the help of statistics; fourthly, the fundamental connection between empirical observation and mathematical expression are established by the process of measurement.

Quantitative approach employs strategies of inquiry such as experiments and surveys, and collect data on predetermined instruments that yield statistics data (Creswell, 2008). The assumption underlying quantitative approach of formulating hypotheses that are tested through controlled experiment or statistical analysis is that research designs should be based on the positivist model of controlling variables and testing pre-specified hypotheses. Traditionally, the positivist perspective governs claims about what warrants knowledge, therefore sometimes quantitative research is called "scientific method" or doing "science" research (Cook and Campbell, 1979; Shadish *et al*., 2002; Schneider *et al*., 2007).

2.1.1.1 Experiment

Experiment includes true experiment and quasi-experiment (Campbell and Stanley, 1963). In true experiment, subjects are assigned randomly to treatment conditions; in contrast, quasi-experiment use nonrandomized designs (Mayer and Davis, 1999). The basic intent of an experiment is to find the causal paths through testing the impact of a treatment (or an intervention) on an outcome, all other factors that might influence that outcome have been controlled during that process. Then comparing the group which receives a treatment with the other group which does not receive treatment, the experimenter can isolate whether it is the treatment or other factors that influence the outcome.

2.1.1.2 Survey

A survey design provides a quantitative or numeric description of trends, attitudes, or opinions of a population by studying a sample of that population. Surveys may focus on different topics including preferences, behavior, or factual information, depending on its purpose. Surveys include cross-sectional and longitudinal studies using

questionnaires or structured interviews for data collection (Babbie, 1990). Probability samples and non-probability samples are two types of survey samples, from sample results, the researcher aim to generalize or make claims about the population. There are several ways to conduct a survey (Dillman, 1978; Ornstein, 1998), the most common modes include 1) telephone; 2) mail (post); 3) online surveys; 4) email; 5) personal in-home surveys; 6) personal mail or street intercept survey; 7) hybrids of the pre-mentioned. The choice of modes is influenced by cost, coverage of the target population, flexibility of asking questions, respondents' willingness to participate and response accuracy (Groves, 1989; Lynn, 2008).

2.1.2 Qualitative Methods

Qualitative research is the examination, analysis and interpretation of observations for the purpose of discovering underlying meanings and patterns of relationships, including classifications of types of phenomena and entities, in a manner that does not involve mathematical models. Compared with quantitative research, it asks broad questions and collects word data from participants, looks for themes, describes the information in themes and patterns exclusive to that set of participants, and aims to gather in-depth understanding of human behavior and the rules that govern such behaviour (Patton, 2002). Qualitative method investigates "why" and "how" questions that are related to decision-making rather than "what", "where", and "when" questions. Hence, smaller but focused samples are more often needed than large samples (Denzin and Lincoln, 2000).

In qualitative approach the inquirer often makes knowledge claims based primarily on constructivist perspectives or advocacy/participatory perspectives or both. Qualitative strategies emphasize an interpretive approach that uses data to pose and also resolve research questions. Researchers develop categories and meanings from

the data through an iterative process. In the process, the initial understanding of the perspectives to be studied is developed at the begging stage of research, then it is tested and modified through cycles of additional data collection and analysis until coherent interpretation is reached (Strauss and Corbin, 1998; Baptiste, 2001). Thus, although qualitative methods provide less explanation of variance in statistical terms than quantitative methods do, they develop richer explanations of how and why processes and outcomes occur (Markus and Robey, 1988).

Strategies associated with qualitative approaches are bountiful, including ethnographies, grounded theory, case studies, phenomenological research, and narrative research (Creswell, 2008). The researchers collect open-ended, emerging data with the primary intent of developing themes from the data. The data collected could be interview, group discussion, observation, reflection field notes, various texts, pictures, and other materials.

2.1.3 Mixed Methods

Mixed methods research, defined by Creswell (2008), is a research design with philosophical assumptions as well as methods of inquiry. As a methodology, it involves philosophical assumptions that guide the direction of the collection and analysis of data and the mixture of qualitative and quantitative approaches in many phases in the research process. As a method, it focuses on collecting, analyzing, and mixing both quantitative and qualitative data in a single study or series of studies. Its central premise is that the use of quantitative and qualitative approaches in combination provides a better understanding of research problems than either approach alone. Through comparison, Table 2.1 illustrates the differences between qualitative and quantitative methods.

Table 2.1 Comparison between qualitative and quantitative methods

Qualitative methods	Quantitative methods
Small focused sample	Large sample
A variety of data formats, including text, sound and image	Quantifiable data only
More exploratory	More conclusive
Rich data including people's experiences and motivations	Often impersonal
Statistical tests are not required	Statistical analysis is used to draw conclusions
Research findings cannot be generalized	Research findings can be generalized if sample is large enough
Measures of attitudes and opinions often require that judgments be made by the researcher, which opens up the issue of researcher bias	Attitudes and opinions are measured by scoring and rating scales

Mixed methods research provides strengths that offset the weaknesses of both quantitative and qualitative research. Qualitative methods have been seen as deficient because the information produced is based on limited number of participants studied, and even if more general conclusions are made, they are personal interpretation on hypotheses. Quantitative methods can be used to verify such hypotheses. On the other hand, exclusive reliance on statistical or experimental testing of hypotheses has been soundly criticized in the social sciences for mainly two reasons (Kaplan and Duchon, 1988).

The first attack is to the assumption that science progress will only be achieved through statistical or experimental tests. Glaser and Strauss (1967) claim that inductive qualitative research is much more convincing for theory building than continual hypothesis testing. Statistical significance testing of hypotheses is weak in understanding the context or setting in which people talk.

The second fault is the reliance on experimental or statistical control as the defining feature of scientific research. It is expected that the numeric measurements will yield unbiased results that can be generalized to larger population. To achieve this goal, it is required to use quantifiable data and statistical analysis (Downey and Ireland, 1983; Kauber, 1986) and also remove the effects of context in order to produce generalizable and reproducible results. However, social systems involve many uncontrolled and unidentified variables; therefore, quantitative approach does not apply as well in natural settings as in controlled ones (Cook and Campbell, 1979; Manicas and Secord, 1983; Maxwell, *et al*., 1986). Moreover, experimental design requires simplification and abstraction of questions, which may remove the specific features from the subject, and result in obvious results.

Combining qualitative and quantitative methods provides a richer, contextual basis for interpreting and validating results (Cook and Reichardt, 1979; Meyers, 1981; Maxwell *et al*., 1986). Because it provides more comprehensive evidence for studying a research problem than either quantitative or qualitative research alone; it helps answer questions that cannot be answered by qualitative or quantitative approaches alone (Creswell, 2008). Mixed methods approach tends to base knowledge claims on pragmatic grounds, which could be consequence-oriented, problem-centered, and pluralistic. With mixed methods, researchers collect data either simultaneously or sequentially to best understand research problem (Light and Pillemer, 1982). The data collection also involves gathering both numeric information as well as text information so that the final database represents both quantitative and qualitative information (Van Maanen, 1983). Collecting different kinds of data by different methods from different sources provides a wider range of coverage that may result in a fuller picture (Bonoma, 1985). Moreover, using

multiple methods increases the robustness of results because findings can be strengthened through triangulation and cross-validation (Benbasat, 1984; Bonoma, 1985).

2.2 Research Design for this Study

The central premise of this study is that different partners in a PPP project have different objectives. In PPP project evaluation, experts inevitably express their opinions representing one partner, public sector or private sector. Therefore, they may possess divergent opinions on different DMFs. It has some support in the literature but requires further empirical validation. Consequently, no one so far has recruited the degree of differences between partners on DMFs as a parameter in PPP project evaluation. Although many researchers are dedicated to develop novel evaluation models by employing advance techniques, they all solely use one parameter in their models. The parameter is various forms of overall scores which reflect expert opinions as a whole.

This research is conducted in three phases as shown in Figure 2.1. Phase 1 answers the questions associated with the construction of the novel evaluation scheme. It is the core part of this research. To develop a more feasible, practical and effective evaluation scheme by introducing the degree of difference between partners as an additional evaluation parameter, three questions should be answered beforehand. The first question is whether there is a need in China to conduct urban water reform by involving PPP model. The second question is what decision-making factors to be evaluated in a PPP project evaluation scheme. The third question is what scoring systems should be adopted in the evaluation scheme. The first two questions are interpreted in Chapter 3. Data and evidence are collected by means of extensive

literature review, survey, case study, and interview. Then in Chapter 4, the evaluation scheme is proposed in details including the procedure of making DMFs checklist, criteria of expert selection, survey method, data analysis process, and the instruction of Importance-Difference Evaluation Model (IDEM). This provides a theoretical lead for the quantitative phase of study. The third question is also illustrated in Chapter 4 by comparing different scoring systems and explaining the reasoning of choosing criteria.

Phase 2 is an implication of the proposed evaluation scheme. In Chapter 5, the quantitative results are displayed and numerical evaluation parameters are generated. Then the case study results are presented in terms of themes and subthemes supported by quotations. This real case study is used to validate the proposed evaluation scheme. Phase 3 is an extension of the first two phases. In Chapter 6, the DMFs are input into a calculator established by this study to evaluate the impacts of policy choices on project profitability. Policy recommendations are made to facilitate the success of PPP projects in the urban water supply sector in China.

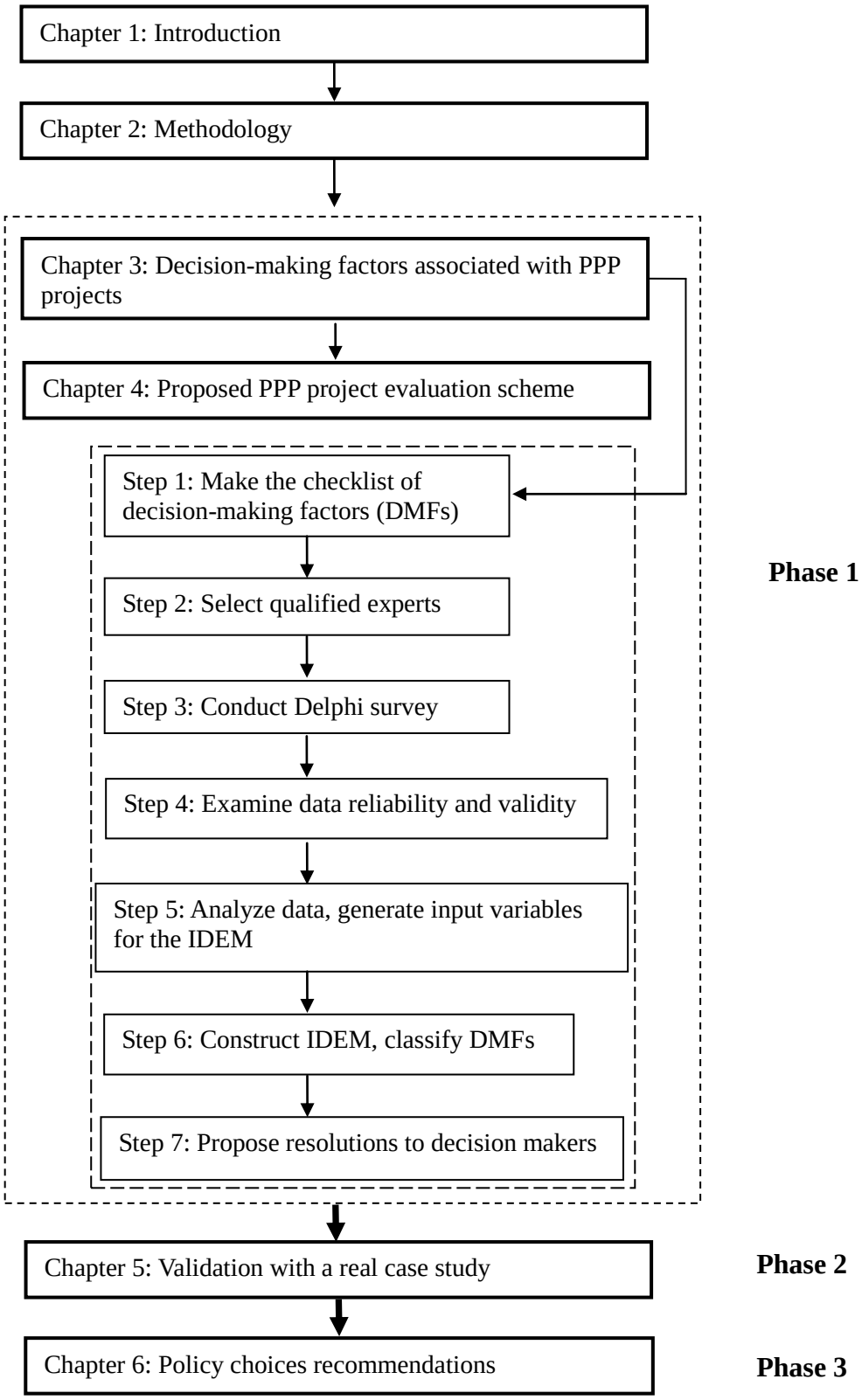

Figure 2.1 Research framework

2.3 Research Methods Employed in this Study

2.3.1 Literature Review

Literature review is to describe, summarize, evaluate and clarify background information relevant to a particular field or topic (Boote and Beile, 2005). It gives an overview of the field of inquiry, aims to identify studies, models, case studies that supporting the topic, and establish the area of research. 'Literature' covers books, journal articles, newspaper articles, historical records, government reports, theses and dissertations.

In this research, an extensive literature review related to PPP project in the urban water supply sector is first conducted. The literatures are selected from the citation database: Web of Science. To avoid missing related literature, keywords that can cover a wider rang are used. 'Private' and 'water' are the most identical keywords related to this topic. There are three thousand literatures which include both of these two words in their topic are selected. Nevertheless, it is felt that too many papers are selected by this search, and some of them may not be directly relevant to the current study. Therefore, the titles of these literatures have been scanned to narrow down the scale to more relevant papers. Important but missed articles are identified from cross referencing of cited studies. More than 300 literatures are finally selected. These literatures can be grouped into three fields.

Papers in the first field are the most abundant. The contents of these literatures are diversify, however the core question they try to answer is whether there is a need to conduct urban water reform by involving PPPs. They could be case studies to introduce experiences, narrative researches to present the history of urban water reform, or quantitative researches to evaluate the relationship between variables and

the choices of model to provide water supply services. The research gaps summarised is that although PPPs have been proved to be succeed worldwide, their applications in the urban water supply sector in China is still limited. Due to the unique political and economic environment in China, it is valuable to state the necessity to introduce PPPs under the Chinese context.

Papers in the second field focus on various factors that to be considered during the implementation period of PPP projects. These factors include driving factors, impeding factors, partner objectives, critical success factors, and risks. They can be case studies to identify these factors, or surveys to evaluate the relative importance of certain kind of factors. The insufficiency is that in the process of decision making, the decision makers will consider all the factors that may lead to an impact on the project regardless of what type of factors they are. However, no one has provided a platform to across compare the relative importance of these factors.

Papers in the third field are aiming at developing reliable and practical evaluation models for PPP projects. Recently, techniques including Fuzzy Set Theory, Delphi Survey Technique, AHP, and Artificial Neural Networks have been introduced for building evaluation models. However, there is only one evaluation parameter in their models. The parameter is the score of relative importance reflecting opinions of experts as a whole. In practice, experts representing different partners possess different opinions on decision making. Therefore, some researchers claim it not appropriate to treat experts' opinions equally.

2.3.2 Survey

Survey method has been adopted in this study due to a number of advantages (1) it is relatively easy to administer; (2) cost-effective; (3) it can reduce or obviate geographical dependence; (4) efficient at collecting information from a large number of respondents; (5) a wide range of information can be collected, including attitudes, values, beliefs, and behaviour; (6) statistical techniques can be applied to the survey data to determine validity, reliability, and statistical significance even when analyzing multiple variables; (7) many questions can be asked about a given topic giving considerable flexibility to the analysis; and (8) provide privacy for responding.

Three surveys are conducted in this study. The first survey is launched in Chapter 3 to reveal the problems faced by the urban water supply sector, and identify the driving and impeding factors of PPPs implementation. Questionnaires were sent to all the registered urban water supply companies in a province. The second survey is conducted in the case study in Chapter 5. It uses Delphi survey method. Experts from public sector and private sector are invited respectively to evaluate the pre-selected DMFs to generate numerical parameters for constructing the evaluation model. The third survey is presented in Chapter 6. The survey was conducted in an urban water supply company. The purpose of the survey is to investigate factors that will influence the quantity of water consumption. Information of 1000 customers was randomly selected. Data has been input to the Statistical Package for Social Sciences (SPSS) to perform multiple linear regressions.

2.3.3 Interviews

Interview is a method for conducting qualitative research. It is most effective when the goal of said research is to gain insight into understanding the experiences of others. Interviewing differs from other methods of data collection in that it is often more exploratory in nature, and more flexible in practice. Researchers can tailor the questions they ask to the respondent in order to get rich, full stories and the information they need for their project. They can make it clear to the respondent when they need more examples or explanations to gain insight into people's interior experiences, specifically how people perceive and how they interpreted their perceptions. In this, researchers can understand the process of an event instead of what just happened and how they reacted to it. In this study, qualitative interviews have been conducted in Chapter 3 to validate the checklist of DMFs generated by literature review and case studies, and also in Chapter 5 to get in-depth understandings of problems associated with PPP projects.

2.3.4 Case Study

2.3.4.1 Case Study as a Research Strategy

According to Yin (2003), "the distinctive need for case studies arises out of the desire to understand complex social phenomena", however, the traditional 'scientific' methods, usually experimental method, are inadequate to understand how people behave in context (Gillham, 2000), whereas "case study method allows investigators to retain the holistic and meaningful characteristics of real-life events". Case study is preferred when: (a) it tries to illuminate a decision or set of decisions where 'how' or 'why' questions are being posed; (b) the investigators have little control over events,

nor can they manipulate the behavior of those involved in the study; (c) the focus is on a contemporary phenomenon which can only be studied or understood in context and embedded in the real world; or (d) precise boundaries between the phenomenon and context are difficult to draw.

Depending on the type of research question posed, the extent of control an investigator has over actual behavioral events, and the degree of focus on contemporary as opposed to historical events, Yin (2003) divides case studies into exploratory case study and descriptive case study two types. In contrast, Stake (2000) identifies three types of case studies: intrinsic, instrumental, and collective case studies. A collective case study is the special case in which the instrumental study is extended to several cases. For the distinction between intrinsic and instrumental case studies, if the focus of research is on the unique features it is intrinsic case study; whereas if the focus of research is on the generalizable features it is instrumental case study (Hartley, 2004).

2.3.4.2 Sources of Evidence

A unique strength of case study research is its ability to deal with a full variety of evidence (Yin, 2003). Also, it is a strategy which enhances data credibility (Patton, 2002). According to Yin (2003) there are but not limited to six possible sources of evidence for case studies: documentation, archival records, interviews, physical artifacts, direct observations, and participant-observation. These evidences are collected by means of interviews, observations, work samples, as well as document and record analysis.

Comparing to other qualitative approaches, case study strategy seeks a range of different kinds of evidence which has to be abstracted and collated to get the best possible answers to the research questions. No one kind or source of evidence is

likely to be sufficient on its own. Each evidence source contributes to reach a holistic understanding of the phenomenon being studied. In case study, the researcher must ensure that the data are converged in the analysis process rather than handled individually, in an attempt to understand the overall case, not the various parts of the case, or the contributing factors that influence the case. Yin (2003) maintains that data analysis consists of "examining, categorizing, tabulating, testing, or otherwise recombining both quantitative and qualitative evidence to address the initial propositions of a study". Yin (2003) also briefly describes five techniques for analysis: pattern matching, linking data to propositions, explanation building, time-series analysis, logic models, and cross-case synthesis, whereas Stake (2000) describes categorical aggregation and direct interpretation as types of analysis. In fact, Patton and Appelbaum (2003) point out that "the ultimate goal of the case study is to uncover patterns, determine meanings, construct conclusions and build theory."

2.3.4.3 Case Selection

In this study, the strategy of case study appears in three chapters. In Chapter 3, explanatory case studies are presented to explain the complex causal links between decision making and project effects. The DMFs checklist generated in previous process has been applied in these case studies to reveal what are the factors that have an impact on the project outcome, and how they will influence the outcome. Although the cases cover different backgrounds, it is strongly recommended to establish an effective communication mechanism to assist decision making.

The case study used in Chapter 5 is a validation of the proposed evaluation scheme. This case study seeks to determine whether the proposed scheme can effectively and precisely identifies the DMFs to be considered so as to assist the decision makers to take efficacious moves; also it explores how to possess the reliability and feasibility

when utilizing this scheme. A case study is chosen because it would be impossible to have a true picture of decision making without considering the context within which it occurred, and it should be in context that the decision making skills can be developed and utilized. Therefore, a county level urban water supply company which has experienced reform is selected as this context.

In Chapter 6, case studies are adopted to provide evidence for building theories and logic models to guiding the following research on testing variables and policies to be recommended. In addition, it helps to understand the nature and complexity of the processes taking place (Baxter and Jack, 2008).

2.4 Chapter Summary

The basic inquiry of this research is how to establish a reliable, objective, feasible and effective evaluation scheme to assist decision makers to identify the DMFs to be pondered over PPP projects in the urban water supply sector in China. Due to the complexity of this research, mixed methods are adopted on collecting and analysing both quantitative and qualitative data to provide a richer and contextual basis for interpreting and validating results. Literature review, survey, interview and case study have applied in different stages of this research.

CHAPTER 3 DMFS ASSOCIATED WITH PPP PROJECTS

3.1 Introduction

When the private sectors are involved in implementing traditionally public sector owned projects, these projects are tended to be subject to more risks than other traditionally procured projects, and are more complex to manage, on the grounds that wider range of stakeholders may have different objectives and interests associated with the project (Shen *et al.*, 2006). Therefore, disputes may appear in any phase of a PPP project. Misunderstandings which are not handled properly always result in suspension, termination and failure of projects. To propose effective approaches for alleviating this situation, first of all, it is required to identify the factors that are considered by stakeholders in their decision-making process, and which finally affect the outcomes of those projects. These factors are defined as DMFs in this research. DMFs in PPP projects have a wide spectrum, including multiple objectives to be achieved, risks to be avoided (Dias and Ioannou, 1995; Zayed and Chang, 2002; Yuan *et al.*, 2008; Xu *et al.*, 2010; Cheung and Chan, 2011), partner selection criteria, drivers and obstacles for adopting PPPs (Chen and Doloi, 2008; Chan *et al.*, 2009; Yuan *et al.*, 2010), and success factors for PPP implementation in China (Chan *et al*., 2010a; Meng *et al.*, 2011). In general, four methods have been adopted in prior studies to identify DMFs: (1) literature review, (2) case study, (3) survey, and (4) interview. This research makes use of all the four methods through a systematic procedure to identify DMFs associated with urban water supply PPP projects in China.

3.2 Literature Review and Content Analysis

A comprehensive literature review was conducted to identify the DMFs of PPP in the Urban Water Supply Sector in China. Relevant published literature including textbooks, research reports, journal articles, conference papers, government statistic year books, and internet materials were reviewed thoroughly.

3.2.1 Drivers and Obstacles of PPPs

Drivers are reasons for change and the forces to propel the change. In this research, public sector, who operates the urban water supply service, is responsible for making the decision that whether to transfer the ownership, operation and/or management of this service into the form of PPP. Those benefits that expected to be achieved through the transfer as well as the forces from various aspects that added to the decision makers are the drivers of PPP. The desired benefits are defined as partners' objectives in this study, and drivers in this section are the theories calling for PPP. Obstacles also have two major types. If there are evidences to prove that the desired benefits are non-achievable, those evidences are obstacles. Another type of obstacle is the insufficiency in securing PPP outcomes. In some situation, drivers and obstacles are two-side evaluations of a specific factor. Research on drivers and obstacles of PPPs can be divided into two phases. The focus in the first phase is to discuss whether there is a need to transfer the urban water supply service into PPP from. In the second phase, the inquiry is how to secure the implementation of PPP.

3.2.1.1 Driving Forces: Necessity of Reform

Private sector has participated in public service delivery since the 1980s. It has grown steadily in both industrialized and developing countries around the world. Compared to services such as power supply, telecommunications, and transportation, the

implement of PPPs in urban water supply sector is relatively late and light. There have been considerable controversies toward the necessity of reform in urban water supply sector. A number of researchers have proposed the pros and cons of transferring control over essential services to a for-profit company.

- Cost Savings

The fiscal deficit is a thorny problem faced by the government. General methods for offsetting fiscal stress are creative book-keeping, higher taxes, and increased borrowing; however public officers have exhausted or eliminated the possibility of using these methods. At the same time, local governments are not permitted to issue debentures. Therefore, there are only two options for the public sector to reduce deficit: cut service or raise productivity. It is unpractical to eliminate or cut back urban water supply services, because the requirement of water supply has been increasing. More important, reliable water supply service is vital to the prosperity of the nation and the stability of the society. By contrast, increasing productivity is more politically attractive (Savas, 2000).

Privatization is suggested as an effective approach to improve productivity because it has the potential to reduce cost. Ferris and Graddy (1998) tested a privatization decision-making model on 1,433 cities with populations of over ten thousand. The model covered four broad areas: public works, public safety, health and human service, and recreation and the arts. Cost savings was cited as the most significant consideration for privatization. In addition, empirical studies conducted by Morgan (1977), Crain and Zardkoohi (1978) and Raffie *et al*. (1993) also show that private production is less costly.

However, in researches conducted by Fox and Hofler (1986) and Byrnes (1991), no significant differences between public and private production have been found. Stein (1990) raises another caveat that although contracting out services to private sector has consistently been found to be more productive than delivering the service by public sector; the improved productivity has not proved to be sufficient to reduce the total expenditure of governments. DeHoog (1985) gives two directions on researching cost saving issues. One is to illustrate the reasons that induce cost savings, the other is to explain clearly the extent to which the savings can be made.

Ferris (1986) suggests that cost saving can be achieved when any one of the three conditions is met: "(1) a sufficient number of organizations willing to supply the service, (2) a lower employee compensation cost with the external provider, and (3) a cost savings from scale economies, and example of which is capacity utilization." In other approach, Poole (1996) brings up an interesting point by observing that privatization not only relieves the government of the need to fund infrastructure, "privatized enterprises, unlike their state-owned counterparts, also pay taxes like other businesses, thereby adding to government's ordinary tax revenues."

It is argued that this decision ultimately stems from disappointment with the performance of the public sector and a perception that the discipline and financial incentives of capital markets will spur greater efficiency. In general, if there are no perceived problems with the public sector including high cost and/ or low performance, there is usually little incentive for public officials to consider privatization (Nightingale and Pindras, 1997; Megginson *et al*., 1996).

- Efficiency VS Equity

Besides cost saving, to determine whether to open the finance channels to the private sector by introducing market mechanisms, it is important to examine the equilibrium between efficiency and equity. According to Kettl (1994), government exists in part because markets have failed to serve the public interest. Furthermore, government aims to serve the public with broader values, including equity, representativeness, and responsiveness. If the public sector model itself after the private sector, that will lose the meaning of its existence.

One area of dispute is related to whether private sector will choose to benefit the public. Theoretically, bureaucratic approach takes equal treatment of citizens as its primary values. They concern the quality of public service and pay attention to issues of social justice, fairness in government action, and environmental protection (Jennings, 1991); whereas market approach think about money and efficiency instead of rights" (Peters, 1996), private companies concerned with maximizing profit might opt to reduce services or only serve those clients who are most economically provided (Savas, 2000).

However, according to Public Choice Theory, which assumes that the behaviour of public officials is governed predominantly by desire for economic gain or power, they make every move in order to enhance their own economic interests (Simon, 1993). It exposes that the phenomenon of inefficiencies will arise inevitably when water supply service are operated under public ownership. As "economic man", who is dominated by economic motives, is the universal agent, there exist conflict between group selection and individual selection, where altruism, or the sense of

social responsibility, will appear as group interest. For private sector, to serve their own long-term interests, altruistic acts such as providing services to marginal or unproductive groups will still happen.

Since private sector may also take altruistic acts, public interest becomes a measure of judging government performance, which evaluates how cheaply it delivers public services to be the basis of governmental service level (Box, 1999; Peters, 1996). Therefore, the problem to be concerned by the decision makers is, as Peters (1996) notes, that "the distinction between rights and economics in not always easy to maintain".

Disputes in more areas also appear. Bendick (1989) states that, private contractors are well suited for straightforward services, but the record of successful experience thins in more complex, indefinable, long-range, and subjective services. Study conducted by Cohodas (1997) shows that after outsourcing, technology workers will have better career paths, make more money, and are happier in their private sector jobs, while unskilled workers may experience a wage decrease. According to Nightingale and Pindus (1997), the case for improved efficiency through privatization lacks the empirical evidence about whether the public sector or the private sector is more effective. Surprisingly, the findings produced by a small sample showed that "whenever there is a shift, either from the public sector to private sector, or vice versa, there is improvement".

- Long-Term Interests

Although it is expected to introduce competition through privatization, the problem, as Peters (1996) cautions, is that competition may not be easy to promote due to size restrictions, specialization of products, and the market uncertainty, as water supply

service may be delivered more efficiently as monopolies rather than through competition, and even if privatized, it tends to retain its monopoly status and must be regulated by government (Wiltshire, 2007).

According to Rothschild (1995) "the market economy is the product of a naturally occurring, spontaneous evolutionary process." In a market economy, for a company to survive over time it must hold as much territory, or market share, in its niche as possible. Governments also exist, according to this approach, in the same environment (North, 1996). Traditional theorists maintain that economy is a predictable under a logical government who is searching for a better society to serve the public interest, plan, control, manipulate, and repair it. It is possible for a government to actually allow a former public enterprise to cease operations without interceding (Megginson *et al.*, 2000). While, Savas (2000) finds that "the greatest impediment to privatization by contracting is the fear of loss of control which was named by 51 % of responding officials to a 1987 survey of county and city officials." It is worthy notice that the adaptive efficiency may not lead to an efficient equilibrium, but instead leads to a chaotic environment.

- Economic Forces

According to Savas (2000), while public funds have shrunk, and individual affluence has grown, the need for public services is reducing. Glazer (1988) noted that "this [affluence] leads many to believe they could manage the education of their children, or their own health, more effectively and with greater satisfaction by allocating their own funds to a range of competing organizations, public and private, rather than by paying taxes."

The salient point for decision makers is the realizations that as economic conditions seemingly improve; two events appear to be happening. First, there is a perceived decrease in the dependence on government goods and services by the public. Second, distrust of government is growing. This combination leads to large-scale decentralization proposals calling for less dependence on government, which, according to Glazer (1988) is "politically popular".

- Philosophical Forces

A number of public polls conducted in the United State over the last twenty years (Blendon, 1997; Gore, 1995; Lipset and Schneider, 1983) indicate there is a growing anti-government sentiment coupled with a perception that the private sector is able to outperform political institutions.

One group is based on the simple tenet of desiring less government in the sense of power. The accepted postulates of this group rests on the assumption that man is a rational, egoistic actor who seeks to maximize his utility (Mueller, 1984), not simply in the marketplace but also in non-market areas such as politics, where support from politicians can be seen as a commodity. The contention is, according to Hazlett (1996) that "privatization is a process that necessarily undermines the power position of every government official, without regard to his or her ideological convictions." This undermining of power is seen as positive when taken from a *homo economicus* individualist view within the Theory of Politics. Buchanan (1984) contends that, "at some basic philosophical level, the individualist must reject the notion that any rights of governance exist".

Another group opposes government on economic tenets, fearing that "in the long term, the well-being of society will be maximized if economic decisions are left mostly to the marketplace and not politics" (Savas, 2000). Freidman (1962), among others, sees the government's role as minimal as best. One of the ironies of public choice is that, unlike those privatization advocates who espouse cost-savings and efficiency, public choice theorists are uncomfortable with an efficient public sector. Many public choice theorists maintain that even an efficient government will operate only in its own best interest, nor the interest of the public. The fear is that improved efficiency may also lead to an improved stature, creating a new round of government expansion.

- Commercial Forces

It is recommendation that government should not compete with the private sector to perform functions for the public interest. The World Bank embraced a new paradigm consisting of three principles in the area of providing infrastructure:

1) *User funding*. To the greatest extent possible, the users of an infrastructure facility should pay the full costs of its service directly at the point of use.
2) *Dedicated revenues*. The enterprise providing the infrastructure should levy the charges and keep the revenues, rather than the state collecting the charges and then allocating funds for the enterprise from the state' general operating budget.
3) *Market pricing*. The fees charged to users should be based not merely on the costs of operation the enterprise, but on supply and demand, thereby giving users incentives to economize on their use of the services.

- Populist Forces

Simply put, the populist claim that less government is better and that, if government must play a role, it should be at the local level. The allure of privatization to populists bifurcates into two camps. The first camp finds merit in "adaptive efficiency" which will allow societies to explore many ways to solve problems in the decentralized decision-making processes (North, 1996). Osborne and Gaebler (1992) claimed that "it is not the government's obligation to provide services." The role of provider, according to Nightingale and Pindus (1997), can then be filled by community-based and faith-based organizations. Traditional, nongovernmental institutions can provide safety to society by redundancy and help to arrive at an adaptive equilibrium among the conflicting goals of freedom, justice, and efficiency (Savas, 2000). The second camp of populists contends that no one should rely on a sole source of supply (Kolderie, 1984). They "emphasize non-governmental action and citizens duties as well as rights." They point out that, if solutions are not provided at the community level, then volunteerism will be replaced by an uncaring, unwieldy bureaucracy.

3.2.1.2 Obstacles: Difficulties in PPP Implementation

Studies related to PPP in the urban water supply service before the year 2000 are mainly focus on the theoretical dissension on the necessity of employing PPP. Since 2000, the focus of research has been placed on practical perspective. A number of researchers aim to discover the factors restricting the development of PPP, so as to create an environment which is suitable for the implementation of PPP.

Due to the complex nature of urban water supply service, there are many difficulties in PPP implementation. Studies conducted by David and Fernando (1995), Retali and

Moss (1997), and Lobina (2005) have identified some general obstacles which include (1) complex financial arrangement, (2) complex contractual structure, (3) high up-front development cost, (4) complex project process, (5) high risk, (6) high product/service prices long term, (7) high investment, and (8) multiple participants. Garrido (1999) and Boudet *et al*. (2011) take another step from the economic perspective pointing out the difficulties in searching for common interest between public and private partners.

Except for general obstacles, Chen and Doloi (2008) have identified seven China-specific impeding factors which are (1) complex approval systems, (2) opaque and weak legal systems, (3) regulatory constraints on market entry, (4) low market prices for infrastructure products and services, (5) creditworthiness of local utilities, (6) no direct interests to local government and its subordinates, and (7) foreign currency administration difficulty. Similarly, Giraudo and Sasser (1997) have stated the problems related foreign currency; Orr (1997) as well as Lee and Sung (1998) have revealed the weakness regarding the legal systems in China; Chen and Messner (2005) have identified the obstacle in regulatory constraints on market entry that some water plant projects are not attractive for foreign developers. If these projects can be packaged into larger size, it will enhance the chance for attracting the interest of foreign investors.

3.2.2 Objectives of PPP

In PPP projects, multiple participants have different expectations. For private sectors, the primary desire is to seek profit and minimize risks through partnership. For the public sectors, they have more complex and multi-level objectives. These objectives are the drivers for partnership therefore a number of studies focus on this topic.

Li (2003) identifies 15 driving factors in United Kingdom (UK) and groups them into five categories as shown in Figure 3.1. Following his step, Chan *et al*. (2009) aim to compare the driving factors between China and Hong Kong Special Administrative Region. They have conducted a comprehensive literature review on sixteen pieces of relevant published literature including textbooks, research reports, journal articles, conference papers, and internet materials. Finally, they have adopted the factor list generated by Li (2003).

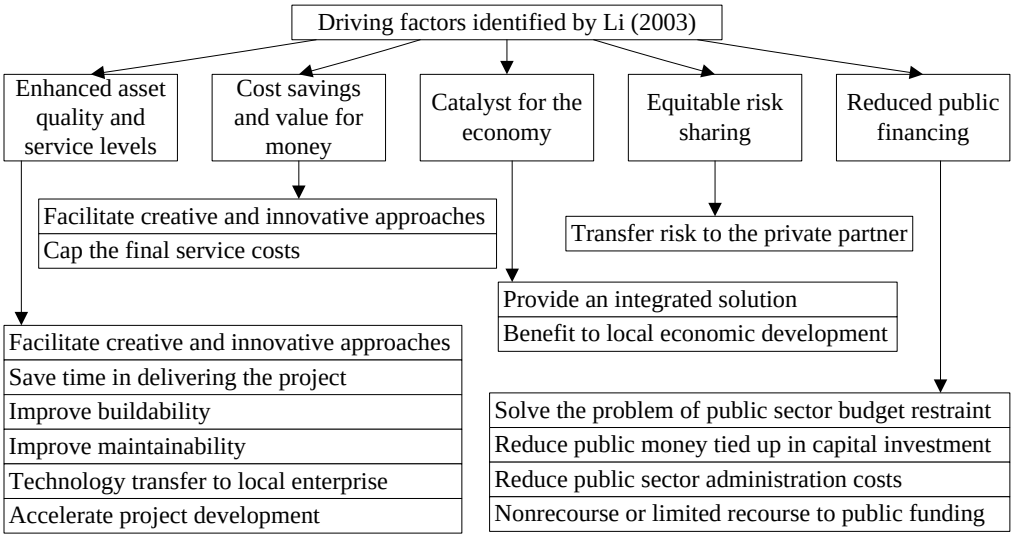

Figure 3.1 Driving factors identified by Li (2003).

Yuan *et al*. (2010a) reveal the driving factors in PPP applications from the perspective of the Chinese public sector basing on two case studies and comprehensive literature review. Then the identified 15 driving factors are evaluated in a structured questionnaire survey to perceive their relative significance. With factor analysis these factors are grouped into five major dimensions:

(1) *More public benefits;*

- Life-cycle cost reduction
- Promoting local economic development

- Making profit from public service
- Improving technology level or allowing technology transfer
- Public sector can acquire additional facilities/services beyond the minimum requirement from the private sector

(2) *Better public service;*

- Acceptable quality of project.
- Quality public service.
- Provide timely and convenient service for the general public.

(3) *Public sector avoidance of financial and risk management restraints;*

- Solving public sector budget constraints.
- Satisfying the need for public facilities.
- Transferring risk to private sector.
- Private sector can earn government sponsorship, guarantee and tax reduction.

(4) *Project performance improvement;*

- Project within budget or under budget in construction and operation.
- On-time or early project completion.

and (5) *Commercialization.*

- Introducing business and profit generating skills to the public sector.

Although this research is basing on transportation projects, the driving factors they proposed are valuable. These empirical studies focus on revealing the relative importance of driving factors; there are also many researches that have identified some driving factors. Yuan *et al*. (2008) demonstrate the objectives for PPP projects can be described as following three points: (1) Time, Cost and Quality are the most

significant goals for any projects; (2) The satisfaction of stakeholders will be helpful for PPP projects; and (3) Sustainable development is the ultimate objective for PPP projects.

In this study, relevant journal papers have been reviewed. Through further comparison and analysis, hierarchies of categories were examined, similar main points and ideas were assembled, and different main themes were finally distilled from the analyzed literatures. These literatures are summarized in Table 3.1. Followed, the identified factors are described.

Table 3.1 Driving factors of PPP from Published Literature

Literature	Equitable risk sharing	Cost saving	Reduce public sector budget restraint	Efficiency improvement	Assets/Services quality enhancement	Innovation and technology transfer	Catalyst for economy	Commercia-lization	Need management skills	Earn benefit from government
Akintoye *et al*. (2003b)	x	x		x		x				
Efficiency Unit (2008)	x	x		x	x	x	x			
European Commission (2003)	x	x					x			
Li (2003)	x	x	x	x	x	x	x			
Environment, Transport and Works Bureau (2004)		x		x	x	x	x			
Grimsey and Lewis (2004)	x	x		x	x		x			
United Nations Economic Commission for Europe (2004)	x	x					x			
Li *et al*. (2005b)	x	x				x				
Chan *et al*. (2006)	x				x	x				
Corbett and Smith (2006)	x	x								
New South Wales Government (2006)	x					x				
Boussabaine (2007)	x				x		x			
So *et al*. (2007)	x	x			x		x			
Chen and Doloi (2008)	x		x			x		x	x	
Kumaraswamy and Anvuur (2008)						x			x	
Chan *et al*. (2009)	x	x	x	x	x	x	x			
Yuan *et al*. (2010a)	x	x	x	x	x	x	x	x	x	x
Meng *et al*. (2011)			x	x	x				x	

Equitable Risk Sharing

In urban water supply PPP projects, there are many types of risks associated with the procurement, delivery and operation of water supply facilities and services. These risks mainly relate to financing, market, as well as facility maintenance. In every phase of project, risks may occur, which include construction risk, design risk, environmental approval risks, land acquisition risks, etc. (Ingall, 1997; Efficiency Unit, 2008; Akintoye *et al*., 2003a; European Commission, 2003; Li, 2003; Grimsey and Lewis, 2004; United Nations Economic Commission for Europe, 2004; Li *et al*., 2005b; Chan *et al*., 2006; Corbett and Smith, 2006; New South Wales Government, 2006; Boussabaine, 2007; So *et al*., 2007). To be more specific, the risks may be the completed time of construction work, construction cost, operation cost and service quality. According to Li *et al*. (2005a), there might be unforeseen increases in the capital costs of the projects, or higher than expected service delivery and maintenance costs. The uncertainty and risks inherent in public projects probably make public sector spend more financial resources on these projects without a PPP solution. Therefore, Li *et al*. (2005a) demonstrate that risk transfer is a primary objective in PPP project procurement. Yuan *et al*. (2010a) also manifest that one key benefit of PPPs is transferring high project risk to the private sector.

In addition, Hong Kong Government's Efficiency Unit (2008) pointed out that to allocate risks to parties that are the most able to manage/control them is the most ideal situation of risk management. Chan *et al*. (2009) point out that the private sector is in general more efficient in asset procurement and service delivery. Yuan *et al*. (2010a) also designate that the high risks associated with infrastructure and services can be controlled better by private sector which has professional competence and relevant experiences. It is better for the private

sector to be responsible for design, build, operation, and maintenance than the public sector. However, the public sectors should also take their responsibilities in risk sharing.

Under the current guidelines in China, the public sectors are required to provide explicit information about risk allocation to private sector bidders during the contract procurement process for a project.

Cost Saving

Cost saving may be achieved from mainly two areas. In the overall cost saving aspect (Grimsey and Lewis, 2004), it can be achieved through the optimum combination of whole life-cycle costs, risks, completion time, and quality (Ingall, 1997; Efficiency Unit, 2008; European Commission, 2003; Li, 2003; Grimsey and Lewis, 2004; Li *et al.*, 2005a; Chan *et al.*, 2006; New South Wales Government, 2006; Boussabaine, 2007). There might be unforeseen increases in the capital costs of the projects, and higher service delivery and maintenance costs than expected (Li *et al.*, 2005a). These uncertainties and risks probably make the public sectors spend more financial resources on the projects if without PPP involvement. On the other hand, if the private sector takes over the responsibility for design, construction, operation and maintenance, the public sector partner can divest themselves of routine risks, facility administration costs can be reduced substantially. Furthermore, the public sector partner avoids large nonrecurring investments and can arrange its own budget policy from a new starting point (Tieva and Junnonen, 2009). Therefore, the public sector will carefully calculate and compare government costs through public funding and the transition cost to private sector.

The second approach of cost saving could be a result of the private sector's innovation and efficiency that the public sector may not achieve (Akintoye *et al*., 2003b; European Commission, 2003; Li, 2003; Environment, Transport and Works Bureau, 2004; Grimsey and Lewis, 2004; United Nations Economic Commission for Europe, 2004; Li *et al*., 2005a; Corbett and Smith, 2006; So *et al*., 2007; Efficiency Unit, 2008). Private sector generally achieves higher operational efficiency in asset procurement and service delivery by applying their expertise, experience, innovative ideas/technology, and continuous improvements (Chan *et al*., 2009).

Reduce Public Sector Budget Restraint

In China, infrastructure used to be a public regime. Due to the administrative and fiscal decentralization policy, the revenue of the central government has been falling. As a result, local governments have to be responsible for carrying out actual infrastructure development which requires high upfront capital expenditure and long return period. To sustain the rapid economic growth and improve social welfare, the local government has to rely more and more on the market mechanism to make revenues, and develop new funding sources in addition to public financing (Chen and Doloi, 2008). PPP can effectively free up the local government from budget restraint. The government does not have to pay high cost at a time or only has to provide periodic service payments. Consequently, the public funding required for public services can be reduced and redirected to support other sectors including education, healthcare, and community services (Li *et al.*, 2005a; Efficiency Unit, 2008). Regarding the benefits, public sector gives incentive to private sectors like guarantee and tax reduction, some even join a non-profitable project and a profitable project to a single contract. For example, to attract private sector investment, Ahmed and

Sohail (2000) suggested that one favored solution was to combine sanitation and water supply together as a package for contractors. According to Yuan *et al*. (2010a), the development of PPPs has a close relationship with the macro-political and economic environment.

Efficiency Improvement

Over the past two decades, most of the urban water supply services are provided by the China government. However, it has been questioned and reassessed at various levels and in different form that whether the government has adequate resources to operate urban water supply services in an effective and efficient way to secure the quality of the services (Pessoa, 2008). Unfortunately, public sectors are frequently seen as ineffective in resource allocation and poor in management. Burdened with bureaucratic procedures, the public sector is usually incapable of acting quickly to adapt to changes and, as a result, the services provided will deteriorate over time. Therefore, the China government has been trying to separate the administrative and commercial functions through structural reform (Dimitriou and Trueb, 2005). In contrast, the private sector, which is capable to provide these services, are always large and well-organized companies, and can deliver public services with high performance (Yuan *et al*., 2010a).

Quality Enhancement

Quality enhancement refers to both the quality of construction and maintenance and elevated level of service. In a PPP project, the private sector partners need not only to design and build the water supply facilities including water plant and water pipe network, but they also have to be responsible for the long-term maintenance of the facility/service. Usually, the concession period of urban water

supply projects will last for decades, therefore the private sector has to design and construct the service/facility to ensure better maintainability (Li, 2003; Environment, Transport and Works Bureau, 2004; Grimsey and Lewis, 2004; Chan *et al*., 2006; Boussabaine, 2007; So *et al.*, 2007; Efficiency Unit, 2008), at least within the concession period. Sometimes, according to Chan *et al*. (2009), the private sector would only receive payment upon meeting certain requirements of the project.

More attractiveness for PPP procurement is that the private sectors could make revenue from the project to service financial debt (Li *et al*., 2005b). The revenue stream of customers connected and water sales are almost the only resource to earn money for the private sectors. Therefore the private sectors have to try their best to reduce the costs, provide timely and convenient service for the general public, satisfy the need for public, and develop the market to make profits (Yuan *et al*., 2010a). To achieve time-saving, convenience, and cost saving, it relies on good project operation and maintenance (Zhang, 2006; Sobotka and Czarnigowska, 2007).

Innovation and Technology Transfer

Innovation is another important advantage that the private sector can bring to public services. Generally speaking, the public sectors expect to see new technology at work and benefitting local economies; however they may not be as innovative as in the private sector (Chan *et al*., 2009). The private sector is continuously searching for new technique to increase their competitive edge and seeking life-cycle cost reduction (Akintoye *et al*., 2003b; Efficiency Unit, 2008; Li, 2003; Environment, Transport and Works Bureau, 2004; Li *et al*., 2005b; Chan *et al*., 2006; New South Wales Government, 2006).

Catalyst for Economy

PPPs provide an integrated solution for public infrastructure/services. For the private sector, if priced accurately and costs managed effectively, the projects can provide reasonable profits and investment returns on a long-term basis. For the public sector, they can charge tax to improve government revenue (Chan *et al*., 2009). In addition, because the PPP are always involved to relatively large-scale projects, which requires multilateral cooperation, different collaborating parties are encouraged (European Commission, 2003; Environment, Transport and Works Bureau, 2004; United Nations Economic Commission for Europe, 2004; Grimsey and Lewis, 2004; Boussabaine, 2007). By working together, different sectors can explore the strengths and weaknesses of each other, and, where appropriate, join together to create business opportunities (Efficiency Unit, 2008; Li, 2003; United Nations Economic Commission for Europe, 2004; So *et al*., 2007). Through this, public sector also can acquire additional facilities/services beyond the minimum requirement from the private sector, which are benefit to local economic development.

Commercialization

The commercialization of urban water supply projects meets the expectation of the public sectors in mainly two aspects. Firstly, when the government takes the responsibility for urban water supply, the citizens takes it the government obligation to provide them with qualified water and it is their welfare to use water at a low price. As a result, many government-owned water supply companies have been operated at a loss. Due to the lack of competition mechanism, public sectors have no incentive to improve quality and reduce cost,

which adds a serious financial burden to the government. The structural reform of government intended to separate the administrative and commercial functions of government. Through commercialization reform, it is aimed to improve the economy, efficiency and effectiveness of infrastructure projects and services. The governments also intend to use PPP as a stimulus to explore new directions in the reform and experimentally raise the market price of infrastructure products and services generally (Chen and Doloi, 2008). Therefore, to commercialize the infrastructure products and services becomes one driving factor in PPP applications in China.

Additionally, non-competitive industry structures and/or the lack of capital market discipline are the salient features of the urban water supply sector in China. In such environments, the market information revealed is not sufficient and information asymmetries are overwhelming (Yuan *et al*., 2010a). Therefore, like most developing countries, a much more demanding form of regulation is required. In the process of commercialization, capital regulations, entry regulations, and pricing regulations will all be re-established.

Needing Management Skills

Private sector is believed to be more efficient in providing quality infrastructure products and services than public sector organization. It is because they have advanced technology and management skills. The local government aims to select an appropriate private sector partner with appropriate experience, adequate technology and management skills to reduce the risk of inefficiency (Kumaraswamy and Anvuur, 2008). Accordingly, the public sector also expects the private sector to introduce business and profit generating skills to manage other public projects or future PPP projects (Chen and Doloi, 2008).

Earn Benefit from Government

Shen *et al*. (2006) point out that PPP projects are more complex and tended to be subject to more risks than other traditionally procured projects. For the private sector, the attractiveness of PPP projects related to urban water supply services is a long-term stable revenue stream secured through the partnership mechanism. On the other hand, the public sector also expects to establish a good long-term stable relationship with a strong private sector through government sponsorship, guarantees and tax reduction.

3.2.3 Risk associated with PPP Projects

Risk is a crucial issue in the PPP projects, which has been studied broadly and has been proved by many cases. Shen *et al*. (2006) point out that PPP projects are usually subject to more risk risks compared to those projects that are procured traditionally, because they are more complex when compounding in implementing public sector projects where multiple project objectives are expected by a wide range of stakeholders who have different interests associated with the projects. Various risks and uncertainties often hold the government back and make the consortium go bankrupt. Literatures always take four approaches to study risks of PPP projects. Risk identification, risk allocation, risk assessment and risk management. Two research methods are adopted in their studies: case studies and empirical surveys. A number of academic researchers provided detailed risk registers for PPP projects (Li *et al*., 2005a; Andi, 2006; Yuan *et al*., 2007; Jin and Doloi, 2008; Zeng *et al*., 2008). It is believed that a comprehensive list of risk factors will provide PPP practitioners with an useful tool in setting up

and executing a successful PPP concession agreement (Xenidis and Angelides, 2005), which can also serve as a basis for risk identification, evaluation, allocation, and response.

3.2.3.1 *Risk Definition*

Hertz and Thomas (1984) define risk as the integration of departures between planned goals and possible sequences due to the uncertainty of impersonal conditions and subjective decisions. According to Al-Bahar and Crandall (1990), risk identification can be defined as the process of systematically and continuously identifying, categorizing, and assessing the initial significance of risks associated with a construction project. Hottenstein and Dean (1992) define project risks as the probability that contractors or owners cannot achieve their goals in a project.

3.2.3.2 *Category of Risks*

Risks exist in every process of a project including developing, financing, building and operating. Risks found in typical cases include project delay risk in Euro Tunnel (Francis, 1993), political risk in two BOT projects in Thailand (Ogunlana, 1997), financial risk in Hunan Power plant in China (Ke *et al*., 2010), and force majeure in Jiangsu Sewage Treatment Plant in China (Ke *et al*., 2010). Therefore, it is essential for both the public sectors and private sectors to evaluate all potential risks throughout the life cycle of project.

Beidleman *et al*. (1990) classify risks into four types according to project phases, as shown in Figure 3.2: development phase (technology, credit and bid risks); construction phase (completion, cost overrun, performance and political risks);

operating phase (performance, cost overrun, liability, equity resale, and off-take risks); ongoing risks (interest rate and currency risks). Whereas The Efficiency Unit (2008) of the Hong Kong Special Administrative Region in China classified in their guideline for conducting PPP projects the key types of risks. These include: demand risk; design and construction risks; operation and maintenance risks; technology/obsolescence risk; finance risk; legislative risk; approval risk; and hazard risk.

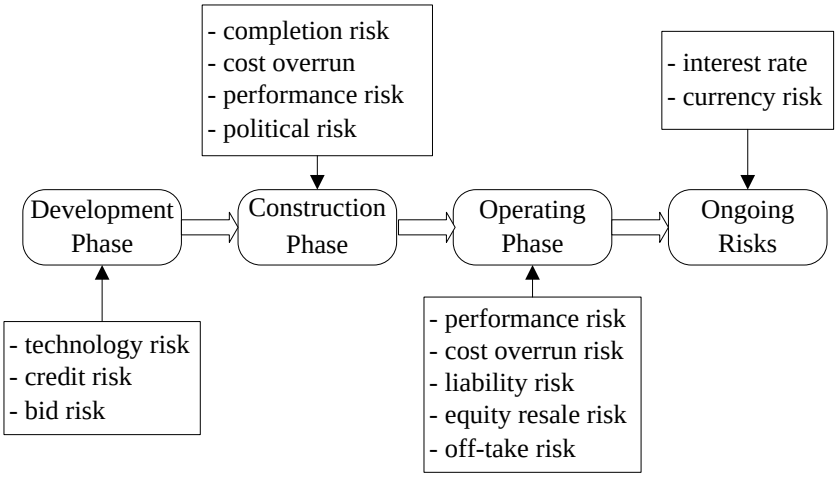

Figure 3.2 Risks associated with different phases of a PPP project.

Dias and Ioannou (1995) classified the sources of risks into ten categories shown in Figure 3.3: country risks (political and regulatory risks), force majeure, physical, financial, revenue, promoting, procurement, developmental, construction, and operating. Whereas Delmon (2000) identifies the sources of risks encompassing capital budget, construction time, construction cost, operation cost, politics and policies, market conditions, cooperation credibility, and economic environment.

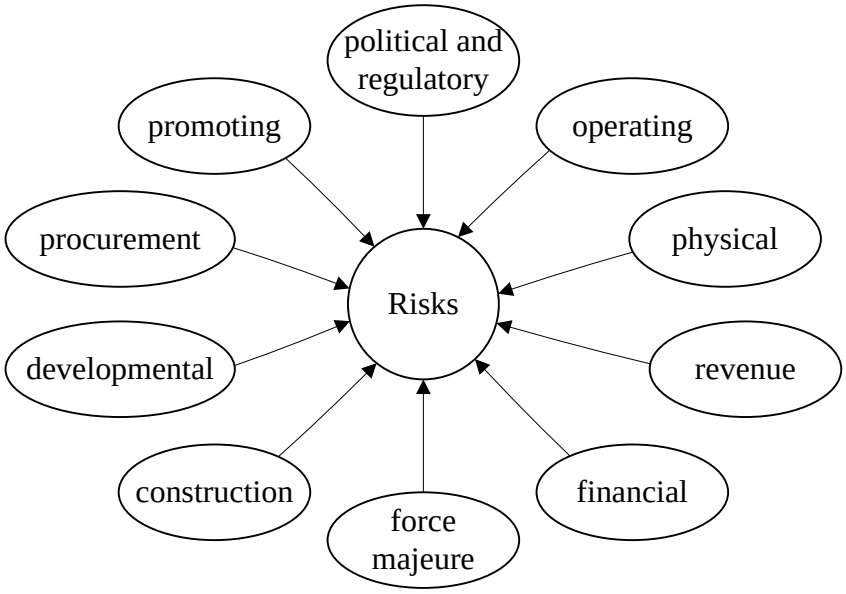

Figure 3.3 Ten sources of risks.

Aleshin (2001) takes another step by integrating Work Breakdown Structure (WBS) and Risk Breakdown Structure (RBS) to analyze the risk existing in the international construction projects in Russian. The sources recommended by this study are technical, management, environmental and commercial risks.

On the basis of RBS, Yuan *et al*. (2008) divided sources of risks into external and internal risks in Figure 3.4. External risks in PPPs are those which are relatively uncontrollable, including inflation and legislative changes (Frilet, 1997; Wang *et al*., 2000). Because of their uncontrollable nature, there is a need for the continual scanning and forecasting of these risks and for the development of the project for managing and controlling the effects of external forces (Yuan *et al*., 2008). Therefore, this risk type contains four risk groups including Political risks, Social risks, Legal risks, and Economic risks, which could strongly influence the achievement of the objectives of PPP projects. Economic risks present the risks caused by external economic environments including local, national and international environments. PPP projects are very sensitive to external economic

environments because of their longer capital chain than typical construction activities. There are some variations concerning economic risks. Stein (1995) includes currency exchange rates, inflation and cost of capital (interest rates) into the scope of economic risks.

Internal risks are relatively more controllable and will vary between projects. For PPPs, different PPP projects have different characteristics, and different PPP types (BOT or Private Finance Initiative). Examples of internal risks include resource availability, the location of the project, and the conditions of contract. Many previous researches (Wang *et al*., 2000; Grimsey and Mervyn, 2002; Akintoye *et al*., 2003a) have achieved a common sense about the stages of a typical PPP project, which includes preparation (procurement process), financing, design and construction, operation, and transfer.

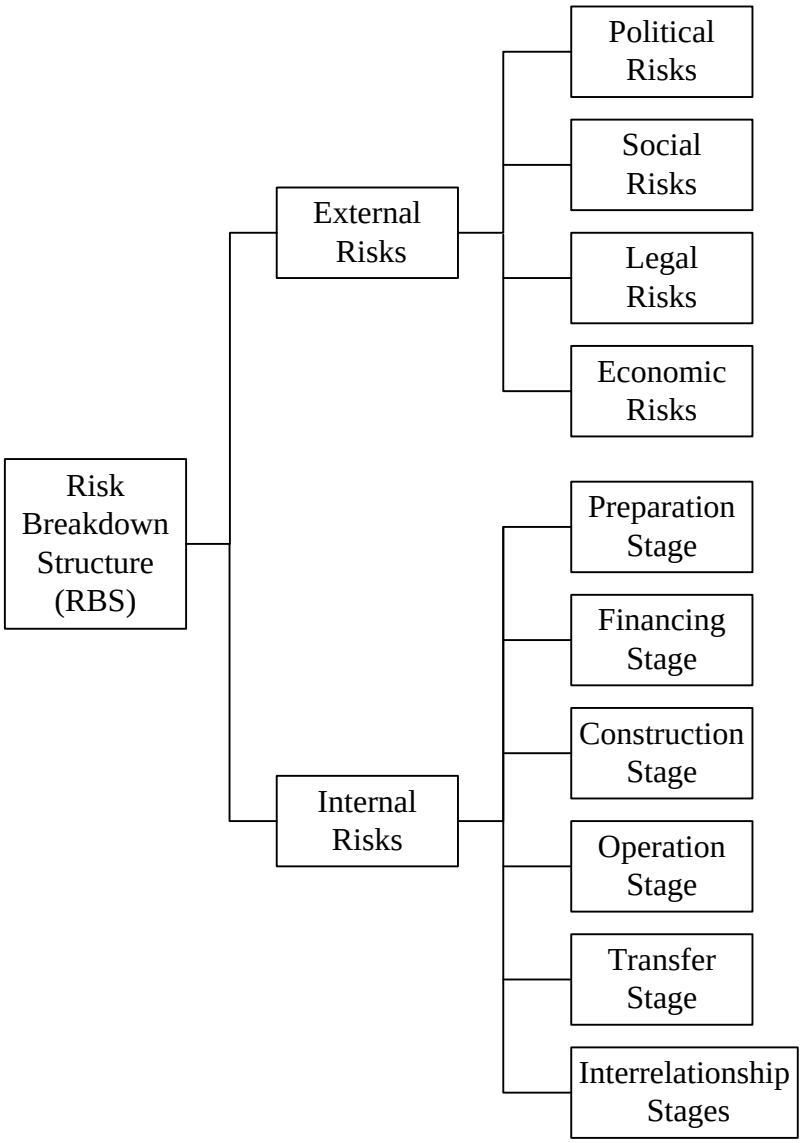

Figure 3.4 Risk breakdown structure.

Unkovski and Pienaar (2009) considered three major types of risks in their study: technical, financial, and legal risks, and concluded that PPP method is considered to be advantageous in South Africa because it is lower in cost and more manageable when compared to using the traditional method where the government finances and delivers the project themselves.

Chen and Shi (2009) defined PPP risks according to two main groups: systematic risks and nonsystematic risks. Systematic risks refer to those that are caused

externally and cannot be controlled by the concessionaire. They include political risk, legal risk, financial risk and contingent risk. Nonsystematic risks are those risks that are related to the project construction and operation. These can include completion risk, operation risk, and market risk.

Besides, Yuan *et al*. (2007) emphasize that in China there are many risks related with politics, economy, and regulation. Policy changes, unclear step-in management, and bureaucracy would result in political risks (*Wang et al.*, 2000; Yuan *et al.*, 2007). Support of government department is an important success factor for PPPs. There is some benefit share and risk distribution between government and private partners which should firstly achieve one kind of mutual forgiveness on the basis of long-time cooperation. In order to effectively implement PPP projects in China, critical risks identification is important for entire risk management system. Chen and Doloi (2008) point out that the China unique risks are all related to or affected by the local government in one way or another. Therefore they advocate that the government should take more responsibility for providing a suitable environment to engage PPP projects. Li and Liu (2009) suggested that to implement PPP projects in China, the risks of the project need to be considered from different angles, including curiosity, long-term risks, complexity, various levels within the project, and different goals of stakeholders.

3.2.3.3 *Risks Assessment*

To evaluate risk criticality, questionnaires are widely employed to rank the identified risk factors through some kinds of scoring system to account for both the probability of risk occurrence and the consequent impact on the project. Zeng

et al. (2008), Roumboutsos and Anagnostopoulos (2008), and Li *et al*. (2005a) reported the rankings of risk factors in China, Greece, and the UK respectively.

Wang and Ke (2008) advocated that a reasonable and practical risk evaluation can help: (1) assess how critical risk factors deter the realization of project objective; (2) assess and ascertain project viability; (3) avoid unsatisfactory projects and enhance enterprise margins. Previous researches on risk evaluation mainly focused on traditional construction projects, and actual empirical research studies targeting PPP projects are still limited (Xu *et al.,* 2010).

Risk assessment is usually performed at the pre-contract stage, when it is still flexible to consider how the risks could be managed (Choi *et al.,* 2010). However, data collection at this stage is frequently not available; therefore, risk criticality cannot be evaluated accurately. Xu *et al.* (2010) presented a fuzzy synthetic evaluation model for assessing the risk level of PPP highway projects based on the data obtained from a two-round Delphi survey. It revealed that political risk is the most significant risk that places critical barriers for PPP highway projects to succeed in China.

Knight and Fayek (2002) applied a fuzzy logic model to predict cost overruns on engineering design projects. Wang and Elhag (2008) developed a fuzzy group decision making approach for bridge risk assessment. Forbes et al. (2008) stated that there are a total of 36 different methods available to identify and evaluate risks. However, the practical application of risk evaluation techniques on construction projects is limited, and it is confined mainly due to a lack of confidence in the technique (Forbes *et al.,* 2008). Li and Zou (2011) presented a fuzzy analytical hierarchy process as a risk assessment technique for a PPP expressway project in China. The results derived slightly different findings that

planning deficiency, low project residual value at the end of the concession period, lack of qualified bidders, design deficiency, and long project approval time were assessed as the top five risks for the project.

3.2.4 Critical Success Factors

3.2.4.1 *Project Success*

Before identifying the Critical Success Factors (CSFs) for PPP urban water supply projects, the definition of PPP project success should first be determined. The concept of CSF was developed by Rockart (1982) as "those few key areas of activity in which favorable results are absolutely necessary for a manager to reach his/her goals". Morledge & Owen (1999) developed the concept of CSF to identify certain weaknesses associated with the practical application of Rockart's method. Six main area of weakness are identified: (1) Subjectivity; (2) Bias; (3) Human inability to process complex information; (4) Change in relation to surrounding environments, time dependency; (5) Imprecise definitions; generalization; and (6) Qualitative performance measures.

According to Rowlinson (1999), CSFs are those fundamental issues inherent in the project that must be maintained for teamwork to take place in an efficient and effective manner. They require day-to-day attention and operate throughout the life of the project. Jefferies *et al*. (2002) mentioned that project success should be evaluated from the whole life-cycle aspect. Yuan *et al*. (2010b) pointed out that project success depends on whether the objectives of key stakeholders have been achieved.

Consequently, different lists of CSFs are developed from these studies. Although similarities can be found, less is known about the relative importance of these CSFs. In this session, the author conducted an extensive literature review, compared and integrated the related researches to establish as comprehensively as possible a checklist of CSFs for urban water supply PPP projects in China to support the building of a negotiation model for potential private promoters as well as for governments.

3.2.4.1 *Critical Success Factor Identification*

The CSF methodology is a procedure that attempts to make explicit the key areas that are essential for management success (Boynton and Zmud, 1984). This method has been used as a management measure in the PPP project related research field since the 1990s.

Tiong (1996) explored the six CSFs and 24 sub-factors in competitive tendering and negotiation model for BOT projects based on the empirical data collected from 32 private promoters and 30 government responses in ten countries and areas including Australia, Canada, Hong Kong, Indonesia, Malaysia, Pakistan, Philippines, Thailand, United Kingdom and United States. Askar and Gab-Allah (2002) discovered the problems faced by the parties involved in BOT projects in Egypt, and pointed out that some CSFs identified by Tiong (1996) are missed in Egyptian BOT projects. It indicated that although BOT projects have similar concept, when applying them in different countries and area, the CSFs may be different.

In China, Qiao *et al.* (2001) established a framework to identify the CSFs in BOT projects, and finally generated 8 independent CSFs: appropriate project

identification; stable political and economic situation; attractive financial package; acceptable toll/tariff levels; reasonable risk allocation; selection of suitable subcontractors; management control; and technology transfer. In Australia, Jefferies *et al*. (2002) summarized 11 CSFs from literature review, and developed a CSF framework including 15 CSFs through a case study to analyze how relevant parties can successfully manage build-own-operate-transfer (BOOT) project procurement;

In the United Kingdom, Li *et al*. (2005a) examined 18 CSFs for PPP and Private-Finance-Initiative (PFI) projects, with factor analysis, the 18 CSFs were categorized into 6 groups. After conducted a comprehensive literature review, Chan *et al.* (2010) adopted the CSFs list generated by Li *et al*. (2005a) to conduct a comparative research in China (including the Hong Kong Special Administrative Region). They also used factor analysis, and the CSFs are divided into 5 groups. The CSFs categories in these two studies are compared in Figure 3.5.

Zhang (2005) and Li *et al*. (2005b) also identify that many private sectors also want to obtain government sponsorship, guarantee and tax reduction by the way of corporation with public sectors, by which a good long-term stable partnership can be established. This kind of partnership is also a successful factor for PPP projects in many previous researches.

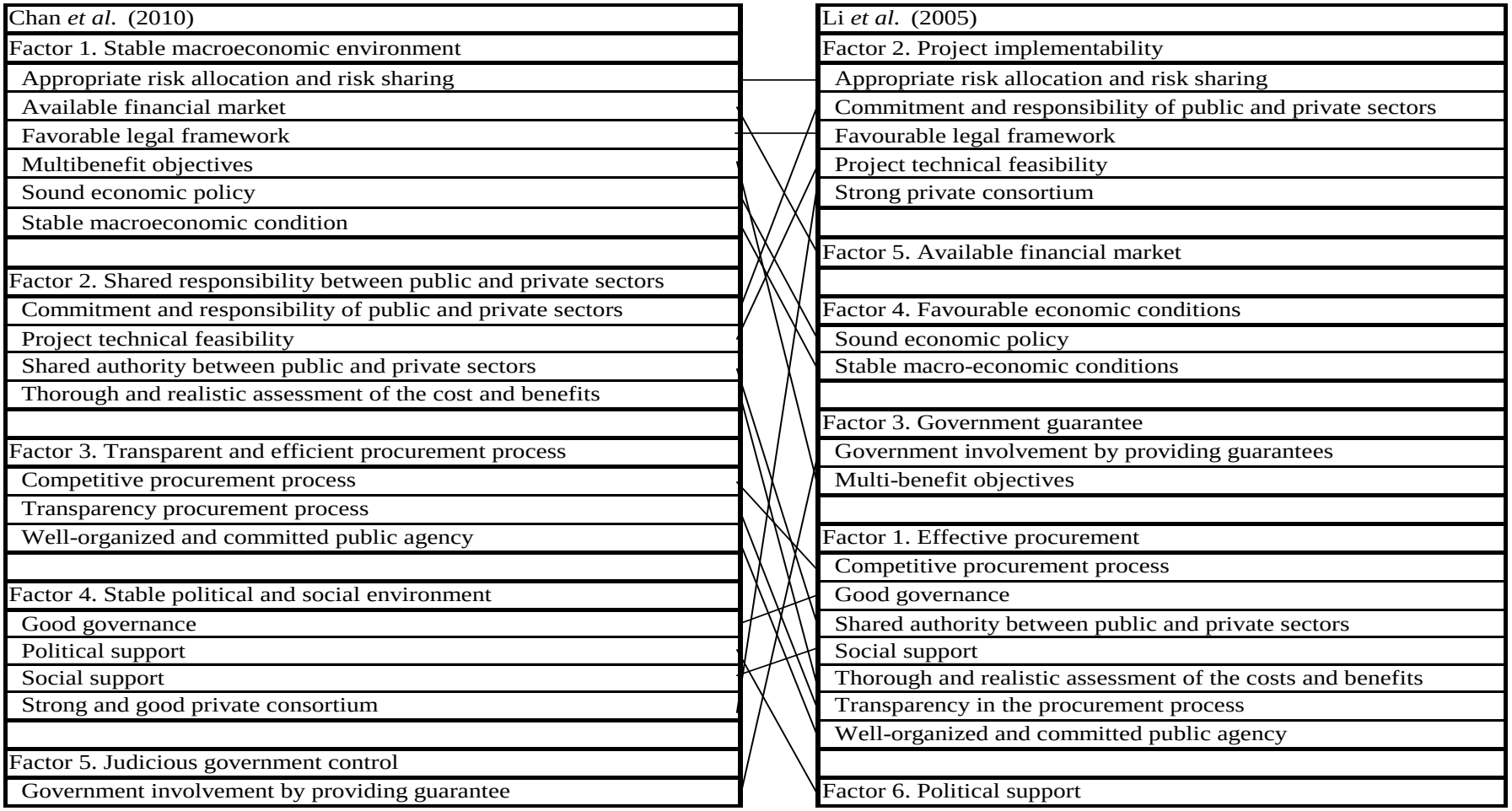

Figure 3.5 Grouping of CSFs for PPP in representative literatures

Meng *et al.* (2011) identified 8 key factors leading to the success of Transfer-Operate-Transfer (TOT) urban water supply projects in China through four real case studies. They measure project success primarily from the government perspective, with due attention to the investor's and public interests. The 8 CSFs are project profitability, asset quality, fair risk allocation, competitive tendering, internal coordination within government, employment of professional advisers, corporate governance, and governmental supervision.

Ng et al. (2012) explore the key successful ingredients to be assessed at the initial stage of PPP projects as perceived public sector, private consortium and general community, via a questionnaire survey and a series of expert interviews conducted in Hong Kong. Tariff, cost effectiveness, financial attractiveness, strong private consortium, and reliable service delivery are all rated as highly importance to the success of PPP schemes.

Tsamboulas *et al*. (2013) identify public acceptance as a vital factor in PPPs, and they suggest that for the purpose of transparency, governmental agencies and other organizations should make their guidance, documentation, and analysis reports accessible to the general public. Frilet (1997) also evaluate social support as the foundation and key factor of PPP project. Especially in China, society and general public, whose participation rights have not obtained effective safeguard. Therefore, the benefits of society and public cannot obtain full and correct reflection, which has harmed base of PPPs. PPPs encourage government to develop good governance on the basis of reasonable framework of law and regulation (Zhang, 2005). While the application of the PPP method in China develops very fast, the laws and regulations are not satisfactory as well as lack of specially legislation about PPP method and the problems of existing standard documents Yuan *et al.* (2008).

Critical success factors identified by previous literatures are compared and analyzed. General factors are broken-down, similar factors are integrated. Finally the identified CSFs are summarized in Table 3.2, related references are also list after the CSFs.

Table 3.2 CSFs of PPP in literatures

CSFs	References
Project profitability	Tiong (1996); Qiao *et al*. (2002); Li et al. (2005b); Zhang (2005); Corbett and Smith (2006); Chan et al. (2010);
Strong private consortium	Qiao *et al*. (2002); Li et al. (2005b); Zhang (2005); Corbett and Smith (2006); Chan et al. (2010); Meng et al. (2011); Ng et al. (2012)
Competitive and transparent procurement process	Qiao *et al*. (2002); Li et al. (2005b); Zhang (2005); Corbett and Smith (2006); Jefferies (2002); Chan et al. (2010);
Appropriate risk allocation and risk sharing	Li *et al.* (2005b); Chan et al. (2010)
Strong government support	Kanter (1999); Li *et al.* (2005b); Chan et al. (2010); Meng et al. (2011)
Good partners' relationship	Li *et al.* (2005b); Zhang (2005); Chan et al. (2010)
Available financial market	Tiong (1996); Li *et al.* (2005b); Zhang (2005); Chan et al. (2010)
Government guarantee	Li *et al.* (2005b); Chan et al. (2010)
Good governance	Qiao *et al*. (2002); Chan et al. (2010)
Stable and transparent political/social situation	Li *et al.* (2005b); Chan et al. (2010)
Effective management control	Tam et al. (1994); Qiao et al. (2001)
Social support	Frilet (1997)； Zhang, (2005); Yuan *et al.* (2008); Tsamboulas *et al*. (2013)

3.3 Urban Water Reform in China

According to Chen and Doloi (2008), the launch of a PPP project in China is either demand driven, policy driven, or efficiency driven. When there is a gap between the increasing need of infrastructure development and the insufficient capital, it will be demand driven; when there is a demand of commercializing infrastructure services and promoting reform in infrastructure investment and financing area, it will be policy driven; while if there is a require of advanced technology and management skills, it will be efficiency driven.

3.3.1 The Gap between Demand and Capital

With the accelerated pace of economic reform, private sector participation in many competitive sectors have achieved favourable results. The limitations of public monopoly in the urban water supply sector gradually unfolded as well. The gaps between increasing demand and shortage of public funding, low efficiency and effectiveness in practice are the main problems that the urban water supply sector facing.

- Increase in Water Demand

As a result of industrialization and urbanization, the demands for water consumption in urban areas have been increasing dramatically since the late 1970s. According to the China Statistical Yearbook issued by the National Bureau of Statistics (NBS), the urban population in 1995 was 351.74 million and reached 669.78 million in 2010, which increased 90.42%. These figures only covered the registered permanent urban residents. If floating population was also taken into account, the people inhabiting urban areas were much more numerous than in the previously mentioned statistical results. During the same period of

time, the water supply for residential use in cities increased from 15.81 billion tons in 1995 to 23.88 billion tons in 2010, which increased 51.01%. By comparison, the increase in urban population is much faster than the increase in urban water supply for residential use. If water for industrial use and other purposes is further considered, the problem of water shortage will become more severe. On the other hand, the renovation of existing water supply facilities is also necessary, as many old water pipe networks are dilapidated (Meng *et al.*, 2011).

- Shortage of Public Funding

Due to the administrative and fiscal decentralization policy, the revenue of the central government has been falling. As a result, local authorities, who are actually responsible for the infrastructure development, must rely on their own revenues and the market mechanism to sustain local infrastructure development. Local infrastructure funding traditionally comprises local tax revenue, loans, and extra-budgetary revenues that made up of user fees, ad-hoc levies, asset-sales, etc. (Mahadevia, 2002). To accommodate the big demands for infrastructure, local governments need new funding sources to invest the new projects.

Traditionally, water supply projects were financed by local governments and operated by state-owned water supply enterprises. Unfortunately, local governments are facing the increasing need for water supply and the great pressure of fund shortage. Figure 3.6 shows the total revenue and expenditure of local government from 1990 to 2010. The total deficit of local government appears exponential growth. In 1990, the total revenue of local government was 194.47 billion Renminbi (RMB, literally “the Chinese people’s currency”) Yuans, whereas the total expenditure was 207.91 billion RMB Yuans. The expenditure to

revenue ratio was 1.07, which meant the expenditure only exceeded the revenue for a small portion. In 2000, this ratio increased to 1.62 with 640.61 billion RMB Yuans' revenue and 1,036.67 billion RMB Yuans' expenditure. By 2010, this ratio further expanded to 1.82 with 4,061.30 billion RMB Yuans' revenue and 7,388.44 billion RMB Yuans' expenditure. The Chinese government believes that PPP is an effective way to ease their financial burden (Liu and Yamamoto, 2009).

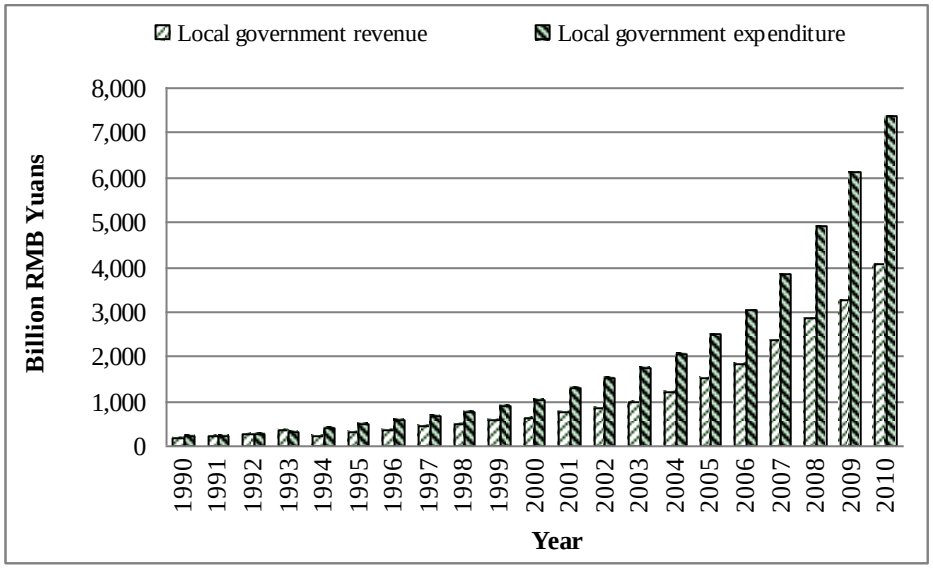

Figure 3.6 Local government revenue and expenditure

- Low Efficiency and Effectiveness in Practice

Urban water supply projects in China primarily remain under state ownership. However, state-owned enterprises are beset with many problems (Chao, 2000). Among them, the most common weaknesses of state-owned enterprises include overstaffing, low efficiency, waste, and high cost. Because most of these enterprises are running under a deficit proposition, the survival of these enterprises often relies on government subsidy. On the other hand, water is a natural monopoly commodity. What the water supply enterprises provided are living necessities therefore competition is quite limited. Besides, state-owned

enterprises lack personnel autonomy. In this situation, staffs in state-owned enterprises usually do not pay enough attention to the customers' concerns and interests. Therefore, they usually cannot provide their customers with satisfactory services.

3.3.2 PPP Policies in China

The applications of PPPs in the urban water supply sector of China have experienced mainly three phases. The remarkable events are summarised in Table 3.3 in chronological order. The first phase is 1949-1994. Since 1949 when China started to establish a socialist regime, "private sector" was officially defined as ''economic organizations that aim at making profit, in which assets are privately owned and which have eight or more employees'' (Provisional Regulations of Private Enterprises in PRC, the State Council, June 25 of 1988), and it has been regarded as politically sensitive. Although economic reform was launched in1978, and the central government decided to transform the purely planned economic system into a market-oriented economic system in 1992 (Mayo and Liu, 1995), the government remained in control of water services, energy provisioning, waste management, and public transport, because "they are closely related to people's lives and economic development. During this period of time, public sectors were not only responsible for financing, but also for building, operating, and maintaining urban utility projects. Few entries into this market were given to private sectors and foreign investors. The purely public approach often caused problems such as a lack of competition and low efficiency and effectiveness in practice" (Kwak *et al*., 2009).

Table 3.3 Remarkable events in the urban water supply sector of China

Year	The Main Event
1978	Economic reform (except water services, energy provisioning, waste management, and public transport, etc.).
1986	"Provisions for the Encouragement of Foreign Investment" promulgated by the China State Council (CSC).
1992	Deepen economic reform (transform the purely planned economic system into a market-oriented economic).
1995	"Circular on Attracting Foreign Investment through BOT Approach" ([1994] No.89 Policy Paper, the former Ministry of Foreign Trade and Economic Cooperation, Jan.16, 1995). The first edition of "Guidance Catalogue of Foreign Investment" issued by the State Development and Planning Commission (SDPC)
1997	The second edition of "Guidance Catalogue of Foreign Investment" issued by the SDPC.
1998	"Provisions for the Assets Reorganization of State-owned Enterprises through the Utilization of Foreign Capitals" issued by the National Economic and Trade Commission (NETC).
2000	"Provisions for the Utilization of Foreign Capitals in Urban Utility Projects" issued by the Ministry of Construction (MOC).
2001	"Suggestions on Facilitating and Guiding the Investment of Private Sectors" issued by the SDPC.
2002	The third edition of "Guidance Catalogue of Foreign Investment" issued by the SDPC. "Principles of Accelerating the Marketization of Public Utilities" (No.272 Policy Paper, the MOC).
2004	"Measures on Public Utilities Concession Management (No.126 Policy Paper, the MOC). "Decisions on the Reform of Investment System" promulgated by the CSC. The fourth edition of "Guidance Catalogue of Foreign Investment" issued by the SDPC.
2005	"Opinions on Strengthening Regulation of Public Utilities" (No.154 Policy Paper, the MOC).
2007	The fifth edition of "Guidance Catalogue of Foreign Investment" issued by the SDPC.

The second phase is 1995-2002. On January the 16th of 1995, the former Ministry of Foreign Trade and Economic Cooperation (MFTEC) promulgated the

"Circular on Attracting Foreign Investment through BOT Approach", which formed the first legal ground for private sector involvement and foreign capital investment in Chinese urban infrastructure. During this period, pilot BOT projects were approved by the National Development and Reform Commission (NDRC). The earlier experiences of BOT projects brought in needed capital and investment to develop China's urban water infrastructure. But it illustrated also many problems. Based on the experiences and lessons learned from pilot projects, the Chinese government formulated more policies to promote PPP. In December of 2001, the State Development and Planning Commission (SDPC) issued "Suggestions on Facilitating and Guiding the Investment of Private Sectors". It is the first time that the central government explicitly encourage the private sector to invest in water supply. In December of 2002, the Ministry of Construction (MOC) formulated "Principles of Accelerating the Marketization of Public Utility Projects", in which the government formally permitted private sectors and foreign businesses to invest in public utility projects through the introduction of concession arrangement and equity transfer of state-owned enterprises. Therefore, the end of 2002 has been widely regarded as a milestone of the establishment of concession system for public utility projects.

The third phase is 2003-date. From late 2002, the full-fledged commitment of the Chinese government to private involvement in the urban water supply sector began to develop. According to the first and second editions of "Guidance Catalogue of Foreign Investment," issued by the SDPC (1995, 1997), foreign investors were prohibited from water plant, water pipe network, and sewage disposal projects in urban areas, however, they were authorized by the third, fourth, and fifth editions (2002, 2004, 2007). Besides, the national policies for regulating PPP projects were gradually improved, and were clearer to follow. In the No.126 Policy Paper issued by the MOC and "Decisions on the Reform of

Investment System" promulgated by the China State Council (CSC) in 2004, they specified the procedure of how to involve the private sectors in public utilities through awarding concession right, where "concession management" refers to all forms of private sector participation. In the year 2005, the MOC issued No.154 Policy Paper to strengthen the regulation of public utilities. This policy paper emphasized that the water sector provide basic public and social goods and that the governmental regulation remains essential (Fu and Zhong, 2005). So far, the Chinese government not only opened the investment channel in the urban water supply sector, but also issued guidance policies, and repositioned the role of the public sector.

3.3.3 Problems facing by the Urban Water Supply Sector in China

In general, if there are no perceived problems with the public sector including high cost and/or low performance, there is usually little incentive for public officials to consider privatization (Nightingale and Pindras, 1997; Megginson *et al*., 2000). To explore the problems associated with urban water supply companies, an empirical questionnaire survey was undertaken in a province. The author contacted the urban water supply association to get the contact information of all registered urban water supply companies in the province. Then the managers of these companies were invited by phone or by face-to-face interview to participate in this survey. The questionnaire contains three parts: in the first part, the participants were asked to evaluate ten problems to see if it is the problem they have been facing; in the second part, they were asked to evaluate the expected benefits of PPP; in the third part, they were asked the willingness to conduct PPP. The first two parts are based on Likert scale, in which 1= not important, 2=slightly important, 3=important, 4=very important,

and 5=extremely important; whereas the questions in the last part can be treated as nominal variables.

In this survey, 131 urban water supply companies were reached, 109 of them fulfilled this survey representing a response rate of 83%. Among the respondents, 36 companies have experienced reform which accounts for one third of the companies. The form of reform is diversified. Most of these companies were restructuring in the form of sharing holdings, in which the staff of the company share the holdings; whereas two of them have had failure in PPP.

3.3.3.1 Problems Perceived

In this survey, ten problems identified from literatures and interviews have been provided with the participants. The results are summarised in Table 3.4. All the problems have been perceived by more than half of the urban water supply companies. Interestingly, comparing with all the problems listed here, the need to construct new water supply facilities is not as urgent as the need to control underground water exploration and improve management efficiency. Figure 3.7 shows the profile of evaluations regarding to each problems. Notably, nearly one third of these companies evaluated budget constrains as the most important problem. The need of controlling underground water exploration is the second according to the percentage of companies that perceive it as the most important problems. More one fourth companies recognize the need to repair existing old water supply pipelines as the most important problem. In addition, one fifth of the companies evaluate low water tariff and water shortage as the most important problems.

Table 3.4 Problems perceived in the urban water supply companies

Ranks	Problems	Accumulative percentage		
		5	4	3
1	Underground water exploration	28.0	79.0	95.9
2	Low efficiency in management	2.8	56.5	90.7
3	Improved water standards	8.3	46.3	88.9
4	Budget constrains	28.7	68.5	87.0
5	Over staffing	10.2	59.3	85.2
6	Water shortage	20.4	62.0	84.2
7	Low water tariff	21.3	63.9	83.3
8	Needing repair old pipelines	25.9	63.0	78.7
9	Non-profitability	13.9	65.7	78.7
10	Needing to build new infrastructure	12.0	49.1	62.0

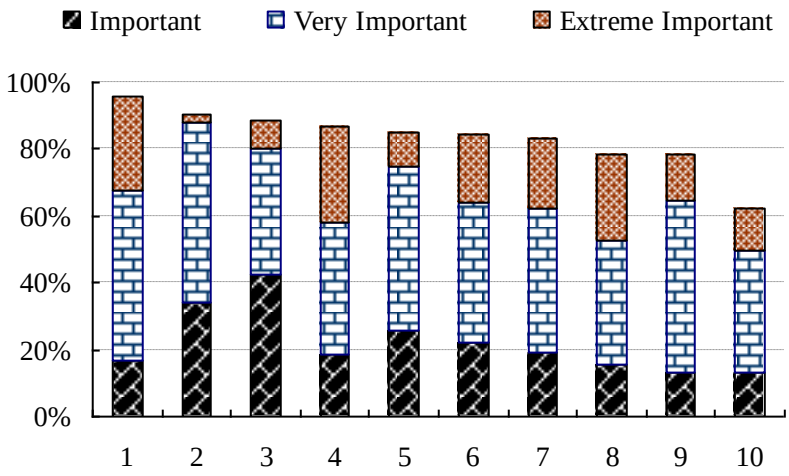

Figure 3.7 Profile of problem identification in urban water supply companies

3.3.3.2 Expected Benefit of PPP

In this section, five aspects of benefits related to PPP are presented to the participants. They can give scores according to their expectation of these benefits. The results in Table 3.5 shows that at least 80% of the companies expect to improve their current situation in the five aspects. Compared with the perceived

problems, participants' attitude toward expected benefit are more moderate in that only a small portion of companies evaluate the benefits as extreme level as shown in Figure 3.8. Notably, 93.5% of the companies expect to improve service quality through PPP. The second expectation is to make profit. It is reasonable because nearly 80% companies are operating at loss. Comparing with other benefits, the desire to get capital from PPP is slightly lower, however still 81.5% companies have this expectation. Through further interview with these companies, it is found that many of these companies are relying on the government subsidy therefore they care more about operation and less about financing.

Table 3.5 Expected benefits for PPP

Ranks	Expected Benefits	Accumulative percentage		
		5	4	3
1	Improve service quality	6.5	50.0	93.5
2	Make profit	7.4	46.3	92.6
3	Save cost	2.8	47.2	88.9
4	Improve management	5.6	58.3	87.0
5	Fill capital gap	1.9	47.2	81.5

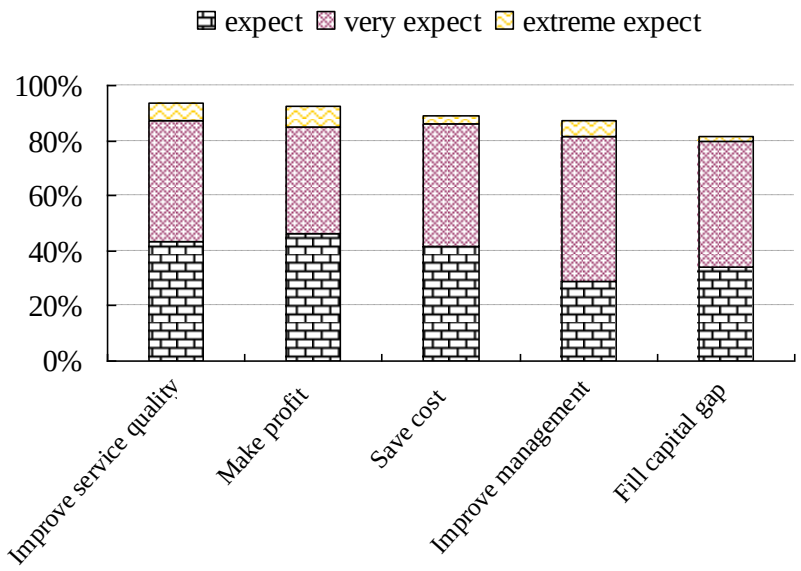

Figure 3.8 Profile of expected benefits

3.3.3.3 Willingness on PPP

Some open-ended questions are also investigated in this survey. Inquiries and results are summarised in Table 3.6. For those companies that have not experienced reform, more than half companies do not know that government has permitted private sector to invest in urban water supply sector. 37% companies are aware of the PPP policies. Surprisingly, only 5.5% of the companies have the willingness to involve PPP, although 88.9% companies believe PPP will have positive impact on urban water supply service. Through in-depth interview, several reasons of the inactive response toward PPP can be summarised. First, some managers declare that they do not have the right to consider this issue, and they have to follow the decision made by the government. Second, as overstaffing is a common problem in urban water supply companies, the replacement of the redundant employee is a critical issue. Third, the concern is that private sector may seek for profit and ignore the affordability of users. Fourth, some managers allege that the urban water supply companies are operated under losses, therefore it is difficult to find investors that may be interested in them.

Table 3.6 The urban water supply companies' willingness toward PPP

Questions	Aware	Unaware
Permission of private sector to invest in urban water supply sector	47.9%	52.1%
PPP policy	37.0%	63.0%
Willingness to contract out	5.5%	94.5%

3.4 Experiences and Lessons from Empirical PPP Practices

According to Meng et al. (2011), more than 20 PPP water supply projects have been implemented in recent years, many of which are successful, but unfortunately some of which are not successful. In this research, four case studies have been analyzed. Each case study has its characteristics.

3.3.1 Chengdu No.6 Water Supply BOT Plant (B)

The earlier experiences of BOT projects brought in needed capital and investment to develop China's urban water infrastructure. But it illustrated also many problems. The issue of the fixed investment return to investors was one of these problems. After intensifying control over foreign exchanges and loans in the late 1990s, the General Office of the State Council promulgated a specific circular in 2002 to correct foreign investment projects with fixed investment returns, by modifying the relevant contract terms, buying back all shares of foreign investors, transferring foreign investment into foreign loans, or dismantling contracts with often severe losses.

As implementation problems were slowly or not adequately addressed or resolved at the national level, local governments started to issue local policy papers on specific water projects. For instance, the Interim Provision on Administrating Concession Right of Chengdu (No.131 Policy Paper of Chengdu Municipality, 2001) was issued for implementing the BOT project of Chengdu No.6 Water Supply Plant (B), which was the first water BOT pilot project approved by the NDRC.

3.3.2 YN Water Plant

The YN Water Plant is located in a county near the border line. The new town of the county is identified by the provincial government as one of the special zones in the year 2000, and special management and special preferential policies will be applied in this zone. This zone has a total area of 6.5 square kilometres. The design capacity of tap water per day was 7,000 tons. The first phase of water facility construction which provides 3,500 tons per day tap water was completed and put into operation in 2007. To raise funds for completing the designed water supply capacity, in 2009, the local government decided to find a private investor to construct the new water supply facility and operate the whole water supply service in the county.

Although field investigation was conducted and several rounds of negotiations were made, the local government and the investor finally failed to reach an agreement on some critical points. From the government point of view, this project should be attractive to investors. Firstly, special preferential policies will be applied in this special zone. Secondly, they have a long-term contract for supply of water to boundary city outside China. Thirdly, the water resource is abundant for the water supply company to utilize. The water plant is located at a higher elevation, after treatment, water will run down to the users in town rely on gravity, so that power costs will be relatively low. Besides, as all the facilities were newly built, the maintenance expense will not be high. Moreover, based on the information provided by the government, the annual return will reach 16%. While from view of the private sector, this project is risky in mainly two aspects. Firstly, overseas output water consumption accounts for more than a half of the estimated water demand. This increases political risk in that changing of boundary policy may influence the water demand dramatically. If over sea output

is abolished, the annual return will be negligible. Secondly, it is difficult to find appropriate local management personnel.

The reasons of failure can be attributed to the ineffective communication. Although government hoped to find a partner from private sector, they felt difficult to ensure the annual return rate for investor. In addition, they haven't considered the compensation mechanisms for potential risks to the private sector carefully. Indeed, it is difficult to make reasonable compensation plan for this complicated long-term projects.

3.3.3 Well-known PPP Projects

Experiences are drawn from empirical studies and PPP practices as shown in Table 3.7. Veolia Water, as a concessionaire, entered China in the 1980s and now manages 22 municipal contracts in China. Its service covers design and build, operation and maintenance, as well as full service concessions including distribution and customer services. The first 20-year water management contract with Veolia Water was signed in the city of Tianjin in 1997 for the renovation, operation and maintenance of a water plant. Later in 2002, Veolia Water signed a 50-year full-service water contract for Shanghai's Pudong business district. In the following year, a 50-year municipal outsourcing service contract for water and wastewater in Shenzhen was signed. Valuable experiences are learned from these projects. In addition, lessons are learned from failing PPP projects, such as Shenyang No.8 Water Plant and Shanghai Da Chang Water Plant. From these case studies, it is concluded that factors including project profitability, fair risk allocation, and internal coordination within government are critical to the success of the implementation of PPP projects in the urban water supply sector in China

(Xu et al. 2011). Furthermore, information asymmetry is found to be the most fundamental reason for project failure and ineffective negotiation.

Table 3.7 General information of selected PPP water supply projects in China

Project name	Concessionaire	Year of contract signed	Concession period	Status
Chengdu No.6 water plant B	Veolia & Marubeni	1999	18 years	Disturbed - in operation
Lanzhou water supply	Veolia	2007	30 years	In operation
Shanghai Da Chang water plant	Thames	1996	20years	Withdraw in 2004
Shanghai Pudong water supply	Veolia	2002	50 years	In operation
Shenyang No. 8 water plant	Suez	1995	30 years	Terminated in 2002
Shenzhen water group	Veolia	2003	50 years	In operation
Tianjin Lingzhuang water plant	Veolia	1997	20 years	In operation

3.5 Interviews with Experts and Experienced Practitioners

In addition to literature review and case studies, interviews with PPP experts and experienced practitioners from public sectors, private sectors, and academic organizations have also been performed. Those experts and practitioners include: 10 practitioners from public clients, 5 consultants, 5 concessionaires, 3 contractors, 10 financiers, 3 lawyers, 3 central government officials, 12 local government officials, and 5 academic experts. In the course of interviews, both specific questions regarding a particular PPP project and general questions regarding the general practice of PPPs in urban water supply projects in China have been discussed. To ensure effective data collection, multiple interview techniques were taken, which includes face-to-face conversation, telephone calls, and e-mail communication. Many experts emphasized that to invest in water supply projects in China, the investors are required not only to have financial

analysis and operating capability, but also to be able to understand the nature of the project, the local and national policies and regulations, and be familiar with local investment environment and local culture as well.

3.6 Generation of Checklist

In the process of DMF identification, risk factors, driving factors, impeding factors, and success factors which identified in previous studies, as well as experiences and lessons learned from PPP practices were further analysed, distilled, and coded. General concepts were broken down, whereas similar points are merged. After these, the generalized DMFs list was reviewed by PPP experts and experienced practitioners, leading to the final checklist of the DMFs.

CHAPTER 4 A NOVEL DMF EVALUATION SCHEME FOR PPP PROJECTS

The road to winning and managing a PPP project successfully in China is not easy. The process is complex, time-consuming and expensive. In addition, the success of each phase determines the fate of the next phase. Previous chapters illustrated the necessity of establishing a reliable, practical, cost-saving and efficient project evaluation schemes to facilitate decision making. In this chapter, this scheme is proposed, and the feasibility of each step of this scheme is clarified.

4.1 Structure of the Evaluation Scheme

In previous chapters, two research gaps are identified. The first is that although a lot of studies have focused on the evaluation of factors in a specified area, in the actual decision-making process, decision-makers make a judgment directly on the issues they care about, and will not deliberately distinguish the type of the factor. Therefore, there is a need to provide an integrated checklist for the decision-makers to evaluate, and this checklist should include all the kinds of factors: driving factors, impending factors, objectives, risks, and critical success factors. The second research gap is that the published models for evaluation have not revealed the differences of experts that representing different partners. Therefore in this study a seven step scheme, as shown in Figure 4.1, is established to remedy the insufficiency. The detailed instruction of each step is illustrated in the following sections.

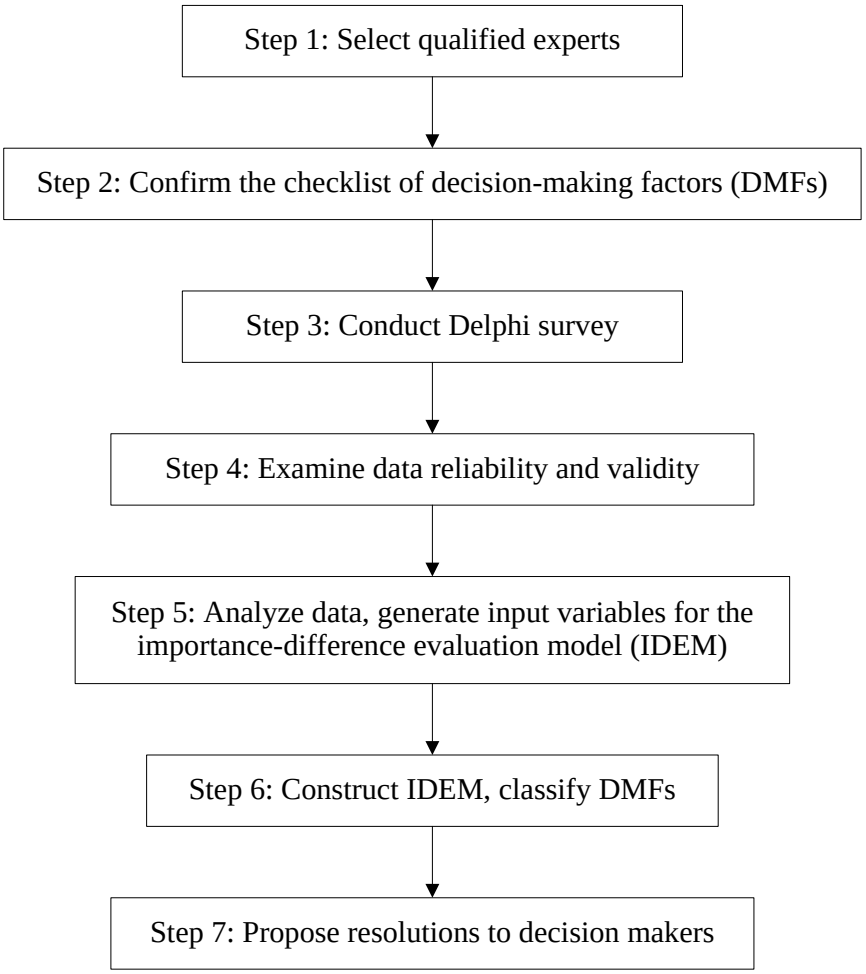

Figure 4.1 Structure of DMF evaluation scheme

4.2 Selection of Expert Panel

The central premise of this study is that different partners in a PPP project have different objectives. This scheme is applied to settle disputes that occur in any stage of the project by discovering the critical and controversial factors. In PPP projects, disputes generally occur between the public sector and the private sector. For an urban water supply project, the private sector refers to the investor, whereas the public sector refers to the government. As the decisions made related to urban water supply may have essential impact on people's livelihood, it is necessary to solicit the opinions for the full rang. Therefore, five responsible persons on each side are required to be selected into the expert panel.

For the private sector, the representatives should include at least one investor, the general manager, the financial manager, the technological manager, and the customer manager. For the public sector, similar composition of representatives is required, but it is more complicated in personnel selection due to the complex structure of government. A recommended spectrum would be the mayor, the vice mayor in charge of civil construction, the vice mayor in charge of finance, officer of housing and urban-rural development bureau/department, and officer of water resource bureau/department.

4.3 Checklist of DMFs Confirmation

The basis of DMFs identification is historical data and relative experience. However, similar DMFs cannot be duplicated in different projects. If the most important DMFs cannot be identified, it will strongly affect the performance of PPP projects. Systematic identification methodology should be established to find the most critical DMFs, which can be applied in specific projects to completely and correctly solve disputes.

The procedure of DMFs confirmation is recommended. Firstly, identify the status of the project. In the present study, the cut-off point is the moment that signing the contract. The period before the signing of contract is preparation stage, whereas the time slot after the signing of contract is the implementation stage. In the preparation stage, the DMFs may include driving factors, impending factors and risks. In the implementation stage, the DMFs may include objectives, risks and the problems encountered. The draft checklist of DMFs can be selected from this research in Chapter 3. After that, the checklist should be provided to all the experts in the panel for review. In the review process, every expert can add or

delete DMFs according to their experiences and perceptions on the project. The factor should be added if anyone expert has proposed it, whereas the factor can only be deleted when all the experts have deleted it. After that, the final checklist of DMFs is formed.

4.4 Delphi Survey

The Delphi survey method fits best when there are no adequate historical data for adopting other methods (Martino 1973). Also, it is typically used to provide a judgment or opinion on a specific subject area, rather than to produce a quantifiable measure or result (Linstone and Turoff 1975). Regarding the nature of this study, adopting Delphi survey method is appropriate. In the process of Delphi survey, a series of intensive questionnaires interspersed with controlled opinion feedback are provided to the experts. This means the consolidated results of each round will be fed into the next round. Therefore, it is possible to extract the maximum amount of unbiased information from a panel of experts.

Implementing Delphi requires conducting several rounds survey until the consensus is reached. In the first round, participants are requested to rate every DMF with respect to its importance based on a five-point Likert scale, in which 1= not important, 2= possibly important, 3= important, 4= very important, and 5= extremely important; In the next round, participants are presented with the group responses of DMFs' mean scores and rankings from the previous round, seeing if they want to adjust their original determinations. The returned questionnaires should be checked and edited to ensure completeness and consistency. When no participant wants to changed his ratings, it arrives at the end of the survey.

In the Delphi survey, results are produced from the judgments made by experts instead from previous historical data. Therefore, the procedure for expert panel selection is essential to the success of survey. In this scheme, all the experts are required to be the responsible persons that involve in the project therefore data collected from them will be reliable and informative. Besides, in a Delphi study, the number of participants varies generally from 3 to 15 (Rowe and Wright 1999). This scheme requires 5 experts from public sector and 5 experts from private sector. This requirement is reasonable.

4.5 Data Analysis Techniques

4.5.1 Mean Score Ranking Technique

Mean is the most widely used and reported measure of central tendency (Lind et al. 2002). Mean score (*MS*) is applied in this study to establish the relative importance among DMFs. *MS* for each DMF is computed by Eq. (1) basing on the five-point Likert scale.

$$MS = \frac{\sum (f \times s)}{N}, (1 \le MS \le 5) \quad (1)$$

where:

s: score given to a particular DMF by the expert, ranges from 1 to 5 (1=Not Important and 5=Extremely Important);

f: count of numbers of a particular score (1–5) given on a particular DMF;

N: number of experts who gave scores on a particular DMF.

The *MSs* of DMFs are used to determine the rankings in different groups. Then, the *MSs* together with the rankings are compared across groups to triangulate the relative importance of the DMFs and reveal the differences of preferences on DMFs between different interest groups.

4.5.2 Cronbach's Alpha

Cronbach's alpha is a coefficient of internal consistency. It is commonly used as an estimate of the reliability of psychometric test scores for a sample of examinees. The statistic can be defined as:

$$\alpha = \frac{K}{K-1}\left(1-\frac{\sum_{i=1}^{K}\sigma_{Y_i}^2}{\sigma_X^2}\right) \quad (2)$$

where:

α : Cronbach's alpha;

K : number of DMFs;

σ_X^2 : variance of the observed total test scores;

$\sigma_{Y_i}^2$: variance of i^{th} DMF for the experts.

Theoretically, alpha is the ratio of two variances. Empirically, Alpha varies from negative infinity to 1. The smaller the value of $\sum_{i=1}^{K}\sigma_{Y_i}^2$ is, the higher the value of alpha produces. Therefore, higher value of alpha indicates a higher degree of reliability.

4.5.3 Kendall's Concordance Analysis

Kendall's coefficient of concordance (*W*) is a non-parametric statistic. It can be used for assessing agreement among evaluators. Kendall's *W* varies from 0 (no agreement) to 1 (complete agreement). It can be calculated by Eq. (3) (Siegel and Castellan 1988), however, when the number of attributes is greater than 7, chi-square, which is calculated by Eq. (4), is used as a near approximation instead.

$$W = 12\frac{\sum_{i=1}^{n}(R_i - R)^2}{p^2(n^3 - n) - pT} \tag{3}$$

$$\chi^2 = p(n-1)W \tag{4}$$

where:

W: Kendall's coefficient of concordance;

n: number of DMFs being ranked;

R_i: ranks assigned to the i^{th} risk factor;

R: mean score of the R_i values;

p: number of respondents;

T: correction factor for the tied ranks.

If the value of chi-square exceeds the critical value at some significance level (usually 0.05), then *P* is smaller than 0.05. It indicates agreement among the respondents. Otherwise, it is concluded that there is no overall trend of agreement among the respondents, and their responses may be regarded as essentially random. Hence the results of the evaluation are regarded invalid.

4.5.4 Mann Whitney *U* Test

The Mann Whitney *U* test is a nonparametric statistical hypothesis test for assessing whether one group independent observations tends to have larger values than the other. Under the null hypothesis the distributions of both groups are equal, so that the probability of an observation from one population (*X*) exceeding an observation from the second population (*Y*) equals the probability of an observation from *Y* exceeding an observation from *X*, that is, there is a symmetry between populations with respect to probability of random drawing of a larger observation. Under the alternative hypothesis the probability of an observation from *X* exceeding an observation from *Y* (after exclusion of ties) is not equal to 0.5. The alternative may also be stated in terms of a one-sided test, for example: $P(X>Y) + 0.5\,P(X=Y) > 0.5$. The statistic of this test is *U*, which is compared to a table of critical values based on the sample size of each group. If *U* value exceeds the critical value at some significance level (usually 0.05), then *P* is smaller than 0.05, and the null hypothesis is rejected, therefore it is concluded that there is significant evidence to show the difference between the two groups. Otherwise, there is no sufficient evidence to reject the null hypothesis, and it is concluded that there is no significant difference between two groups.

4.6 Construction of IDEM

This model is constructed in two dimensions. One dimension uses the mean score of importance calculated basing on all the participants' evaluations as the overall importance parameter. The second dimension uses the degree of difference between public sector and private sector on evaluating the importance of each DMF. The degree of difference is generated by Mann Whitney *U* test.

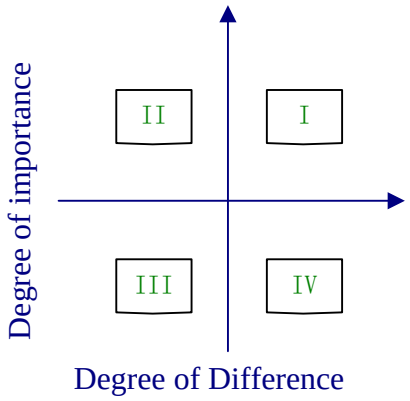

Figure 4.2 Sketch map of IDEM

This model takes into account the mean scores of importance as well as different opinions between sectors. Figure 4.2 is an illustration of the IDEM. With IDEM, DMFs can be divided into four quadrants by X-axis and Y-axis. Y-axis represents the importance level of DMFs. The mean scores in the overall evaluation are taken as the values for Y-axis, from 1(not important) to 5(extremely important). X-axis represents the level of difference/agreement on opinions between the public and private sectors.

For various evaluation results from different experts, it is necessary to extract the essential information based on a large number of evaluation data. In other words, an importance boundary is a requisite for distinguishing each factor with different importance degrees. The determination of importance boundary can be converted into a 1-dimensional data clustering problem. In data mining, k-means clustering algorithm is a very useful and effective method to partition a number of observations $X = (x_1, x_2, ...x_n)$ into k clusters $S = (s_1, s_2, ...s_k)$. It is designed to cluster n observations into k sets with the nearest mean (i.e. minimize the within-cluster sum of squares). Mathematically, it can be expressed as follow:

$$\min \sum_{i=1}^{k} \sum_{x_j \in s_i} \| c_i - x_j \|$$

Where c_i is the centroid (i.e. the mean of points in S_i) of cluster *i*.

In this case, all evaluation data is expected to be clustered into two sets. According to all experts' evaluations, two clustered sets distinguish data which is important and less important, respectively. Based on k-means algorithm, an improved MATLAB program is constructed to overcome the drawbacks of traditional k-means MATLAB program. It features the following two aspects:

i) A heuristic iteration number is produced. This is designed to avoid local optimum.

ii) A clone original data set is constructed. This is designed to clarify the cluster boundary.

The improved MATLAB program is based on the original function of MATLAB (i.e. kmean.m).

Based on k-means algorithm, the importance boundary is formulated as:

$$boundary = \frac{\min\{x_i \mid x_i \in s_1\} + \max\{x_j \mid x_j \in s_2\}}{2}, \quad (c_1 > c_2)$$

4.7 Category of DMFs

In IDEM, DMFs in different quadrants have different indications. The first quadrant indicates that although differences on opinions between the public and private sectors are significant, DMFs in this quadrant are regarded very important in the overall evaluation. In the second quadrant, the DMFs are regarded very

important in the overall evaluation, and received agreements between two sectors on their evaluations. The third quadrant suggests that DMFs in this quadrant are not as important as those in the first two quadrants and no significant difference on opinions between the public and private sectors. The fourth quadrant discloses that the DMFs are evaluated not as important as those in the first two quadrants; however, the differences on opinions between the public and private sectors are significant. Therefore, attentions should still be paid to these DMFs.

CHAPTER 5 APPLICATION OF DMFS EVALUATION SCHEME

A novel DMFs evaluation scheme is established in the previous chapter. The purpose of the scheme is to assist the decision-makers to screen the DMFs so as to identify the causes of disputes and propose appropriate counter measures. In this chapter the evaluation scheme is exercised in a real case study to examine the validity, feasibility and reliability of the scheme. Following the application of the scheme, interviews with the participants are conducted to get feedbacks of this scheme. Furthermore, this chapter explores the predicament encountered by the government owned water supply enterprise, attempts a trial of interpretation between those problems. A picturesque case is provided to get a clear insight into the implementation of PPP, and thus makes it possible to trace the root of problems confront along PPP implementation and seek suitable solutions.

5.1 Objectives of Case Study

The elaboration of theoretical issues related to the objectives of study can provide essential guidance to select appropriate cases. As the study investigate how PPP can produce distinctive outcomes, the unit of analysis should have been involved in a PPP. Only a small number of cases could be the subject of study, because this study wanted to collect data extensively from each arrangement—collecting data directly from each of the participating organizations rather than covering just the lead organization. This constraint was again based on theoretical issues because this study desires to investigate the dynamics of each arrangement and not just to apply some input-output framework.

The purpose of this chapter is to describe the initiatives taken by a small-scale water supply project procured under the PPP model in improving performance and insuring reliable water supply service. An institutional analysis (Grigg, 2005) was conducted among government officers, investors, managers, staff and customers of the water supply enterprise. With the measurement instrument designed and widely tested by the Water and Sanitation for Health (WASH) Project as a reference (Cullivan *et al*., 1988), this study aims to explore the following research questions:

(a) What was the situation of water supply service before the introduction of PPP?
(b) Why is there a need for introducing PPP in the provision of urban water supply service?
(c) What kind of problems occur implementing PPP?
(d) How to evaluate the outcome of PPP?
(e) How to provide an operating environment conducive to foster the success of PPP?

5.2 Data Collection and Case Selection

Multiple data-gathering techniques in this institutional assessment were applied: interview, observation, document reading and paper and pencil surveys. Field investigations and customer surveys were also carried out to evaluate service quality. The feedbacks gathered from the process are put forward along the discussion. The challenges towards the implementation of PPP have also been highlighted.

As the objective is to investigate the dynamics of decision making process, multiple sources of evidence should be collected extensively, thus only a small numbers of cases could be the subject of this study. To explore the impacts of involving PPP on water supply industry, the case to be studied would be in which routinization of PPP was known to have occurred, so that the entire routinization process could be studied, and the data had to be collected retrospectively. This case emphasizes actual behavioral events in the routinization processes, in contrast to an alternative methodology focusing on people's perceptions. There are only a few successful PPP projects in China to select. However, for the cases where PPP has taken place for a certain time period, it is difficult to get the first hand information required. To meet all the requirements, the research team carried out a pilot PSP try-out in a county level water supply project.

5.3 Case Background

The selected case is located in a county of a big agricultural province in central China. It is an ancient town undergoing rapid economic development. The earliest piping networks for water supply were constructed in 1978. Although the town has an average annual rainfall of 803.9 mm, there is no catchment to store rainwater. Therefore, the river passing through the town is the sole water resource available, and the water quantity and quality highly fluctuate with seasons. In around year 2000, although water quality in the river was deteriorating due to pollution, no appropriate water treatment measures were adopted. Moreover, due to the lack of maintenance, 90% of existing water supply pipelines had leaking or blocking problems, thus needing replacement. As the water supply service was then very unreliable, people began opening their own

water wells to get potable water, which brought about environmental problems and health concerns. The county government had tried hard to solve the water service problems. Unfortunately, at that time, there were a number of areas competing for investments, and the county government was unable to rise the needed funding for rehabilitating the water services.

Figure 5.1 Map of urban Water Distribution Network in *City N*

The water service problems were exacerbated by population growth (from 70,000 in 2000 to 100,000 in 2006) which made expansion of the existing water supply infrastructure and exploration of a reliable water resource desperately needed so as to meet the increasing water demand. Through investigation, a water resource with sufficient water storage and better water quality was found 10km from the town. Through a loan borrowed from the central government in 2004, the county government decided to build a piping line to transmit water from that water resource to the town. This piping line was originally expected to put into use in 2006. Nevertheless, the water distribution network and water utility in the town were dilapidated. Since the hope that the central government

would support the construction of new water supply infrastructure was elusive, introduction of PPP became a more feasible approach for the county government as more legal, administrative and tariff-setting restrictions on foreign investments in public service delivery had been lifted by the central government.

Through negotiation, a foreign investor signed a contract with the county government in May 2006, and started to construct a new water treatment plant. In August 2006, the investor began to take over the water supply service in the town. In May 2007, construction of the new water treatment plant was completed, and water from the new water resource could then be transmitted to the plant for treatment before supplying to the town. It was expected that the involvement of PSP could reconstruct water distribution networks in the county step by step and provide reliable water supply.

5.4 Necessity of Involving PPP

5.4.1 Unreliable Water Supply Service

Water quality is a critical issue as it related to the health concern. The water provided to customers was pumped from the river passing through the town. Although the town has an average annual rainfall of 803.9 mm, there is no catchment to store rainwater. Therefore, the only available water resource in the town is the river. However, the water quantity and quality highly fluctuate with seasons. As a result of industry development and increasing water consumption, water quality in the river has been deteriorating due to pollution. In order to supply adequate water which meet the national standards to the customers, new water resource must be found. Through investigation, a water resource with

sufficient water storage and good water quality was found 10km away outside the town. With a loan borrowed from the central government in 2004, the county government decided to build a piping line to transmit water from that water resource to the town.

However, even if new water resource is available, when they arrive at the end users, they will still be contaminated by the existing water distributing networks. Actually, due to the lack of maintenance, 90% of City N's existing water supply pipelines had leaking or blocking problems. As a result of this, customers who live third floor or above could hardly get water. Moreover, the supply of water always got interrupted by pipeline bursts. Therefore, it is essential to have a replacement of the pipelines. Besides, rapid urbanization and population growth made expansion of the existing water supply infrastructure desperately needed so as to meet the increasing water demand. Unfortunately, the county government could not afford to support such a huge financial burden.

5.4.2 Loss of Customers

As the water supply service was then insufficient and very unreliable, many users began opening their own water wells to get potable water, which brought a series of environmental and social problems. First, overexploitation of underground water resources may cause serious environmental problems such as ground subsidence, salinity intrusion, and ecosystem deterioration (Cai and Ringler, 2007; Xia *et al.*, 2007). Second, water quality cannot be secured if users directly take raw water to use, which raises the problem of health concerns. Third, when some users are able to use free water, more and more users will follow them. When they use water free of charge they will not save water, thus the actual water consumption will increase, which then aggravate the problem of water

scarcity. Moreover, water scarcity and dissatisfactory water quality are interacting with each other and threatening food safety, economic development and quality of life in China.

5.4.3 Negligible Cost Recovery

The main revenue of a water supply enterprise is the income of water sales. However, the unreliable water supply service can hardly keep stable customers. When users have option to use water for free, they will not like to pay for the water supplied by the water supply enterprise. Unaccounted-for water (UFW) is an indicator to reflect performance of water sales, which is the fraction of water produced, but NOT sold.

Water supply enterprise can only charge water bills according to the readings on water meters, thus the costs of producing unaccounted-for water should be digested by water supply enterprise itself. A smaller UFW ratio indicates that the water supply enterprises could get higher water sales revenue for supporting their survival and development. In general, UFW ratio below 10% is regarded as good performance. For water utilities in low-income areas, where the water distribution systems are relatively old (of over 30 years old), their UFW ratios usually do not exceed 30%. Regarding the small scale of water distribution network in City N, the UFW ratio should have been lower than 30%. However, it was as high as 90%, which means that only 10% of the water produced could obtain payment from the customers. It is evident that the cost of recovery was negligible. Under such situation, the water supply enterprise in City N could hardly survive.

5.4.4 Poor Operational Performance

Low Efficiency

The water supply enterprise in City N can hardly get revenue from water sales, thus even its daily operation was dependent on the subsidies from the local government. Under this situation, staffs were not willing to take responsibility of their work. Similar with other state owned enterprise, over staffing is a common problem. This could be substantiated by an indicator, the number of employees per 1000 connections, which used for measuring operational efficiency. Generally, less than 4 employees per 1000 connections can be regarded as efficient. However the water supply enterprise in City N had 20 employees per 1000 connections. Such sufficient staffing did not help to improve its service quality and productivity.

Service Coverage

Many other performance indicators also showed that the water supply enterprise under government operation had low effective and productivity. Service coverage is considered as a concept expressing the extent of interaction between the service and its intended customers. This interaction is not limited to a particular aspect of service provision, but ranging over the whole process from resource allocation to achievement of the desired objective. The evaluation of coverage on the basis of such concept enables the management to identify the bottlenecks in the operation of the service, to analyse the constraining factors responsible for such bottlenecks, and to select effective measures for service development. For the measurement of coverage, the ratio between the number of people for whom a certain condition is met and the target population can be used. In this case, the

former is the number of registered connections, while the target population can be estimated based on the connections of electricity users, as water supply service and electricity supply service are similar in their distribution strategies. Service coverage of water supply in City N was 37%, which is an unreasonably low ratio, indicating that more than one half of the electricity users did not use water supply service and implying that the development of water supply service was sluggish.

Active User Ratio

The active user ratio (AUR) is the ratio between the number of connections who pay their water bills regularly and the number of total registered connections. AUR of water supply in City N was 40%, which means that more than one half of the connections did not use water supplied by the water supply enterprise or they did not regularly pay for the water they used.

Metered Connection

Metered connection is the ratio between the number of connections which are reachable by the staff of water supply enterprise to take records of the water meters regularly and the number of total registered connections. The ratio of metered connection in City N water supply was 70%, meaning that one third of the registered users could not be found in reality for various reasons, including changes in property owners, re-planned streets leading to changes in correspondence addresses and so on, as the water supply enterprise in City N did not have a system to update user information.

The water service problems were exacerbated by population growth (from 70,000 in 2000 to 100,000 in 2006) which made expansion of the existing water supply infrastructure and exploration of a reliable water resource desperately needed so as to meet the increasing water demand. Through investigation, a water resource with sufficient water storage and better water quality was found 10km from the town. Through a loan borrowed from the central government in 2004, the county government decided to build a piping line to transmit water from that water resource to the town. This piping line was originally expected to put into use in 2006. Nevertheless, the water distribution network and water utility in the town were dilapidated. Since the hope that the central government would support the construction of new water supply infrastructure was elusive, introduction of PPP became a more feasible approach for the county government as more legal, administrative and tariff-setting restrictions on foreign investments in public service delivery had been lifted by the central government.

5.5 Involvement of PPP

5.5.1 Investment from Private Sector

Through negotiation, a foreign investor signed a contract with the county government in May 2006, and immediately invested to construct a new water treatment plant. In August 2006, the investor began to take over the water supply service in the town, and renamed the water supply enterprise as City N Water Supply Company Limited (WSCL). In May 2007, construction of the new water treatment plant was completed, and water from the new water resource could then be transmitted to the plant for treatment before supplying to the town. As existing water distribution network was dilapidated, pipeline erosion, block and

bursts resulted in water contamination and water loss frequently, the new manager of WSCL Provided sufficient financial support to reconstruct City N's water distribution networks step by step in order to provide reliable water supply service.

5.5.2 Effective Management

In view of the above findings through its thorough investigation and analysis, WSCL has tried to improve the operational performance of the water plant by implementing different measures.

Firstly, WSCL set a goal of building a good reputation. To achieve this, water quality must be insured. Besides the new water resource and new water treatment plant putting into service, a water quality test laboratory was set up to monitor water quality routinely. In order to provide uninterrupted water service to the customers on a 24/7 basis, the company's technicians scanned the existing water pipelines and found that 90% of the old water supply pipelines should be replaced, however, replacing pipeline requires a certain time period of water supply intermission. In order to lower down the intervention to the customer to the minimum level, WSCL made a plan to replace the old pipelines step-by-step, and at the same time began repairing the leaking points and unclogging the blocked pipelines which are to be replaced on a later schedule. With these actions taken, the number of connections and the ratio of service coverage have been increasing noticeably as more users recognize that WSCL is providing a reliable service. The ratio of UFW also decreased as pipeline leakages reduced

Secondly, WSCL tried to pass information to the customers through their staffs and public education to raise people's awareness that water is a commodity and

everyone should pay for using it; stealing water is illegal; it is not safe to use water drawn directly from underground in the town; and over-exploitation of underground water may lead to serious environmental consequences and accelerate water scarcity. As people have become more aware of these issues, they are more willing to pay for the water supplied to them. As a result, the ratio of active users has increased, and unauthorized water usage decreased.

Thirdly, WSCL enhanced user management by installing a User Management System to dynamically trace the fluctuation of water consumption and update users' information. Besides, when new pipelines were connected to the users, new water meters (with new techniques giving more accurate measurement) were installed outside users' properties to make these meters accessible to the staff of WSCL. Therefore, since 2009, WSCL has been able to regularly monitor almost all its registered users.

Fourthly, WSCL improved human resource management. It clearly defined the division of labour and responsibilities of staff, and introduced performance bonus to motivate its staff. The operational efficiency of has greatly improved.

5.5.3 Operational Measures

After taking over the water supply enterprise in City N, managers of WSCL conducted a detailed study on the operational performance of the predecessor enterprise, listed in Table 5.1. By interviews and site visits, they collected massive information from ex-staffs and the customers, trying to find out the causes of the problems faced by the water supply enterprise in City N.

Table 5.1 Key operational performance indicators for City N's water supply service.

Operational indicator	2006 and Before	2007	2008	2009
Employees per 1000 connections	20	4	3.6	3
Unaccounted-for water	90%	85%	82%	70%
Registered connections	10,000	10,000	11,500	14,000
Service coverage	37%	37%	43%	52%
Active user ratio	40%	43%	49%	61%
Metered connection	70%	80%	90%	98%
Users with wells	No Record	45%	46%	44%
Continuity of supply	No Record	20/7	22/7	24/7

Regarding the high UFW ratio, three major causes were identified: Firstly, a portion of water was lost through leakages from the old pipelines made of steel and corroded due to improper maintenance. Secondly, inaccuracy in metering is also an important reason, which arose from the backward technology of the water meters used by the predecessor enterprise. Those meters did not take records if water trickled from the tap. Moreover, most of those meters had been in use for at least ten years without calibration even though they were not designed to last for that long. Some of the meters might be blocked by the sediments brought long with the old pipeline. Thirdly, unauthorized water usage is an important concern. This is a rather complicated issue because in the Chinese society, people still consider provision of water services an obligation of the government and the general public usually does not perceive water as a commodity, but a public good. Therefore, the households made unauthorized connections from water supply pipeline to steal water. These unauthorized water tubes were found everywhere spreading like a spider web. Besides, as water meters were installed inside houses and apartments, water users could easily prevent the staff of water supply enterprise from taking records of their meters.

Low ratios of service coverage and low active user ratio were caused by the undesirable water quality and unreliable water supply service. As aforesaid, besides the water resource problem, the predecessor enterprise did not have an appropriate water treatment process, thus a large amount of sediments having been brought into the old pipelines and some even transmitted to the end users. Many users complained that the water they got from the predecessor enterprise usually contained visible substances. On the other hand, such sediments also caused pipeline leakages and blockages making users living on the third or higher floors hardly get any water from the tap. For these reasons, most of the users began opening their own water wells, with tap water treated as an alternative use.

5.5.4 Financial Measures

To assess the in-depth performance and get a feel of the long-term sustainability of an organization, it is useful to evaluate the trend of key financial performance indicators over a considerable period of time (Kayaga and Zhe, 2007). Table 5.2 listed four key financial indicators of WSCL from 2006 to 2009. Although the data available covers a relatively short duration, the trend is clear.

Table 5.2 Key financial ratios for WSCL during 2006-2009.

Ratio	2006	2007	2008	2009
Return on investment	-	-	0.001	0.055
Current ratio	96.6	0.766	0.338	0.610
Operating ratio	1.50	1.98	1.61	0.64
Bill collection efficiency	-	0.99	0.99	0.99

Return on Investment

Return on investment (ROI) is a ratio that is considered by investor to be a primary measure of profitability, which is in turn important for an organization's survival and sustainability. For public urban water utilities, it is recommended that only if ROI could surpass 0.10, it is possible for the investor to make the replacement and renewal of the plant and equipment during the infrastructure life cycle.

Current Ratio

Current ratio is equal to current assets divided by current liabilities. It is an indication of a company's ability to meet short-term debt obligations，such as payment of electricity bills and purchase of chemicals.; The higher the ratio, the more liquid the company is. If the current assets of a company are more than twice the current liabilities, then that company is generally considered to have good short-term financial strength. If current liabilities exceed current assets, then the company may have problems meeting its short-term obligations.

Operating Ratio

Operating ratio is a ratio that shows the efficiency of a company's management by comparing operating expense to net sales. An operating ratio that is close to or larger than one is not desirable as it points to inefficient use of resources. It is recommended that the operating ratio for water utility should be below 60%.

Except for bill collection efficiency, which is satisfactory, other financial indicators for WSCL are undesirably low, which would not foster the sustainability of the services. Until the year of 2009, signal of improvement began to show up. Actually, all the financial indicators are determined by the quantity of water consumption.

Although financial ratios got improved in 2009, they are only half of the desirable levels, indicating that the sustainable development of the enterprise could only be guaranteed when revenue from sales of water got doubled. As shown in Figure 5.2, the chain indices of number of connections and water sales revenue are increasing. The jump of water sales revenue in 2009 is the benefit of raised water tariff. While the decreasing chain index of consumption quantity indicates a limited space to improve. The contradiction between the number of connections and water consumption could be explained by Figure 5.3, profile of water consumption quantities.

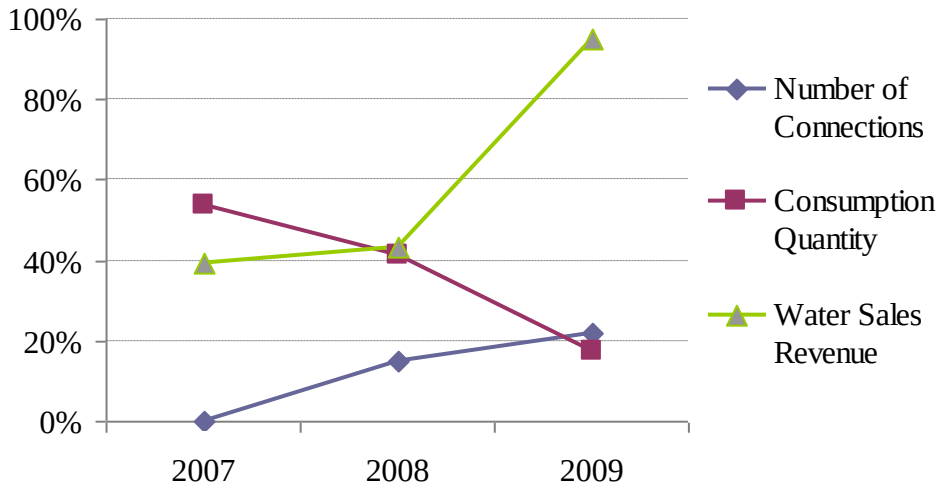

Figure 5.2 Chain indices of number of connections, consumption quantity and water sales revenue.

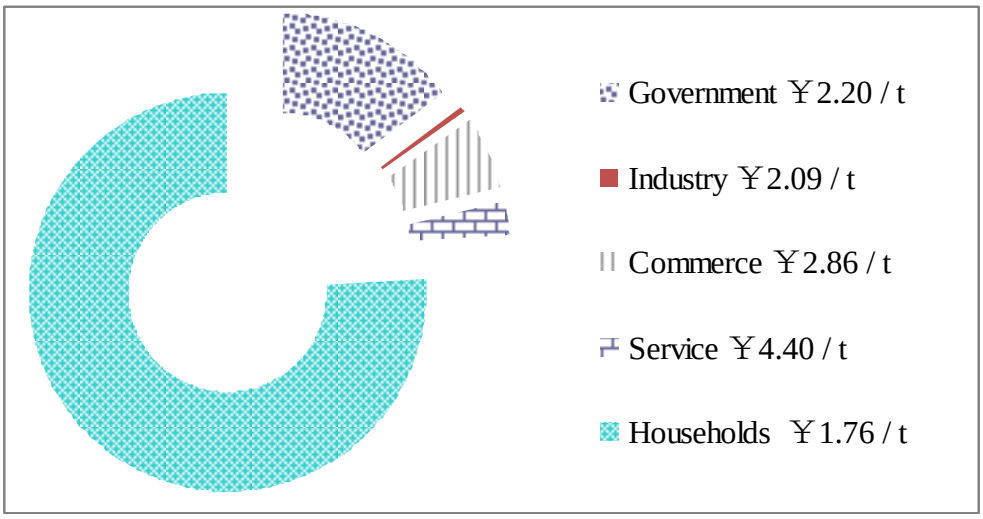

Figure 5.3 Profile of water consumption quantities and water bill for different type of users.

Users are divided into five groups according to the usage and consumption of water, charging for different water tariff. In general, industry users are considered to constitute a high proportion of water consumption however they are scant in this town. Three quarters of water are consumed by households who account for more than 90% in the number of connections. It is tough to rely on households to increase water consumption, as almost half of them have their own wells. Although they know that the water supplied by WSCL has better quality, they still prefer to use free water from the wells. Especially after the raise of water tariff, water consumption decreased further.

To sum up, there are two potential ways to achieve double revenue. One is to raise water tariff, the other is to increase consumption. The former has slim hopes, as holding public hearing is one of the procedures to raise water tariff. The present water tariff in City N is the same with Beijing; however, per capita disposable income is only one fifth of Beijing, which could let aside the first option. The later approach could take effect only if the government could exert power to users to block their wells. Actually, this is what the government have

promised in the contract. There are a large portion of restaurants, hotels, bathing sites, entertainment places, schools, hospitals and government departments withdraw quantities of water from the wells every day.

5.6 Application of DMF Evaluation Scheme

5.6.1 Expert Panel

Five responsible persons in the water supply company and five representatives of the local government are selected to the expert panel. Figure 5.4 shows the organization structure of the water supply company. In this case, five persons are selected into the panel which consist of one director whose main objective is to make profit; the general manager who has to report to the board of directors and manage the relationship with the local government at the same time; the financial manager who cares about the cash flow, revenue and operation cost; the chief engineer who in charge of the water production and water quality as well as pipeline construction and maintenance; the customer manager who focus on customer satisfaction.

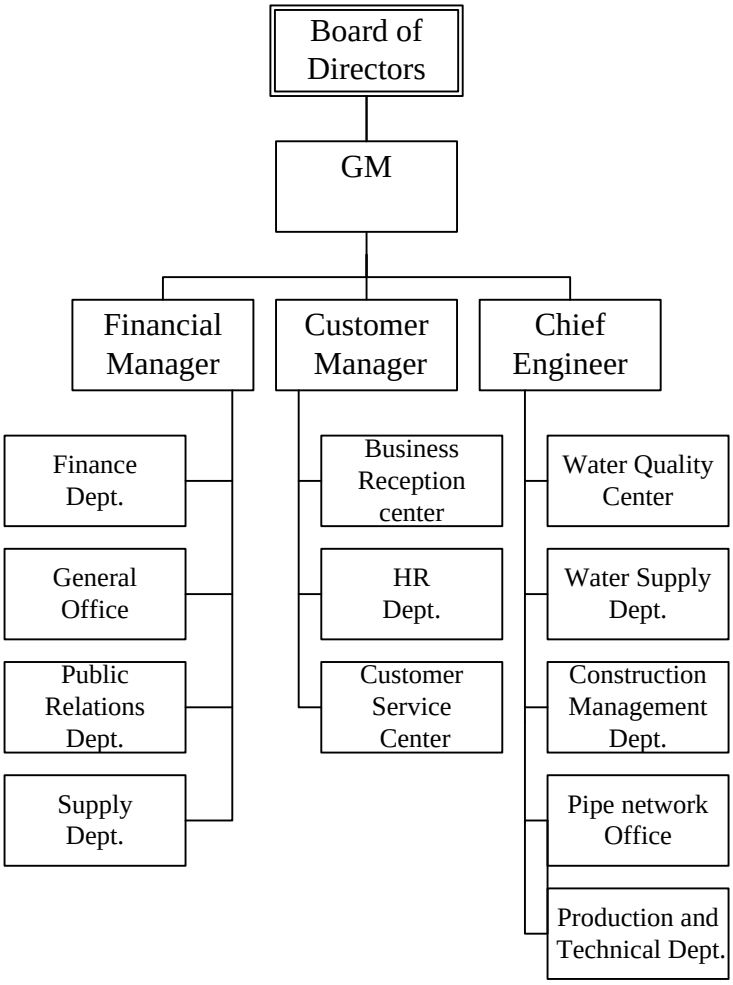

Figure 5.4 Organization structure of the water supply company

The panel of local government also consist of five persons. The mayor has the final approval authority however he will only deal with critical issues, whereas the detailed follow up works will assign to a vice mayor in charge. Therefore, in this case, the vice mayor in charge of civil construction and the vice mayor in charge of finance are invited. Besides, urban water supply company is supervised by the housing and urban-rural development department and water resource department in administration. Hence the head persons in these two departments are also invited to the panel.

5.6.2 Checklist of DMFs

As illustrated in the previous section, the experts invited all have their own focuses. Nevertheless, it requires considering every aspect before making a decision on the strategies directing the development of urban water supply service. After a comprehensive literature review, the author provides with the expert panel a full spectrum checklist of DMFs. All the experts are asked to add and delete DMFs considering the present project, and the final checklist is generated and shown in Table 5.3. These DMFs are annotated with descriptions to ensure that all experts involved in the following Delphi survey have the same understanding of these DMFs.

Table 5.3 Checklist of DMFs to be evaluated

ID	Decision-making factors	Description
F01	Foreign exchange fluctuation	Fluctuation in currency exchange rate and/or difficulty of convertibility
F02	Inflation	The rise of overall price level of products and the fall of purchasing power of currency
F03	Loan interest rate fluctuation	Fluctuations in loan interest rate
F04	Asset assessment	Evaluation of asset quality and accurate value
F05	Project profitability	The potential of making profit for the investors
F06	Accuracy of water demand forecast	Overestimation will result in grandiose profitability; underestimation will lead to insufficient capacity of water utility
F07	Autonomy in water tariff adjustment	The lack of flexible adjustment mechanism of water tariff on frequency and range will result in insufficient operation revenue
F08	Feasibility of financing acquirement	Poor financing market or unavailability of financing instrument results in difficulties in project financing
F09	Water resource availability changes	The current water resource is not assessable due to environmental and/or policy changes.
F10	Operation cost overrun	Operation cost overrun resulting from improper measurement, improper planned schedule or low operation efficiency
F11	Maintenance cost higher than forecast	Cost overrun resulting from inaccurate evaluation of facility
F12	Manager capability	Capability to lead and manage the company and relationship management
F13	Technical personnel capability	Capability to design, operate and maintain facility
F14	Construction delay	Project takes longer than the predicted time to complete
F15	Customers' satisfaction	Raising customer satisfaction will enhance employee confidence and cohesion
F16	General public opposition to the PPP projects	Prejudice from public due to different local living standards, values, culture, social system, etc.
F17	Quality of treated water	Water quality should meet a variety of standards
F18	Customers' willingness to pay	The consumer not being able or willing to pay for the service
F19	Labor placement issues	Staff redundancy is common under public operation, which will result in the requirement of employee discharges
F20	Unstable public partner	The change of cabinet will lead to adjustment and/or delayed implementation of principles and policies formulated by the previous administration
F21	Government intervention in operation	Sectors of local government interferes unreasonably in privatized facilities/services

F22	Leadership of the mayor	It includes decisiveness of mayor, and whether the subordinates departments really obey his command
F23	Government corruption	Corrupt local government officials require bribes or unjust rewards in exchange for favors or influence
F24	Credibility of the government	The risk that the government is unwilling or/and unable to fulfill its obligations defined in concession agreement.
F25	Conflicting or imperfect contract	It mainly includes inequitable risk allocation, ambiguous or inconsistencies, and/or unclear boundary between responsibilities and obligations.
F26	Unsound regulatory mechanism and/or supervision toward private investment	The financial status and expenditures are not monitored and controlled
F27	Failure to obtain statutory approvals	Delay or refusal of project approval or permit by government
F28	Ineffective control of groundwater exploitation	It will result in the decrease of water demand from the water supply utility, not safe, and environmental problem
F29	Transient policy and regulations in PPP	Local government's inconsistent application of new regulations and laws toward PPP projects.
F30	Fair Risk allocation	Risk allocation between private and public sectors
F31	Inability of concessionaire	The consortium not being able to perform its obligations as agreed
F32	Public-private relationship	To obtain the trust, support and cooperation of the government in order to create a favorable external political environment for the enterprise
F33	Emergency response capability	Capability of special purpose vehicle including management, construction, operation, and financing capability
F34	Local investment environment	It includes specific natural, economic and social conditions, preferential policies, including taxation, finance supply, etc.
F35	Local cultural characteristics	Mainly refers to the citizens' educational level, religion, and customs

5.6.3 Delphi Survey

Implementing Delphi requires conducting several rounds survey until the consensus is reached. In this research, two rounds were carried out. In the first round, participants were requested to rate every DMF with respect to its

importance based on a five-point Likert scale, in which 1 = not important, 2 = possibly important, 3 = important, 4 = very important, and 5 = extremely important; it is also allowed to suggest additional DMFs in this round. In the second round, participants were presented with the group responses of DMFs' mean scores and rankings from the first round, seeing if they would adjust their original determinations. The returned questionnaires were checked and edited to ensure completeness and consistency. At the end of the second round, no participant changed his original ratings. Therefore, it is deemed that the survey results are stable, and not necessary to run the survey in a third round. All experts in the panel have participated in both two rounds of survey. This fast consensus results from the rigorous expert selection criteria that every potential participant was required to rate the DMFs in at least three different formats, and only the experts who gave consistent ratings could be selected into the panel. So it is more possible for the experts in the panel to insist their original judgments. Therefore, through two rounds of Delphi survey, the perceptions of the relative importance of each DMF were attained.

In the Delphi survey, results are produced from the judgments made by experts instead from previous historical data. Therefore, the procedure for expert panel selection is essential to the success of survey. To uphold the validity of this study, judgmental/purposive sampling was used. Firstly, PPP projects and their main partners in the urban water supply sector in China were identified. Then the responsible persons of public and private sectors in the partnerships were contacted by email, telephone call or face-to-face interview. Among them, only the experts who have both in-depth knowledge and sound experience in urban water supply PPP projects were selected into the panel.

In a Delphi study, the number of participants varies generally from 3 to 15 (Rowe and Wright 1999). Based on the representative studies on infrastructure PPP projects in China, listed in Table 5.4, the average numbers of experts employed from the public sector and private sector are 10 and 20 respectively. Considering limited number of PPP experts in the urban water supply sector in China, a panel that consists of 10 experts from the public sector and 10 experts from the private sector was finally selected through a rigorous procedure. All experts in the panel have at least 5-year hands-on experience with urban water supply PPP projects and hold positions in either high or middle levels. As PPP projects only have become popular in China in recent years, this spectrum of panel is considered reasonable and adequate for data analysis.

Table 5.4 Representative prior studies on infrastructure PPP projects in China.

Reference	Response	Expert spectrum	Research scope
Chen and Doloi (2008)	15	7 from private sector; 8 from public sector	Driving and impeding factors
Cheung and Chan (2011)	38	16 represent private sector; 9 represent public sector; 13 represent other organizations 15 in water and wastewater project	Risk factor in water, power and transportation sectors
Ke et al. (2010)	46/203	13 from private enterprises; 17 from public enterprise; 6 from government; 10 from academic organizations	Risk allocation
Xu et al. (2010)	93/580	35 from private sector; 13 from public sector; 45 from academic	Risk assessment
Yuan et al. (2008)	25/205	Experienced participator	Critical risk identification
Yuan et al. (2010b)	57/356	5 from central government; 16 from local government 13 public client or enterprise 23 Academic researcher	Driving factors
Zhang (2005)	46	17 from private companies; 12 from public clients; 17 from academia	Partner selecting criteria

The Delphi survey is applied in this study. PPP experts and experienced water supply project practitioners were selected from both public and private sectors in China. They were asked to score each DMF with regard to their importance for several rounds until consensus results are reached. These results were gathered into three groups: public sector, private sector, and overall evaluation. Then the mean score of importance for each DMF in each group was calculated, ranked, and compared across groups. Data reliabilities and validity were examined by Cronbach's alpha and Kendall's *W*. Furthermore, the degree of agreements/differences on opinions between public and private sectors were evaluated by Mann Whitney *U* Test. Finally, a novel evaluation scheme is proposed to further analyse DMFs in a more reasonable approach.

5.6.4 Data Quality Assessment

Data Reliability

To ensure that, at a certain level, the scale (1-5) for measuring the DMFs yields the same results among different respondents, Cronbach's alpha is used to check the internal consistency. The more the alpha is close to 1, the higher the degree of internal consistency it indicates. Table 5.5 shows the values of Cronbach’s alpha in each group. All alpha values are greater than 0.9, indicating high levels of consistency within the survey responses. Comparing the values of Cronbach's alpha, it is found that opinions of experts from the public sector appear to be more consistent within the group. This demonstrates that expert opinion method is more applicable to the public sector.

Table 5.5 Reliability analysis.

Experts	Cronbach's alpha
Private sector	0.9174
Public sector	0.9747
Overall	0.9727

Data Validity

To examine the validity of survey results, the Kendall's coefficient of concordance (*W*) is calculated to measure the agreement among respondents (Cheung and Chan 2011; Yeung et al. 2009). In this study, 20 experts are asked to give scores to 35 DMFs. Rankings for the DMFs are generated according to the scores from most important to least important, and the values of Kendall's *W* are calculated from these rankings. If the test statistic *W* is 1, then all the experts have been unanimous, and each expert has assigned the same order to the list of DMFs. If *W* is 0, then there is no overall trend of agreement among the respondents, and their responses may be regarded as essentially random. Intermediate values of *W* indicate a greater or lesser degree of unanimity among the various experts. Because the number of attributes considered is above seven, as mentioned earlier, the chi-square value is referred other than the *W* value. Table 5.6 shows the Kendall's coefficient of concordance (*W*) and the computed chi-square values for different expert groups. Since the computed chi-square values in all groups are statistically significant at 0.000 (<0.05), there are sufficient evidences to show the unanimity among the respondents within the group in ranking those DMFs. Therefore, the completed survey questionnaires are valid for analysis.

Table 5.6 Concordance analysis.

Expert panels	Kendall's *W*	Chi-square	Asymp. sig.
Private sector	0.387	128.608	0.000
Public sector	0.555	188.759	0.000
Overall	0.345	234.823	0.000

5.6.5 Data Analysis

Rankings and Mean Scores

Conventional evaluation methods always use results of the overall evaluation to present the opinions of experts, and regardless of different interest groups they represent. Through comparison of rankings and the mean scores of DMFs among three groups, this study discusses whether it is reasonable to use the ranking and mean scores in the overall evaluation to represent all the experts' opinions on a PPP project. To this end, the DMFs for adopting PPP in the urban water supply projects are assessed by the public and private sector experts respectively. Their mean scores and standard deviations are calculated and ranked in descending orders, as shown in Table 5.7.

Table 5.7 Rankings and mean scores of DMFs across experts from different panels.

ID of DMFs	Overall			Private			Public		
	Rank	Mean	Std.	Rank	Mean	Std.	Rank	Mean	Std.
F05	1	4.30	1.22	1	5.00	0.00	3	3.60	1.43
F12	2	4.05	1.05	2	4.70	0.48	6	3.40	1.07
F06	3	4.00	0.86	11	4.10	0.74	2	3.90	0.99
F17	4	3.85	1.04	4	4.40	0.84	8	3.30	0.95
F25	5	3.85	1.18	8	4.20	1.03	4	3.50	1.27
F31	6	3.80	1.11	22	3.60	1.35	1	4.00	0.82
F28	7	3.70	1.22	5	4.30	0.95	9	3.10	1.20
F09	8	3.60	1.14	10	4.10	0.99	11	3.10	1.10
F34	9	3.55	1.32	3	4.40	0.70	14	2.70	1.25
F27	10	3.50	1.50	13	4.00	1.63	13	3.00	1.25
F13	11	3.45	1.15	7	4.30	0.48	20	2.60	0.97
F15	12	3.35	1.04	21	3.60	0.70	10	3.10	1.29
F07	13	3.25	1.16	17	3.90	1.20	21	2.60	0.70
F16	14	3.25	1.25	29	3.20	1.48	7	3.30	1.06
F26	15	3.25	1.16	31	3.10	0.99	5	3.40	1.35
F21	16	3.15	1.50	6	4.30	1.06	28	2.00	0.82
F24	17	3.15	1.31	19	3.70	0.95	16	2.60	1.43
F29	18	3.15	1.09	26	3.30	1.06	12	3.00	1.15
F33	19	3.15	0.93	18	3.70	0.67	18	2.60	0.84
F10	20	3.10	1.33	15	4.00	1.05	24	2.20	0.92
F11	21	3.10	1.33	9	4.20	0.79	29	2.00	0.67
F14	22	3.10	1.07	25	3.50	1.18	15	2.70	0.82
F22	23	3.10	1.41	14	4.00	1.05	23	2.20	1.14
F04	24	3.05	1.43	16	4.00	1.33	26	2.10	0.74
F30	25	3.05	1.05	23	3.50	1.18	19	2.60	0.70
F32	26	3.00	1.21	12	4.00	0.82	27	2.00	0.47
F18	27	2.90	1.29	24	3.50	1.43	22	2.30	0.82
F19	28	2.90	0.97	27	3.20	0.42	17	2.60	1.26
F23	29	2.90	1.33	20	3.70	1.16	25	2.10	0.99
F08	30	2.55	1.23	30	3.10	1.52	30	2.00	0.47
F35	31	2.35	0.99	32	3.00	0.82	31	1.70	0.67
F03	32	2.25	1.02	33	2.90	0.88	32	1.60	0.70
F20	33	2.15	1.35	28	3.20	1.14	35	1.10	0.32
F02	34	1.85	0.81	34	2.30	0.82	33	1.40	0.52
F01	35	1.70	0.98	35	2.10	1.20	34	1.30	0.48

Firstly, the top five most important DMFs in the three groups are compared. In the overall evaluation, they are F05, F12, F06, F17 and F25; in the public sector, they are F31, F06, F05, F25, F26 and F12; whereas in the private sector, they are

F05, F12, F34, F17, F28, F21 and F13. Among them, only two DMFs (F05 and F12) in the overall evaluation are also identified as top five by both the public sector and the private sector. This means only 40% of the DMFs identified in the overall evaluation can represent the opinions of both interest groups. Besides, two DMFs (F06 and F25) in the overall evaluation are identified by the public sector as top five, but not by the private sector; in contrast, one DMF (F17) in the overall evaluation is in an inverse situation. To summaries, the top five most important DMFs identified in the three groups are obviously different. Public sector identifies factors that restrict the behavior of private sectors to be important. These factors are inability of concessionaire, conflicting or imperfect contract, and unsound regulatory mechanism and/or supervision toward private investment. In contrast, private sector identifies factors related to the execution ability of the public sector to be important. These factors include local investment environment, quality of treated water, ineffective control of groundwater exploitation, and government intervention in operation. All these factors are important DMFs; however, some are not identified in the overall evaluation.

Secondly, mean scores for DMFs in the three groups are compare, shown in Figure 5.5. In the overall evaluation, mean scores of the 35 DMFs vary from 4.30 (project profitability) down to 1.70 (foreign exchange fluctuation), among which three quarters are above or equal to 3.00, indicating most of the DMFs are regarded important. Three DMFs' mean scores are greater than or equal to 4.00, indicating they are very important; and two DMFs' mean scores are below 2.00, indicating possibly important or not important. Comparably, the mean scores rated by the respondents from the private sector range from 5.00 (project profitability) down to 2.10 (foreign exchange fluctuation) with sixteen DMFs' mean scores greater than or equal to 4.00, and no DMFs below 2.00. For

responses from the public sector, the mean scores range from 4.00 (inability of concessionaire) down to 1.10 (unstable public partner) with only one DMF rated 4.00, and five DMFs below 2.00.

The distribution of mean scores on importance for DMFs in the overall evaluation is consistent with studies conducted by Xu et al. (2010) and Yuan et al. (2008). It is worthy notice that in their study they have not separated the responses from the public and private sectors. However, the results in Figure 5.5 show that the differences of mean scores among three groups are explicit. Except for three DMFs, inability of concessionaire, unsound regulatory mechanism and/or supervision toward private investment, and general public opposition to the PPP projects, the mean scores of DMFs rated by the private sector are typically higher than that rated by the public sector, reflecting greater concerns to the DMFs presented by the private sector. This is reasonable, because in the actual world, public sector concerns more about reliability of its private partners and the social impact of PPP. Due to information asymmetry, although the public sector is willing to open the financial channel to attract private investment, private investors indeed possess cautious attitudes in investing PPP project in the urban water sector in China. The comparison results reveal that it is insufficient to use the overall evaluation results to represent the decisions of experts from different groups.

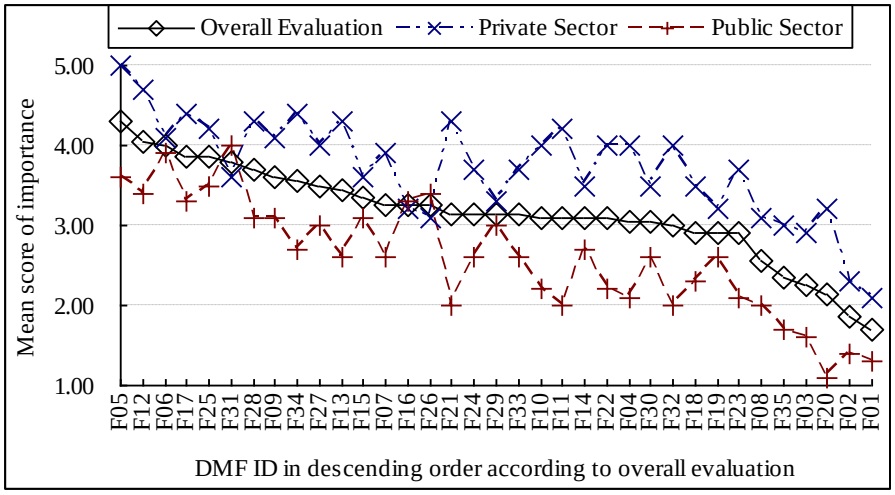

Figure 5.5 Mean scores of importance for DMFs across groups.

In addition, by comparing the mean score curves among public sector, private sector, and overall evaluation in Figure 5.5, it is found that the curve for public sector fluctuates in an opposite direction to the curve for private sector, whereas the curve for overall evaluation averages the differences of the two curves. Therefore, it is obvious that the curve for overall evaluation fails to illustrate the specific fluctuations contained in curves for both public and private sectors. Nevertheless, these fluctuations are importance, because they indicate different decisions toward DMFs by experts from different sectors. This trend concurs with Chen and Doloi (2008), in which ratings between the public sector and the private sector on selecting significant driving factors for Build-Operate-Transfer (BOT) applications in China are compared, and Chan et al. (2005), which focused on the interface factor identification of BOT projects in China. It is reasonable in finding such difference because different partners have different objectives, duties, and organizational cultures. However, these differences observed may not indicate statistical significance as they are interpreted directly by the mean scores and rankings. Therefore, further analysis will be performed to examine the similarities and differences in importance rating between the public sector and private sector.

Degree of Differences of Viewpoints between Public Sector and Private Sector

To elaborate the differences in ratings on DMFs between public sector and private sector, the Mann Whitney *U* test is conducted, and the results are given in Table 5.8. For each DMF, there are 10 scores given by the public sector and 10 scores given by the private sector respectively. Data from the two groups are combined into one group, with each data retaining a group identifier of its original group. In this study, data from the public sector are defined as $\{x_1,\ldots,x_m, m=10\}$, whereas data from the private sector are defined as $\{y_1,\ldots,y_n, n=10\}$. Then the pooled values are ranked from 1 to 20, with the smallest value being assigned a rank of 1. The sum of the ranks of values from the public sector is computed and denoted by W_X while the sum of ranks of values from the private sector is denoted by W_Y. Compare W_X with W_Y and choose the group of which the sum of ranks is smaller. For each value in this group, count the number of values in the other group that has a greater rank. The sum of these counts is denoted by W_{XY} or W_{YX}. The value of W_{XY} is the *U*, and it can be calculated by:

$$W_{XY} = \#\{(x_i, y_j): x_i < y_j,\ i=1,2,\ldots, m;\ j=1,2,\ldots,n\} \quad (5)$$

$$W_{YX} = \#\{(x_i, y_j): x_i > y_j,\ i=1,2,\ldots, m;\ j=1,2,\ldots,n\} \quad (6)$$

$$W_{XY} = W_Y - n(n+1)/2 \text{ and } W_{YX} = W_X - m(m+1)/2 \quad (7)$$

Here we present the hypothesis as:

H_o = there is no difference between the scores of a specific DMF rated by public sector and private sector.

H_a = there is difference between the scores of a specific DMF rated by public sector and private sector.

In this study, all the U values are calculated by W_{XY}. If U is equal to 50, it indicates equal sums of ranks between two groups; if U exceeds 50, it indicates higher sum of ranks in the public sector, whereas if U is below 50, it indicates higher sum of ranks in the private sector. In addition, as U is approximately normally distributed, greater absolute difference between U and 50 indicates higher possibility of difference between groups.

Results in Table 5.8 show that for 57% of DMFs, the values of U are statistically significant at 0.000 (<0.05), therefore, their null hypotheses are rejected; therefore there are sufficient evidences to justify the differences of ratings between two sectors. In addition, for these 20 factors, the scores given by the private sector are statistically higher than the scores given by the public sector. Furthermore, these DMFs are found mainly belonging to three categories. To breakdown, inflation, loan interest rate fluctuation, asset assessment, and project profitability are financial DMFs; operation cost overrun, maintenance cost higher than forecast, emergency response capability, manager capability, and technical personnel capability are operational DMFs; unstable public partner, government intervention in operation, leadership of the mayor, government corruption, fair risk allocation, public-private relationship, and local investment environment are political DMFs.

Table 5.8 Mann Whitney U test for DMFs across sectors.

ID of DMFs	Mann-Whitney U	Asymp. sig. (2-tailed)	Exact sig. [2*(1-tailed sig.)]
F32	1.5	0.000	0.000*
F11	2.0	0.000	0.000*
F20	2.0	0.000	0.000*
F13	3.5	0.000	0.000*
F21	6.5	0.001	0.000*
F10	10.0	0.002	0.002*
F12	10.5	0.001	0.002*
F34	11.0	0.002	0.000*
F35	11.5	0.002	0.002*
F03	12.0	0.002	0.003*
F04	12.0	0.003	0.003*
F07	13.0	0.003	0.004*
F22	13.0	0.004	0.004*
F05	15.0	0.002	0.007*
F23	15.0	0.007	0.007*
F33	16.5	0.007	0.009*
F02	20.0	0.016	0.023*
F17	20.0	0.018	0.023*
F28	22.0	0.028	0.035*
F30	23.5	0.036	0.043*
F09	24.0	0.042	0.052
F18	25.0	0.049	0.063
F24	27.0	0.074	0.089
F27	29.0	0.097	0.123
F08	29.5	0.096	0.123
F01	30.5	0.101	0.143
F14	32.5	0.155	0.190
F25	32.5	0.166	0.190
F15	36.0	0.262	0.315
F19	39.0	0.357	0.436
F29	39.5	0.405	0.436
F31	58.0 (42.0**)	0.529	0.579
F26	56.0 (44.0**)	0.636	0.684
F06	45.5	0.716	0.739
F16	53.5(46.5**)	0.785	0.796

* Difference is significant at 0.05 level.

** *U* value calculated by W_{YX}, others calculated by W_{XY}.

5.6.6 Importance-Difference Evaluation Model

Values for X-axis are adopted from Mann Whitney *U* in Table 5.8, in which every value of *U* for the DMFs is calculated basing on the group which has a smaller sum of ranks, thus the values of *U* for F31, F26 and F16 should take the smaller values in Table 5.8. As stated before, *U* close to 50 indicates similar opinions between groups, and *U* close to 0 indicates different opinions between groups. For Y-axis, the importance boundary is identified by K-means clustering. The overall importance scores in Table 5.9 are calculated. Figure 5.6 shows the clustered data by different colour, importance boundary is marked as the solid line.

Table 5.9 Mean scores of overall importance for DMFs.

1	2	3	4	5	6	7	8	9	10
1.7	1.85	2.25	3.05	4.3	4	3.25	2.55	3.6	3.1
11	12	13	14	15	16	17	18	19	20
3.1	4.05	3.45	3.1	3.35	3.25	3.85	2.9	2.9	2.15
21	22	23	24	25	26	27	28	29	30
3.15	3.1	2.9	3.15	3.85	3.25	3.5	3.7	3.15	3.05
31	32	33	34	35	-	-	-	-	-
3.8	3	3.15	3.55	2.35	-	-	-	-	-

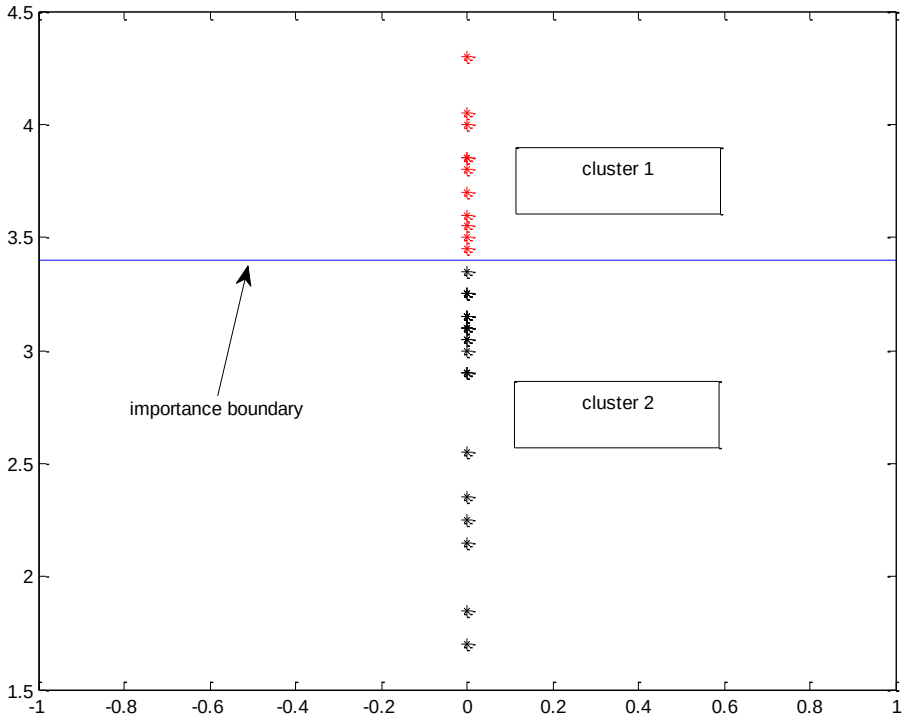

Figure 5.6 importance boundary of evaluation data

Results in the previous section comprehensively illustrate the differences of evaluations on DMFs between the public sector and the private sector. It reveals that as the results in the overall evaluation are the average results of the public sector and the private sector, they cover up the differences on decision making between these two sectors. Therefore, to identify the critical decision-making factors (CDMF) in urban water supply PPP projects, merely relying on the results in the overall evaluation is not sufficient.

Comparing with conventional overall evaluation method, this new model not only identifies important DMFs, but it also reveals the different viewpoints between the public and private sectors by classifying all the DMFs into four categories. This makes it possible to treat these DMFs differently. Take the results in this study for example. By the overall evaluation method, only the top

(usually five) most important DMFs are identified as the CDMFs, they would be F05, F12, F06, F17 and F25. In contrast, by the novel scheme IDEM, DMFs are classified into four quadrants: DMFs in the first quadrant are identified as CDMFs; DMFs in the second quadrant are defined fundamental decision-making factors; DMFs in the third quadrant are identified as systematic decision-making factors; while DMFs in the fourth quadrant are attributed to controversial decision-making factors.

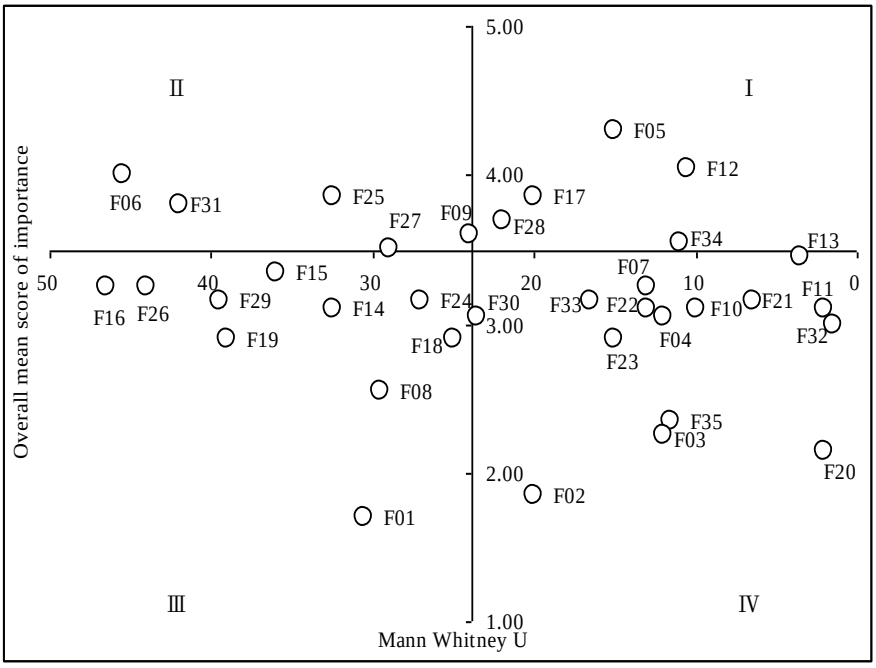

Figure 5.7 Importance-difference evaluation model

5.6.7 Categorization of DMFs

CDMFs identified by IDEM are discussed following, which are F05 project profitability, F12 manager capability, F17 quality of treated water, F28 ineffective control of groundwater exploitation, and F34 local investment environment.

Project profitability is the most important CDMF. In the group of private sector, it receives an average score of 5, which fully demonstrates its importance. In reality, without good profitability, a project can hardly be accepted by foreign and domestic private investors. Therefore, it can be considered as a prerequisite DMF of the project. This finding corresponds well with the research conducted by Meng et al. (2011). From the public sector's perspective, project profitability is ranked after inability of concessionaire and accuracy of water demand forecast, yet is viewed as very important. Although accuracy of water demand forecast is considered to be more important than project profitability, it is the basis for profitability prediction.

Manager capability is ranked by the private sector as the second most important DMF, while the public sector also considers it to be important and ranked it in the tied fifth place. Practically, instead of managing projects by themselves, most investors, especially foreign investors prefer to find professional managers in charge of the projects. These managers required to possess professional knowledge of water supply service, understand and are adaptable to local cultures, and master the skills of negotiation, enabling them to communicate effectively with government officials, investors and subordinate staff. This is essential because the capability of the execution is a key factor for the success of PPP projects.

Quality of treated water is ranked fourth by the private sector and eighth by the public sector. This shows that the private sector pays more attention to it than the public sector does, as it is a great concern for the private sector that if the supplied water cannot meet national water quality standards, adverse social impact and unbearable responsibilities will add to them.

Ineffective control of groundwater exploitation is ranked fifth by the private sector and ninth by the public sector. The concern of the private sector is that if groundwater exploitation cannot be controlled effectively, users will choose to exploit groundwater instead of paying high amount of water tariff, which will reduce the revenue of the water supply company, and in turn affect the project profitability. The concern of the public sector is that unauthorized exploitation of groundwater brings about some adverse environmental impacts. Moreover, without proper treatment, groundwater is not safe for use. In addition, it is difficult to measure the quantity of groundwater exploited, which increases the burden of collecting sewage treatment fee.

Local investment environment is ranked by the private sector as the third most important DMF, while the public sector ranks it as the fourteenth. This shows the difference in the understanding of this issue. The government is suggested to take more responsibility for building a transparent, reliable and sustainable investment environment to PPP projects in China.

DMFs in the second quadrant include F06 accuracy of water demand forecast, F25 conflicting or imperfect contract, F31 inability of concessionaire, F09 water resource availability changes, and F27 failure to obtain statutory approvals. These factors are considered very important in the overall evaluation, and received statistical agreement on their importance. In reality, problems that happen on any of these factors will hinder the project; therefore they are defined as the fundamental decision-making factors.

DMFs in the third quadrant include F01 foreign exchange fluctuation, F08 feasibility of financing acquirement, F29 transient policy and regulations in PPP,

F24 credibility of the government, F16 general public opposition to the PPP projects, and F26 unsound regulatory mechanism and/or supervision toward private investment. These factors are considered not as important as the ones in the first and second quadrants in the overall evaluation, because they are mainly caused externally and cannot be controlled by the concessionaire (Chen and Shi 2009). Therefore, they are identified as systematic decision-making factors, and are worth noting.

In the fourth quadrant, although the mean scores of importance for the DMFs in overall evaluation are not high, they bring in valuable information revealing the differences of decision-making between the public and private sectors. Analysing these factors, it is found that political related DMFs generally appear in this quadrant, including F20 unstable public partner, F21 government intervention in operation, F22 leadership of the mayor, F23 government corruption, F30 fair risk allocation, F32 public-private relationship, as well as F35 local cultural characteristics. It is also discovered that private sector pays more attention to these DMFs than public sector does. Therefore the public sector is suggested contribute to the success of PPP projects by enhancing private sector's confidence in local government. As unified judgments are difficult to form on DMFs in the fourth quadrant, they are attributed to controversial decision-making factors.

Results derived from the novel evaluation scheme proved once again that the differences in decision-making processes between the public and private sectors are significant, and should not be ignored. Therefore, in PPP project evaluation, it is deficient to replace all experts' opinions by the overall evaluation. This new model proposed in this study is a remedy for the overall evaluation method.

5.7 Build a Cultivate Environment for PPP

5.7.1 Contributions of DMF Evaluation Scheme

Successful implementation and development of PPPs in urban water supply projects significantly rely on effective communication between participants from the public and private sectors. However, due to information asymmetry, both partners in PPP are not able to capture the needs and requirements of each other accurately. Therefore, PPP projects usually undergo long term negotiations; some even did not reach cooperation to the very end. This is not only a waste of time, manpower and financial resources, but also causes delay in project development.
To reveal the differences in PPP project evaluation between the public and private sectors, so as to improve communication efficiency, a comparative study is conducted by inviting experts from public sector and private sector respectively to score 35 DMFs with regard to their importance. Data reliability and validity were examined by Cronbach's alpha and Kendall's W. Through statistical analyses, the scores of importance and rankings for DMFs in the overall evaluation and those in the public and private sectors are generated and compared. The comparison results reveal that differences in opinions between the public and private sectors toward DMFs are significant. Mean scores of importance in the overall evaluation average the scores given by the two sectors; therefore fail to illustrate the differences in opinions between the two sectors. Traditional project evaluation methods neglected these differences, by using the results from the overall evaluation to cover up the bifurcation DMFs, which in turn damped the success of PPP projects.

To remedy the inadequacy of conventional overall evaluation, a novel evaluation scheme is proposed. The IDEM classifies the DMFs into four categories: CDMFs,

fundamental decision-making factors, systematic decision-making factors, and controversial decision-making factors. Among the 35 DMFs, project profitability, manager capability, quality of treated water, ineffective control of groundwater exploitation, and local investment environment are identified as CDMFs, because although the scores they receive between the public sector and the private sector are significant different, they are considered very important in the overall evaluation. Besides, it is discovered that the private sector concerns more about financial, operational and political DMFs than the public sector does, whereas the public sector concerns more to find a reliable concessionaire to secure social stability. It is suggested that the government should take more responsibility for providing a more transparent, reliable and sustainable investment environment for the implementation of PPPs in the urban water supply projects in China.

Comparing with the overall evaluation method, IDEM helps to identify and further analyse those critical factors associated with divergent opinions from the public and private sectors. With the two-dimensional DMF classifier, complex information is made clear. Considering the particularity of water supply project management in China, the evaluation scheme proposed in this paper provides a valuable platform for the PPP partners to understand the needs of co-operators, so as to make more scientific, accurate, and strategic planning and facilitate effective communication between the public and private sectors in PPP projects. By learning from previous experiences, the proposed evaluation scheme is feasible and practical to be utilized to PPP projects in the urban water supply sector in China.

5.7.2 The Role of Private Sector in Water Supply Service

The Water supply service encountered serious problems in almost every aspect. To determine the role of Private Sector Participation in this case, it is essential to analyse the reasons for the formation of these issues.

Causal Analysis

There were many inherent deficiencies when water supply enterprise was operated by the county government. However, as water supply is a complex system, the problems encountered are very intricate. Figure 5.8 gives an illustration of the complex causal relationships.

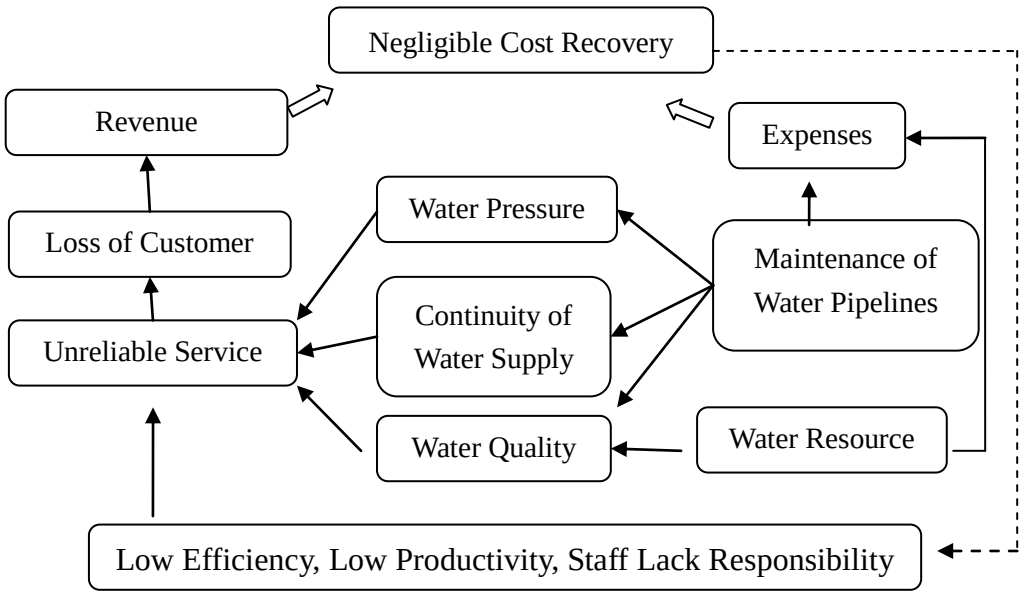

Figure 5.8 Problems encountered by water supply enterprise under government monopoly

Among all the complicated problems that need to be resolved, cost recovery is more crucial. As if the water supply sector cannot receive the expenses from the revenue, the normal operation could not be maintained, and subsequently, brought out a number of other issues. Why the revenue could not meet the expenses? The reasons may be low income, or too much expenses, or both. First, the source of revenue is investigated. As a water supply service, the main income should be the water fee collected. However, as the service provided to the consumers are unreliable, more and more users chosen not to take their services, which resulting in the decrease of water volume sales. Second, the spending is evaluated, including the cost of water production, labor cost, operation expenses and maintenance costs. According to the water volume produced, the production cost is not high; however, when according to the volume of water sales, the cost is too high, due to the high percentage of unaccounted water. Through the interview with the employee of the water service provider, we find out that the salary of the employee is unexpected low; however, as the number of employee is large, the total labor cost is high. The revenue could not even cover this labor cost. Regard to the operation expenses and maintenance costs, no documentation could be found to investigate the real spending. Nevertheless, with the secondary analysis of available data, the problems encountered during operation and the suggested solutions are summarized in Table 5.10.

As mentioned in the previous section, with a loan borrowed from the central government, the water supply enterprise in City N set up a pipeline to transport water from the new water resource to the town. This piping line was originally expected to put into use in 2006. Nevertheless, the water distribution network and water utility in the town were dilapidated. Since the government could give no more financial support to the construction of new water supply infrastructure, introduction of PSP became a more feasible approach for the county government

as more legal, administrative and tariff-setting restrictions on foreign investments in public service delivery had been lifted by the central government.

Table 5.10 Operating problems encountered and solutions

Problems	Reasons	Solutions
High UFW ratio	Leakage of old pipelines	Replace pipelines
	Inaccuracy in metering	Change meters
	Unauthorized water usage	Raise people's awareness through public education
	Water meters inside property	Move water meters outside
Low service coverage	Unreliable water supply service	Insured water quality
Low active user ratio		Uninterrupted water supply
Low meter connection ratio	No updated records of users	User Management System

Objectives of Private Sector

To overcome the previously stated problems, the local government had tried a lot of ways; however, there exist some issues that they do not have the capability to solve. The water quality is limited by the natural conditions, which requires new sources of water. To prevent secondary contaminate of water, keep a standard pressure, and supply water continuously, the dilapidated water distribution pipelines need to replace. All of these solutions need the investment. Besides, efficiency issues, operational issues, and management issues all have an urgent need to address. Therefore, the involvement of private sector was expected to achieve the following goals. Generating new sources of cash flow and financing for enterprises to replace the dilapidated water distribution pipelines, to improve

service quality, and reduce fiscal deficit of government. Improving efficiency in operation, productivity, and inquiry response, applying advanced management skills to motivate the employee, and reduce cost. Other objectives include internal performance enhancement, encourage managed competition, and enable selective outsourcing of services.

Contributions of Private Sector

There are a number of benefits that can be realized from private sector participation in water supply services. To make a clear comparison, some key operational performance indicators for City N's water supply service are listed in Table 5.1. Data in the column "2006 and Before" represent the performance before Private Sector Participation（PSP), while data from 2007 to 2009 represent the performance after PSP.

After PSP, the number of employees per 1000 connections of WSCL has reduced from 20 to 3 per 1000 connections, however, the registered connections increased near a half. Almost all of the registered connections are metered. Although UFW, service coverage and active user ratio still have much space to make progress, they did improved significantly compared with the performance before PSP. With good service quality, WSCL has built a good corporate image in the community. Their responsible attitude made a significant contribution to customer satisfaction and won their loyalty. The findings in this case study echoes the results of the research conducted by Kayaga *et al.* in 2004.

It is obvious that after the introduction of PSP, the performance of the water supply service in the town of City N has improved significantly. All the above performance indicators show that with the involvement of PSP, enterprise can get

broader access to capital, provide more reliable services, raise enterprise image, develop and maintain target customers, add flexibility and autonomy to management and decision making, improve efficiency and enhance profitability. Thus, the introduction of PSP in City N water supply project is a successful try-out.

5.7.3 Challenges for PPP

Besides benefits, there are also several challenges towards private sector participation. These challenges could become barriers or constrains and can become problematic if not handle properly.

Firstly, government officers and private sectors do not share the same long-term objectives. We need to have everyone on the same page. What the government wants to achieve is the stable of the society, while the private sectors objective is to seek profit. Investors will not commit or perform their role in service delivery unless governments also commit and perform their vital role in building and maintaining a supportive regulatory environment, ensuring a transparent process, and clarifying roles, risk allocation, goals and incentives.

Secondly, designing and implementing a successful private participation scheme takes time, political will, and resources, including quality advisory inputs, extensive consultation with stakeholder groups, and early efforts to develop regulatory capacities.

Thirdly, trust among the partners is the key element in building a successful relationship. It is not surprising, although there is an increased understanding that government should not own and/or operate certain types of facilities because of

its less effective utilization of resources when compared with the more flexible and cost-conscious private sector (Antonio and Photios, 1996) and government gradually shifts policy towards PSP in providing water services in China, investors react slowly to embrace it (Kayaga and Zhe, 2007). Conflict may exist everywhere among foreign investors, government officers and local partners, as they may have different social and cultural experiences and concepts. Thus, much effort needs to be put towards fostering better relationships as regular engagement can lead to better trust among the parties involved.

5.8 Summaries

Water supply service when operated by the local government, it may face various problems: negligible cost recovery, unreliable water supply service, loss of customers, poor operational and financial performance, low social satisfaction level, ineffective management, overstaffing, low efficiency and high dependence on subsidies. Among these issues, cost recovery is the essential one, as it will directly or indirectly influence other issues. To make cost recovery possible, the quality of service should be improved, thus investment are required to replace the dilapidated water distribution pipelines.

Private sector participation in the project effectively solved the desired investment problem. It is obvious that after the introduction of PSP, the performance of the water supply service has improved significantly. They provide more reliable services, raise enterprise image, develop and maintain target customers, add flexibility and autonomy to management and decision making, improve efficiency and enhance profitability.

However, the results of financial analysis suggest that the enterprise still does not have the capacity for economically and environmentally sustainable development. Return on investment cannot reach the desired level of the investor, and the local government did not fulfill their commitment. Both the investor and the local government had an inaccurate forecast of the revenue and water demand. One important finding is that a crucial reason lead to the deviation of the forecast is the out of control of underground water exploitation.

Limitations in this case study are summarized. The decision-making process of the private sectors' investment willing is still not clear, as no causal understanding could be developed regarding an investor's actual decision-making process. The initiatives (or factors) which will influence the inventors' decision making could not be ranked in any order of importance, and the potential interactions between factors — and any determination of whether these were part of the same, more general, factor — could not be determined.

To determine the factors that will impact the successful implementation of private sector participation in water supply service, evaluate the relative strength or importance of each factor, as well as at the interactions between factors, a decision- making model will be setup in the following chapter.

To sum up, it is believed that there were many inherent deficiencies when water supply enterprise was operated by the government. As managers did not have the autonomy to hire or fire staff, it made no difference for the staff whether they worked hard or not, and so it was difficult to motivate staff to work with enthusiasm. On the other hand, facilities used for supplying water were dilapidated, which led to poor service quality and complaints from all parties in

the town. Working in this circumstance, staffs can hardly get job satisfaction and their indifferent attitude in turn further worsened the service quality. The unreliable water supply service led to a decreasing number of customers who regularly paid for water bills. As a result, the revenue from sales of water was deplorably low. As water supply enterprise could not recover its operation costs from sales of water, its expenditure, even staff salaries, relied heavily on government subvention. It is evident that under government monopoly, the water supply enterprise in City N was unable to manage urban water supply service efficiently and to undertake the investment necessary to provide adequate levels of service provision.

CHAPTER 6 POLICY CHOICE RECOMMENDATIONS FOR PROMOTING PPP IN WATER SUPPLY PROJECTS

6.1 Agent-Based Modelling

Urban public utilities' commercialization involves many aspects such as utility management system and enterprise ownership. Ownership is the fundamental determinant of operation and management forms. Under command economy, government acts as both owner and provider. With multiple objectives, the manager of the utility is subjected to a number of conflicting influences. Success in institutional reform requires a change in government's roles, and separation of enterprise management and government affairs are of crucial importance. In recent years, with central governments' clearer direction of system reform for water enterprises, most local governments issued related policies. However, as reform is a complex adaptive process, emergent phenomena abound in the transition period and have been progressively accepted as being difficult to predict and even counterintuitive. Therefore, policies and regulations supporting marketization should be implemented systematically to consolidate the success of the reform.

Although many researchers have revealed some approaches to automate and regulate water-supply systems, it is always difficult to understand why policy decisions go one way rather than another and the interpretations are often diverse according to personal feelings. To discuss and understand this phenomenon more effectively, suitable tools should be developed. This is particularly urgent for policy-making under the current transition of the water supply sector. Traditional modelling techniques used in government policy-making mainly rely on

empirical evidences. Models based on purely linguistic descriptions, while infinitely flexible, often fail to be logically consistent. Mathematical models lack flexibility, but gain a consistent structure and general solution techniques (Janssen, 2004; Gilbert, 2007). A surplus of hard technical knowledge combing the advantages of both is currently available in many disciplines as against a death of soft cybernetic and behavioural knowledge (Bonabeau, 2002). Agent-based modelling (ABM), which describes the complex adaptive systems, makes possible the development of well-defined yet flexible models that exhibit emergent behavior, and can capture a wide range of economic phenomena precisely. This paper looks into the complexity and systematic characteristics of government policy-making in water supply systems. ABM is introduced to conduct a flexible dynamic study with unfolding behavior of the model observed step by step. It is anticipated that the conceptual framework established by this study could have the potential for effectively evaluating the current policy under transition economy. Figure 6.1 illustrates the procedure to conduct ABM simulation.

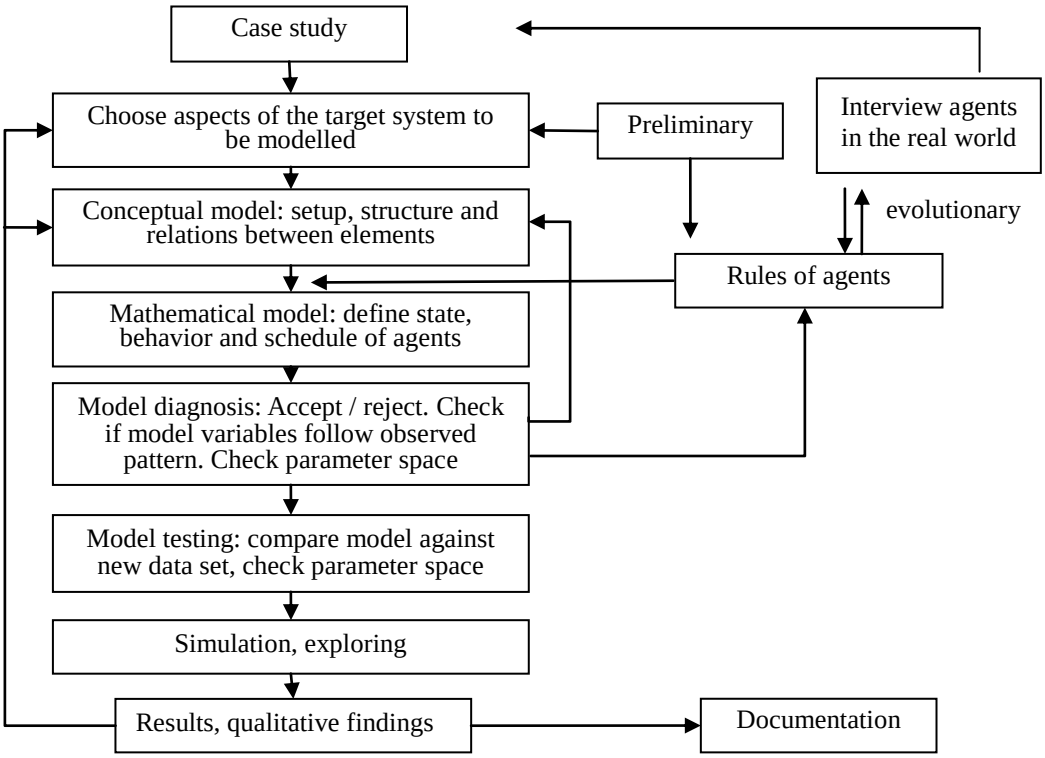

Figure 6.1 Procedures of ABM simulation

6.1.1 Components of ABM

ABM is a powerful simulation modelling technique that has seen a number of applications in the last few years (Paul *et al*., 2007). In ABM, a system is modelled as a collection of autonomous decision-making entities called agents. Each agent individually assesses its situation and makes decisions on the basis of a set of rules. ABM efforts enable researchers to test and develop theories in a way that might not be possible using analytic and experimental methods. A typical agent-based model consists of three components: agent, environment and interaction as shown in Figure 6.2.

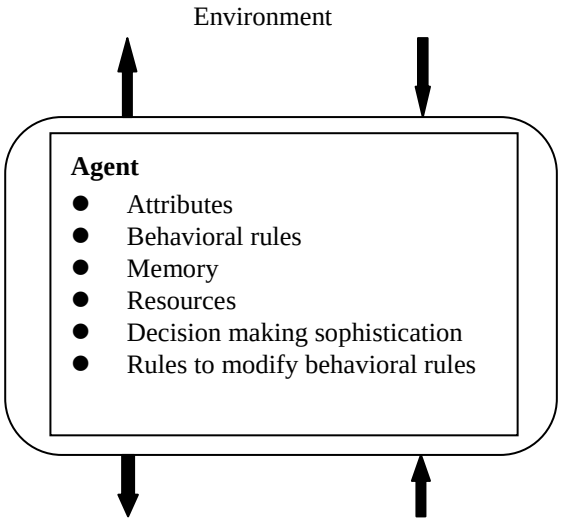

Figure 6.2 Diagrammatic Sketch of Agent-based Model

Agent

An agent is an encapsulated computer system situated in some environment and capable of flexible, autonomous action in that environment in order to meet its design objectives (Wooldridge, 1997). Agents are diverse, heterogeneous and dynamic in their attributes and behavioral rules. From a practical modelling standpoint, agents have certain characteristics: (i) clearly identifiable problem-solving entities with well-defined boundaries and interfaces; (ii) situated in a particular environment over which they have partial control and observability to recognize and distinguish the traits of other agents; (iii) goal-directed, having goals to achieve with respect to their behaviors; (iv) autonomous and self-directed, having control both over their internal state and over their own behavior; (v) flexible and with ability to learn and adapt their behaviors over time based on experience which requires some form of memory to modify its rules of behavior (Wooldridge and Jennings, 1995). Four different categories of agents are identified: Living thing - humans or animals; Physical entity - artifacts, like a machine or a robot, or natural objects; Software process -

executing program code; and Organization - an enterprise, a group of persons, and other entities composed by a set of individuals (Paul et al., 2007).

Environment

Environment is the media for the interaction between agents, such as plants, land and resources. Environment often changes in time and space due to the dynamic features of environment itself and the changes of agents. A typical expression of the environment usually has a multilayer structure of two-dimensional grid (Bousquet et al., 1998), including square, triangular and hexagon. It can also be expressed as a spatial correlation, such as spherical (fully related), Moore Environment (grid point boundary correlation) and the Von Neumann environment (grid side related) (Hales, 2002). Some structures of the environment are illustrated in Figure 6.3.

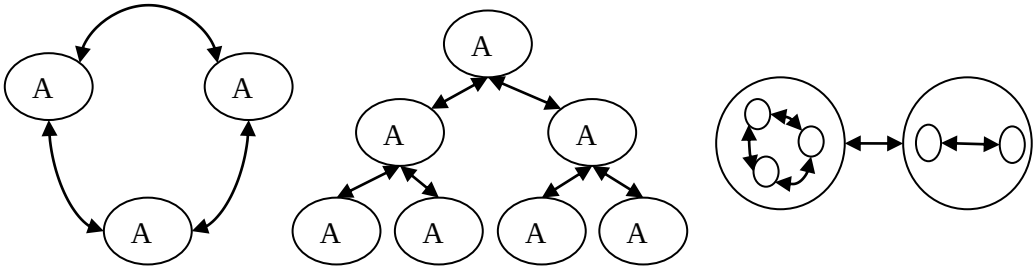

Figure 6.3 Peer-to-peer, hierarchical, and recursive environment

Interaction

The agents will need to interact with one another: either to achieve their individual objectives or to manage the dependencies that ensue from being

situated in a common environment. These interactions could be simple semantic interoperation, traditional client-server type interactions, or rich social interactions (the ability to cooperate, coordinate and negotiate about a course of action). Interactions are conducted at the knowledge-level (Newell, 1982) in terms of which goals should be followed at a prescribed time and by a particular agent. Agents need the computational apparatus to make context-dependent decisions about the nature and scope of their interactions and to initiate interactions that were not foreseen at design time.

6.1.2 Advantages of ABM

ABM is a mind-set more than a technology. Even a simple agent-based model can exhibit complex behavioral patterns (Axelrod, 1997) and provide valuable information about the dynamics of the real-world system that it emulates. Sophisticated ABM sometimes incorporates neural networks, evolutionary algorithms, or other learning techniques to allow realistic learning and adaptation (Epstein and Axtell, 1996). In addition, agents may be capable of evolving, allowing unanticipated behaviors to emerge.

ABM is a canonical approach to model emergent phenomena which are the results of interactions between individual agents, difficult to understand and predict, and sometimes counterintuitive. ABM simulates the behaviors of the agents and their interactions, captures emergence from the bottom up when the simulation is run, and therefore provides a new perspective to explaining emergent phenomena.

In many cases, ABM is the most natural way to describe and simulate a system composed of "behavioral" entities. Whether one is attempting to describe a traffic jam, the stock market, voters, or how an organization works, ABM is often the most appropriate way for describing what is actually happening in the real world. When expert judgment is crucial to the validation and calibration of the model, ABM could be used.

In addition, ABM is more flexible than other modeling techniques. For instance, ABM makes it possible to add more agents to the model. Also, it provides a natural framework for tuning the complexity of the agents with regard to their behaviors, degree of rationality, ability to learn and evolve, and rules of interactions. Besides, using ABM, one can easily change the levels of description and aggregation by playing with aggregate agents, subgroups of agents and single agents with different levels of description coexisting in a given model. One may want to use ABM when the appropriate level of description or complexity is not known ahead of time and requires some tinkering.

6.1.3 Application of ABM

ABM is actively being applied in many practical areas, such as business (Chen and Yeh, 2001; Lee and Kimz, 2008), economics (Holland and Miller, 1991), society and culture (Wooldridge, 2000), crowds, infrastructure (Day and Walter, 1989), and biology (Asher *et al.,* 2009). Its application ranges from small, elegant, minimalist academic models to large-scale decision support systems. ABM decision support models tend to be large-scale applications and are designed to answer real-world policy questions. These models include real data and have passed some validation tests to establish credibility. The process of

defining the rules of the actors evolves in a process of interaction with real world actors. The Importance is that these rules represent an abstract and general representation of varying rules of individuals, and from this body of knowledge, we extract the institutional dynamics.

6.1.4 Conceptual Model

Decision-making simulation in a water supply system is a complex adaptive system. The government's role and position, experience and supervision system are all key factors determining the success of the simulation. Multiple objective coordination, spatial variability, temporal dynamics and reliability analysis should all be taken into consideration. The agents involved in the system are described in Figure 6.4. Interactions between agents and behavioral rules of the agents are defined. Government is the independent agent. By changing different policies and regulations, the interests of investors and consumers will change accordingly.

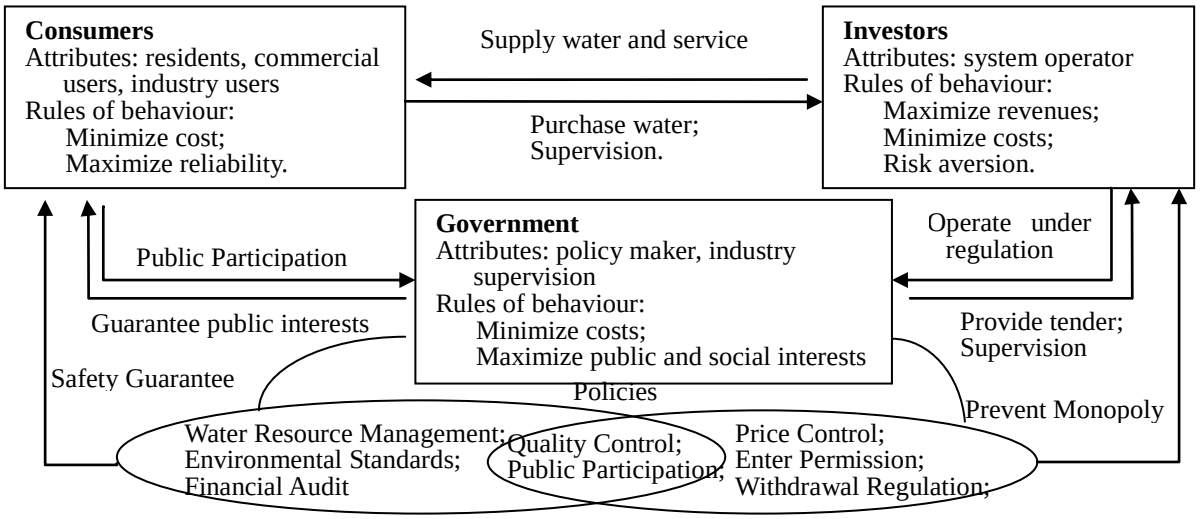

Figure 6.4 Agents and their interactions in policy simulation model of a water supply system

The interactions between consumers, investors and the operating rules make the entire system's dynamics quite hard to understand. Predicting how it would change under a new set of operating regulations cannot be based on intuition or on classical modeling techniques which are not suited to describe the complexities of the behaviors of the these agents. ABM allows regulators to test and predict the effects of different strategies, observe the behaviors of agents in response to changes, and monitor developments. This can provide advance warning of unintended consequences of newly implemented regulations faster than real time without risking early tests in the real marketplace.

The main objectives of government management are to prevent monopoly after the private sector is introduced, and to ensure stable, reliable, environment-friendly supply of water to meet the demand in all aspects of life. Thus, governmental functions should change from enterprise management to industry management, taking supervision responsibility of the whole process in water supply, from investment, construction, operation to service. The fundamental objective of the government is to safeguard public interest and social interest finally by improving the operational efficiency of the water supply sector through market-oriented approaches. Thereby, the public could obtain high-quality products and services with a small amount of payment. Meanwhile, the environmental requirements should be satisfied.

From the perspective of efficiency and fairness, due to the natural monopoly and scale economy characteristics of water supply infrastructure, in terms of supplying products and services for the same quality, tender to one experienced enterprise is more efficient. Hence, the government should control the number of enterprises that are qualified to enter this field. On the other hand, in this monopoly market structure, it is possible for the enterprise to increase its profit

by reducing the product quality and service standards, adversely affecting the overall economic environment and the interests of consumers. Therefore, the government should setup stick regulations to avoid potential monopoly.

From the public health and environmental quality perspective, water supply infrastructure is the link between the natural environment and human life. Public health and environmental quality are very sensitive to the operation of water supply infrastructure. To ensure a stable and continuous supply of water, the government should allow profit margin for the enterprise. To guarantee public and environmental safety, the government should set up regulations to make sure the quality of service is reliable.

6.2 Agents' Behavioural Rules

Based on the information from literature review, survey and case study in PPP projects, the main objectives of the public sector include attracting private sector investing in public service and securing that the service is operated at a reasonable cost. The government will be responsible for price regulation, and consider whether to offer preferential policies to the private sector. The public sector, usually the government, will select the private sector according to some criteria including the financial capability, reliability and experience. They will also inform the private sector the conditions of getting return on investment and profit allocation principles. The private sector will estimate the project profitability according to the condition and principles, and the prediction of service demand. Consumers can obtain consumer surplus through the consumption of service provided by the private sector. The profit functions for each participator are given below.

Private sector profit function

$$\pi_t = P_t D_t - aQ_t - rkQ_t + sQ_t \tag{6.1}$$

where

π_t is the profit of the private sector during time slot *t*.

P_t is the selling price of unit water during time slot *t*.

D_t is the quantity of water demand during time slot *t*.

Q_t is the quantity of water production during time slot *t*.

a is the changeable cost per unit water

k is the initial cost per unit water, which relate to the scale of production.

r is the unit capital cost, which means if private sector borrow a loan from the market the cost they have to spend.

s is the subsidy per unit water from the government. $s \leq a + rk$. It means the government will share some of the expense for producing water.

For the private sector, there are two sources of revenue, one is from water sells, and the other is from the subsidy provided by the government. Also there are two types of cost, one is the operation cost and the other is the investment.

Consumer surplus function

$$U_t = bD_t - P_tD_t \tag{6.2}$$

where

U_t is the consumer surplus during time slot t.

b is the unit cost of water purchase from other channels.

P_tD_t is the bill that the consumers need to pay for water purchase to the private sector during time slot t.

In this function, we can see if the water selling price P_t is higher than b, the consumers will not choose to use the water provided by the private sector. However, if the water selling price P_t cannot cover the expense, the private sector will not invest in the project. In order to balance the interest of both sides, the government has to control the water selling price P_t and give some subsidy to the private sector.

Government subsidy function

$$G_t = \lambda s Q_t + \gamma(1-\lambda) s Q_t \tag{6.3}$$

where

G_t is the expense of the local government during time slot *t*.

s is the unit subsidy that the private sector can get

λ is the portion of subsidy spend from the financial budget of local government, $\lambda \leq 1$

γ is the permitted bad debt rate of the subsidy provided by state-owned financial institutions. $\gamma \leq 1$. State-owned financial institutions can use risk management capabilities to cover part of the financial expenditures.

From the government subsidy function we can see that the government can choose to give subsidy to the private sector from two financial resources: one is from the local government financial budget, and the other way is to give subsidy through the state-owned financial institutions and pay a rate of γ to the institution for the amount of subsidy.

Public sector profit function

$$Z_t = U_t + \theta \pi_t - G_t \tag{6.4}$$

where

Z_t is the profit of the public sector during time slot *t*.

θ is the weight of private sector's profit over consumer surplus. It is defined by the public sector. It is a constant between (0, 1]. θ<1 indicates the

government weighting more on the consumers' benefits. θ=1 indicates the government weighting the benefits of the private sector and the consumers equally.

In the sense that public sector represents the overall social benefit / interest, the profit of public sector thereby includes consumer surplus, the profit of private sector and government expenses. In practice, long-term and sustainable development of PPP can be achieved when the interests of all parties are fully considered. In this study, it is posed as following constrained optimization problem.

$$\max \sum_{t=0}^{\infty} \omega^t Z_t$$

$$s.t. \qquad \pi_t \geq 0$$

where

ω is the discount rate defined as $\omega = 1/(1 + i)$

i is the interest rate

In a PPP project, the private sector has to estimate the profit they can get and make a decision on the amount of investment they can inject. The public sector has to control the water selling price and finalize the amount of different sources of subsidy to the private sector. In game theory, the decision made in the previous step will have an impact on the decisions to be made in the following steps, so in this study the public sector and the private sector will make decision according to the following steps:

Step 1: The private sector confirms with the local government about the return terms of the investment.

Step 2: Private sector action. According to the return terms defined in the first step and the estimation of demand, the private sector will select the initial capital input level *k*. There are two options of *k*. Assuming the private sector choose high level of investment k_h=1, with possibility1- *p*, the production of private sector can meet demand all the time; nevertheless there will be a production surplus. Assuming the private sector chooses low level of investment k_l =1-β, with possibility *p*, the production of private sector can only meet the demand when it is low.

Step 3: Natural action. The actual demand D_t will appear.

Step 4: Government action. According to the investment level selected by the private sector, the government can get the production capacity. Regarding the actual demand, the government can set the water selling price P_t and the unit subsidy *s*.

Step 5: The quantity of production will be determined by min ($Q_{t,}$ D_t). It means if the production capacity is higher than actual demand the quantity of production will be equal to demand, whereas if the production capacity is lower than demand the quantity of production will be limited to the production capacity. When the water is produced and sold the private sector can get payment by the consumer and subsidy by the government.

Substitute equation 6.1, 6.2 and 6.3 to 6.4, then we can obtain the public profit function as follows:

$$\begin{aligned} Z_t &= bD_t - P_tD_t + \theta(P_tD_t - aD_t - rkQ_t + sQ_t) - \lambda tQ_t - \gamma(1-\lambda)sQ_t \\ &= [b - P_t + \theta(P_t - a)]D_t - [\theta(rk - s) - \lambda s - \gamma(1-\lambda)s]Q_t \end{aligned} \quad (6.5)$$

The actual amount of water production is equal to the amount of water consumption, which can be expressed as min (Q_t, D_t). For the convenience of mathematical analysis, unit public profit z_t is utilized and expressed as:

$$z_t = \frac{Z_t}{Min(Q_t, D_t)} = b - \theta(a + rk) + [\theta - \lambda - \gamma(1-\lambda)]s - (1-\theta)P_t \quad (6.6)$$

where s and P_t are independent variables. Parameters θ and λ can significantly influence z_t.

The coefficient of P_t is $-(1-\theta)$, which is always negative due to $0 < \theta \leq 1$. Meanwhile, since the coefficient of s, expressed below, is undetermined, it should be discussed on a case by case basis.

$$\theta - \lambda - \gamma(1-\lambda) = 1 - \frac{1-\theta}{1-\gamma} - \lambda$$

On the condition that $1 - \frac{1-\theta}{1-\gamma} - \lambda < 0$, z_t has the maximum value if and only if $P_t = (P_t)_{min}$ and $s = s_{min}$. Given $\pi \geq 0$, one can easily reach the conclusion that: $s + P_t \geq a + rk$. Therefore, $(s + P_t)_{min} = a + rk$. Since $0 < \theta \leq 1$, $0 < \gamma \leq 1$, and $0 < \lambda \leq 1$, it is easy to proof that the coefficient of s is smaller than the coefficient

of P_t. Under this condition, if and only if $(P_t)_{min} = 0$ and $s_{min.} = a + rk$ will lead to the $(z_t)_{max}$. Thus:

$$(z_t)_{\max} = b + (\gamma\lambda - \gamma - \lambda)(a + rk)$$

Similarly, when $1 - \frac{1-\theta}{1-\gamma} - \lambda > 0$, z_t has the maximum value if and only if $P_t = (P_t)_{min} = 0$ and $s = s_{max} = a + rk$. Thus,

$$(z_t)_{\max} = b + (\gamma\lambda - \gamma - \lambda)(a + rk)$$

Base on the illustration above, one can safely draw the conclusion that unit profit can be maximized if the water is supplied for free and the government covers all the expenses for producing water as subsidy. However, in reality, the water selling price always exists and the government has to make decisions on how to assign subsidy to the private sector.

6.3 Policy Choice Recommendation

This session aims to provide feasible solutions for the decision-makers from both the private sector and the public sector to choose. The final decision can be made through negotiations between these two parties.

6.3.1 Introduction

In previous chapters we pointed out that PPP projects will involve more disputes. To facilitate the success of cooperation between partners in PPP projects, it is important to seek the corresponding point from both sectors. Through thorough analysis, we find out that project profitability is a critical consideration for both sectors. Therefore, we will give policy recommendations to both sectors by comparing the project profitability produced by different policy choices.

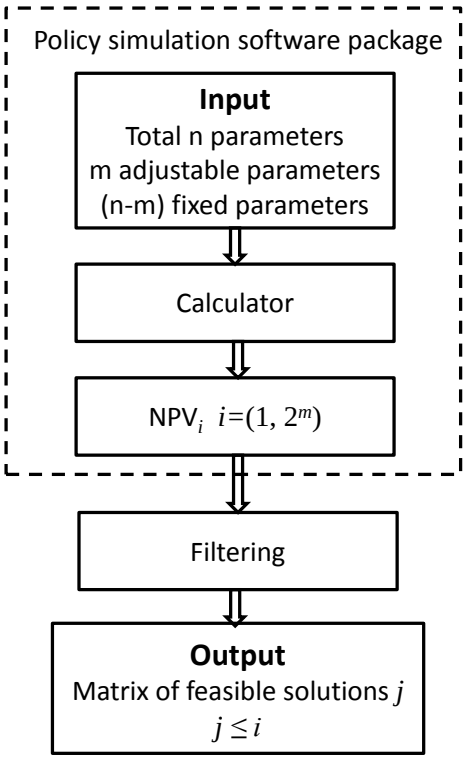

Figure 6.5 Flowchart of policy choice recommendation procedure

Figure 6.5 gives the procedure of policy recommendation. Project profitability is expressed by Net Present Values (NPVs). Firstly, a policy simulation software package is developed to calculate the NPVs under different policy choices. There are *n* input parameters. We can adjust *m* among *n* parameters to get 2^m NPVs, and each NPV reflects a specified policy choice. After evaluation, unachievable policies will be filtered out. Then a matrix of feasible solutions will be provided to the decision-makers to choose.

The policy choice simulation software package has been developed to give recommendations on water supply projects. Figure 6.6 summarises the relationship between input parameters and outputs. All input parameters should be defined according to the characteristics of the target water supply project. The outputs of this package are the NPVs forecasted under different operation assumptions and policy choices. These NPVs are calculated in Microsoft Excel calculation sheets. Accounting principles are applied to produce these NPVs. In all cases, two scenarios of analyse will be conducted to produce NPVs: no risk scenario and with risk scenario. For Risk case, we will run 1000 time simulation. Figure 6.7 shows an example of forecasted NPVs. It shows the distribution of possible NPVs under risk cases. The shadow one gives the NPV for no risk case.

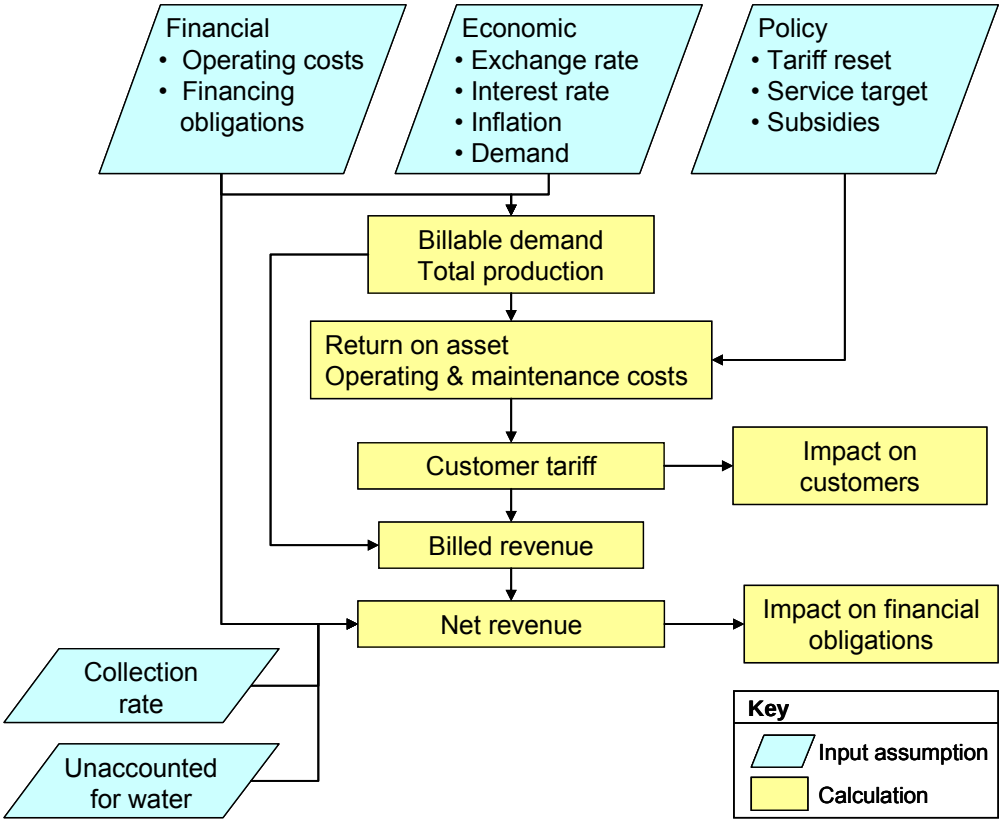

Figure 6.6 Summary of inputs and outputs

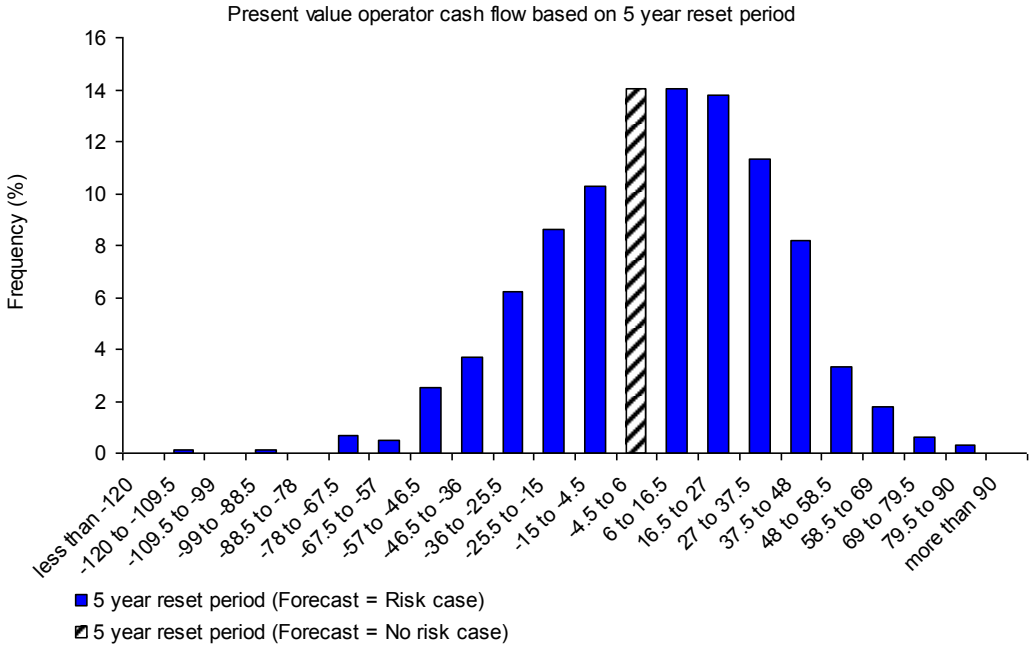

Figure 6.7 NPV prediction

The profitability analysis model contained in this package can be defined as a simulation model of an initial investment and subsequent operations. The cash flow from operations must be estimated carefully on the basis of a thorough investigation. The cash flow and the development of balance sheet is then simulated over the lifetime of the investment. The model is based on given assumptions. For each project, when the attributes of the project are determined, the assumptions will be deterministic accordingly. However, volatilities reflecting uncertainties are added to variables for adjustment. The time unit can be a year or a month, so we will have a yearly or a monthly simulation of operations. Figure 6.7 shows a typical example of a monthly cash flow series in a water supply company. We can see that in summer time, the revenue is higher, because when the weather becomes hot, people begin to use more water.

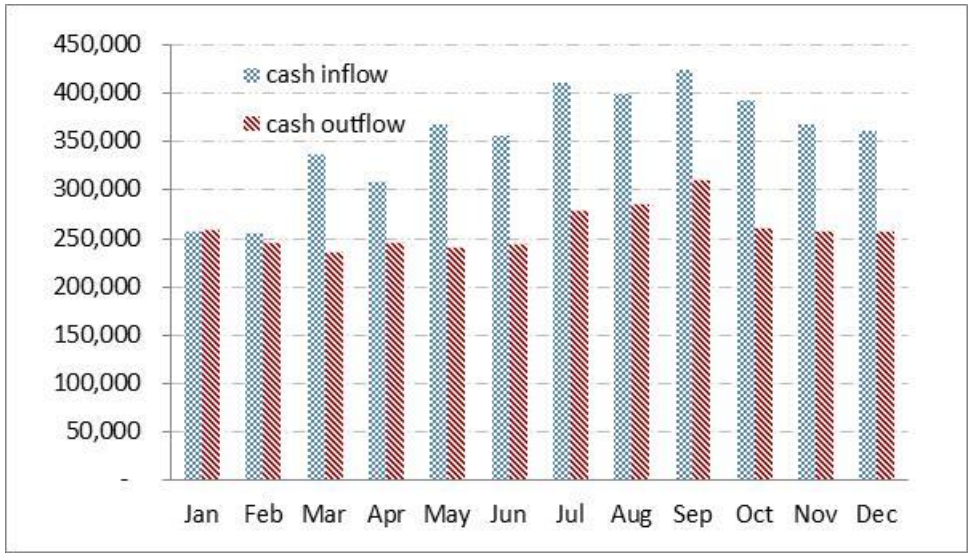

Figure 6.8 An example of monthly cash flow series for a water supply company

This package can be used as a kind of laboratory. It allows the decision makers to study the impact of different policies by asking what-if questions. The results provided by this package are more reliable, so evidence-based decisions can be made. This package has been successfully practiced in a PPP water supply

projects. In the following part of this secession, the use and development of this package will be explained in details. In the target water supply project, we assume the construction and investment preparation period is one year, and the operation contract is for 20 years. These assumptions can be changed easily in the Excel model.

6.3.2 Input Assumptions

Assumptions here are the inputs for the calculations to follow. Users can reset the numerical values of inputs and add additional assumptions easily according to the actual situation. The summary of assumptions and calculation inputs are given in Figure 6.6. The colour code used is that blue for input cells and yellow for calculation cells. All subsequent components of this package are based on these assumptions and contain only formulas but no input cells. The breakdown of the assumptions will be descripted in the following part with a case study for demonstration.

Financial Assumptions

Financial assumptions include three main components: initial investment estimation, operational cost estimation, and financing obligations.

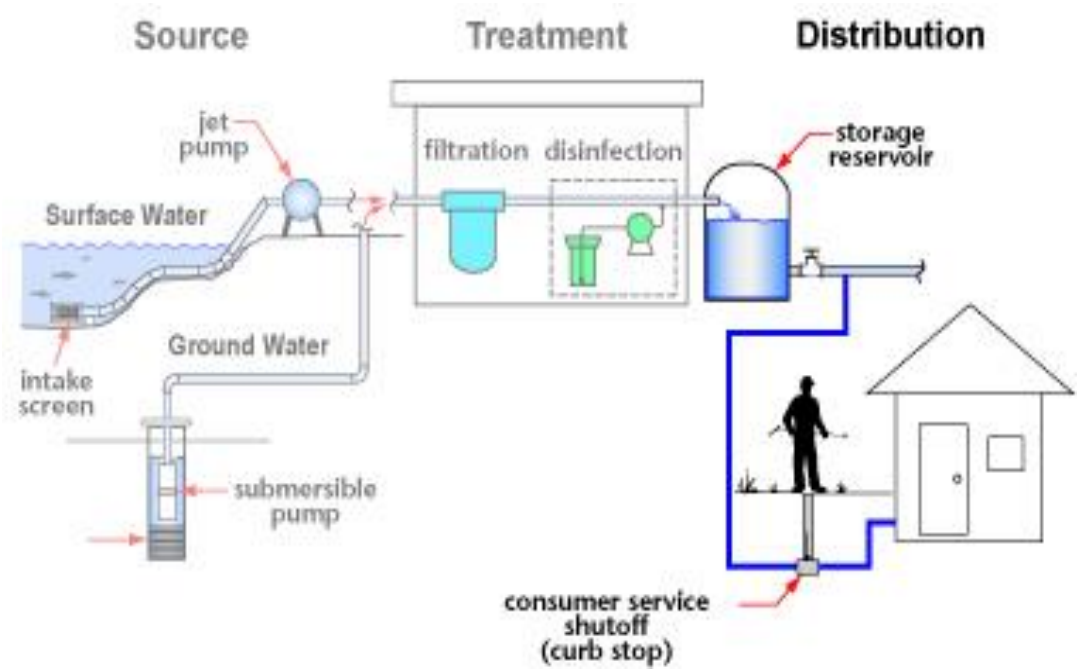

Figure 6.9 Sketch of water supply system

Figure 6.9 shows the sketch of a water supply system. It contains three parts. The first part is the source of water. It can be surface water or ground water. Different source will have different water quality which may determine the water treatment process. The second part is the water treatment plant. After treatment, water will meet the standard for using. The third part is the water distribution network, through which treated water can reach every user.

In a water supply project, the initial investment is needed to explore water resource, build water treatment plant and water treatment equipment, and construct water distribution network. The amount of investment is related to the designed daily production capability and the quality of raw water. In this case study the designed production capability is 30,000 tons per day. The raw water is ground water and water quality is good. Therefore, the initial investment is set 30,000,000 dollars.

Operational cost includes fix cost and variable cost. Depreciation cost is calculated based on the initial investment, because the initial investment is used to construct the fix assets. Depreciation period can be set 10 to 20 years. In this water supply project, 20-year depreciation period is selected. The depreciation is calculated with the straight-ling method. Therefore, the depreciation cost per year is 1,500,000 dollars.

Power charge is an important component of variable operational cost. Power will be used in three processes. Firstly, raw water will be pumped into water treatment plant. Then power will be needed to treat raw water. After treatment, power will be used to pressurize the water to make sure every end user can get sufficient water supply. Power charge will be affected by three factors: 1) the price of the electricity supply, 2) the difference of altitudes between water source and water treatment plant as well as the difference of altitudes between water treatment plant and water distribution network, and 3) the quality of raw water. The amount of power charge can be estimated when these three factors are determined. In this water supply project, the major component of power charge is for pumping water to the water treatment plant and to pressurize the treated water to the end users. The estimated power charge per ton of water is 0.25 dollars.

Chemical charge and maintenance cost are also variable operational cost. Chemical charge is determined by the quality of raw water. Generally, alum will be added for coagulation, and chlorine will be added for disinfection. In this water supply project, the quality of raw water is pretty good, so fewer chemical are needed. The chemical charge is estimated 0.02 dollars per ton of water. Maintenance cost will be spent to maintain the water treatment and distribution equipment and network. It is estimated 0.04 dollars per ton of water in this case study.

Salary is another main component of operation cost. It is determined by the number of staff and the amount of salary per person. The number of staff is determined by the number of connections and operational efficiency. The amount of salary required should be suitable for the local social and economic environment. The local minimum wage standard and average wage statistic can be adopted as references. In this water supply project, the operational efficiency is high, and the local economic development is a bit backward. Therefore, the salary per month is estimated 75,000 dollars.

Except for the operation costs mentioned above, many other expenses are also required, for example, insurance, welfare, hospitality, travel expenses, office expenses, etc. In this project, all these expenses are estimated 80,000 dollars per month.

Financing obligations, in this part it defines the source of finance and the schedule of reimbursement. In a PPP project, different partners may take different shares of financing responsibility for coverage extension and operation. The partner can also choose to fund the project by debt. In this project, all the investment is funded by the private sector, and no loan is borrowed. If any loan is borrowed, the currency of loan, interest, loan period and grace period should be defined.

Table 6.1 summarised all the operational costs estimated in this project. All the following calculations are based on these assumptions. One thing should be mentioned is that all the values of these assumptions can be reset by the users. Additional assumptions can also be added easily by the users.

Table 6.1 Operational Costs Estimation

Total Investment ($)	$	30,000,000
Power Charge ($/t)	$	0.25
Chemical Charge ($/t)	$	0.02
Maintenance Cost ($/t)	$	0.04
Depreciation Cost ($/Y)	$	1,500,000
Salary ($/50P/M)	$	75,000
Other Expense ($/M)	$	70,000

Economic Assumptions

Economic assumptions include four main components: exchange rate, interest rate, inflation, and demand.

For the exchange rate, if the source of financing is from domestic, the users do not have to consider exchange rate; while if the source of financing is foreign currency, the exchange rate should be defined. As the investment involve a long time period, the expected annual change in exchange rate should also be considered. A positive change is a depreciation of the domestic currency, which means you have to pay more domestic currency to buy the predefined foreign currency, and a negative change is an appreciation of the domestic currency. In addition, the annual change in exchange rate may be different from year to year, so volatility is added as a control factor. 1% volatility means that over the period of one year, the exchange rate has the potential to go up or down by 1%. Users can define the value according to their experiences or according to historical data and statistic data.

The current value of inflation is the rate of change of the Consumer Price Index. Long term value of inflation is the long term rate that the current inflation will tend towards. Uncertainty around the inflation happens year by year, so volatility is added as an adjust factor, and 1% volatility means that over the period of one year, inflation has the potential to go up or down by 1%. Users can also define the rate at which current inflation will tend towards its long term value.

Demand is one of the determinative factors that will affect the profitability of the project. The main business revenue is the product of demand and water selling price. Demand can be determined by factors including service population, consumption of water per connection, the availability of other source of water, and the water selling price.

Policy Choices

Policy choices are crucial to project profitability. In general, in a water supply project, the government can give support to the water supply company from mainly three aspects, including tariff adjustment, service target management, and subsidies.

Government has the control over tariff adjustment. On one hand, the government can choose the adjustment frequency; on the other hand, they can also control the range of adjustment. Tap water can be used for different purpose by different kind of users, and the water tariffs are different basing on their using purpose. For example, water tariff for commercial use is higher than the water tariff for household use. If the consumption quantity is higher than a set amount, the user should pay higher water tariff. When adjust water tariff, the government will also consider the possible impact on the demand variation.

Service target management is mainly refers to the management of availability of other source of water. Compared with other life necessities, unlike electricity and gas, water is technically easy to access. Therefore, if users think the water tariff is too high for them, they can easily explore ground water for use. However, if government cannot control ground water exploration effectively, it may lead to severe health problem, environmental problem, and will reduce the revenue of water supply companies.

Subsidies can be given to the water supply companies in various forms. The main reason for giving subsidy usually is that the water supply company is operating at a loss or that the project profitability cannot reach the expectation of the investor. It is important to set a reasonable amount of subsidy. The government can require the water supply company to improve service quality and efficiency to make profit. The water supply company can also negotiate with the government to get an appropriate amount of subsidy.

6.3.3 Calculations

This package contains three main calculation sheets: one year operation calculation sheet, long term operation calculation sheet without risk, and long term operation calculation sheet with risk. Microsoft office-Excel is employed as computing platform. Detailed programming code can be referred to Appendix I. The basic calculation principles include investments and financing, operating statement, balance sheet, cash flow, and profitability measures. The fundamental formula can be described as

$$\text{Profit} = \text{Cash in} - \text{Cash out} - \text{Depreciation}$$

This is a nested function, where the functions of cash in and cash out contain complex components. In a water supply company, the cash inflows are the sum of productions of water selling price and water demand, and the cash outflows consist of two major components: fixed expenses and variable expenses. They can be described as the following formulas.

$$C_{in} = \sum_{i=1}^{N} P_i D_i$$

where C_{in} is Cash inflows, P is water selling price, D is water demand, and i stands for n types of users, each type of user has its corresponding water selling price.

$$C_{out} = C_{fix} + C_{var}$$

where C_{out} is Cash outflows, C_{fix} is fixed expenses, and C_{var} is variable expenses.

$$C_{fix} = C_L + C_I + C_B + C_A + C_T + \varepsilon$$

where C_L is labour and welfare costs, C_I is insurance fees, C_B is business entertainment expenses, C_A is administrative expenses, C_T is traveling expenses, and ε is unexpected expenses.

$$C_{\text{var}} = Q\sum(P_C + P_E + P_M)$$

where Q is the amount of water the water treatment plant produced, P_C is the chemical cost used to produce one ton of water, P_E is the energy cost used to produce one ton of water, and P_M is the maintenance and repairing cost should be used for producing one ton of water.

In the following part, each calculation sheet will be explained in details with a case study. Firstly, we will start the introduction from the simplest situation, the short term one-year operation calculation, which is the basis of long-term calculation.

Table 6.2 One year operational cash flow in a water supply company

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total Revenue	255,478	255,082	335,102	307,686	366,738	354,710	410,297	398,986	422,966	392,399	367,398	360,038
Type I Users (Demand)	31,919	29,860	34,534	35,215	46,703	39,437	46,149	45,491	47,086	43,486	38,447	43,537
Type I Users (Revenue)	70,222	65,692	75,975	77,473	102,747	86,761	101,528	100,080	103,589	95,669	84,583	95,780
Type II Users (Demand)	5,895	4,928	9,316	7,046	7,400	9,163	10,039	9,144	9,767	7,775	8,053	8,606
Type II Users (Revenue)	16,860	14,094	26,644	20,152	21,164	26,206	28,712	26,152	27,934	22,237	23,032	24,613
Type III Users (Demand)	2,040	2,296	2,508	2,794	2,564	2,449	2,871	2,682	3,255	2,188	2,628	3,749
Type III Users (Revenue)	8,976	10,102	11,035	12,294	11,282	10,776	12,632	11,801	14,322	9,627	11,563	16,496
Type IV Users (Demand)	90,580	93,860	125,823	112,368	131,560	131,231	151,946	148,269	157,455	150,492	141,034	126,789
Type IV Users (Revenue)	159,421	165,194	221,448	197,768	231,546	230,967	267,425	260,953	277,121	264,866	248,220	223,149
Total Cost	258,521	245,024	234,966	244,134	239,975	242,604	277,065	284,213	309,432	258,678	255,346	256,496
1) Electricity Fees	87,831	88,894	82,500	89,869	85,510	92,034	98,182	99,365	98,272	92,652	92,965	92,907
2) Chemical Costs	7,026	7,111	6,600	7,190	6,841	7,363	7,855	7,949	7,862	7,412	7,437	7,433
3) Maintenance & Repairing Costs	14,053	14,223	13,200	14,379	13,682	14,725	15,709	15,898	15,723	14,824	14,874	14,865
4) Salary	76,772	78,906	74,472	73,743	71,767	73,664	87,731	83,059	87,293	75,596	75,089	71,946
5) Welfare and Insurance	32,902	33,817	31,916	31,604	30,757	31,570	37,599	35,597	37,411	32,398	32,181	30,834
6) Business Entertainment Fees	7,998	2,495	3,939	1,629	6,239	2,737	4,784	6,629	9,109	5,579	3,049	7,459
7) Traveling Expenses	3,829	10,813	1,356	2,796	1,866	1,776	2,526	10,621	2,646	1,294	3,356	4,376
8) Administrative Expenses	28,110	8,765	20,983	22,925	23,314	18,736	22,680	25,095	51,117	28,923	26,396	26,678

If the company keeps record of the actual one-year operational data, the actual data can be input into the calculation sheet to verify whether the assumptions made are appropriate. If no actual data for the project is available, the calculation sheet will present the assumption results for the experienced project manager to evaluate and adjust the values of assumptions to an appropriate level. Table 6.2 is an example of the one-year operation calculation sheet. It presents an actual one-year operational cash flow.

This calculation sheet contains two parts: the upper part is cash inflows and the lower part is cash outflows. It is found that, in this company, cash inflows are received from collecting water bills. There are four types of users, and for each type the amount of consumption and selling prices are different. The average water selling price is 2 dollars per ton. The daily billable demand is 6,000 tons. The cash outflows contain eight main components. Electricity fees, chemical fees and maintenance fees are all related to the amount of total production. The water supply company produces an average of 12,000 tons water per day. So the cost of electricity fees, chemical fees and maintenance fees are calculated 0.25 dollars per ton, 0.02 dollars per ton and 0.04 dollars per ton respectively, which meet well with assumptions. For a 50 staff water supply company at county level, the estimated salary per month is 75,000 dollars. The actual expense of salary per month is 77,503 dollars. For other expenses, the actual monthly welfare and insurance fee is 33,216 dollars, business entertainment fee is 5,137 dollars, traveling expense is 3,938 dollars, and administrative expense is 25,310 dollars. The total amounts of these expenses are 67,600 dollars, and the estimated amount is 70,000 dollars per month. In summary, the assumptions can well explain the actual operation; therefore they can be used as the basis for long-term operation calculation.

Next, long-term operation calculation sheet will be introduced. In this sheet revenue and costs will be calculated year by year, the income tax and other taxes, and Profit will be calculated as well. Similar to one-year operation calculation, when we subtract total cost from total revenue we can get Cash flow before Tax. Subtracting depreciation and interest of loans, we can get the Profit before Tax. When income tax is calculated basing on profit before tax and subtracted from cash flow before tax, we can get Cash flow after Tax. This together with the invested capital will be used as a measure of the profitability of the project. If loans are borrowed, the interest and repayment of loans will be subtracted and get Net Cash Flow. Finally, the profitability of the investment will calculated with two measures: The Net Present Value (NPV) with a discounting factor chosen by the user and the Internal Rate of Return (IRR).

Before we go to the calculation of revenue and cost, long-term economic factors should be defined. We set the current inflation 5%, long term value 8% and the speed of adjustment 5. The yearly inflation rate will be calculated in the excel sheet with EXP function. For risk case, 2% volatility is added with the normal distribution random function. When the yearly inflation is determined, the yearly consumer price index and the deflation factor will be defined. For foreign investors, the exchange rate will also need to be defined. The real exchange rate is calculated according to the given existing exchange rate and expected growth rate.

As analysed in one-year operation calculation sheet, the revenue of a water supply company can be determined by two main factors: one is the water selling price and the other is the water demand.

Water selling price is controlled by the government, the frequency and range of adjustment is important to the project profitability. Generally, the frequency of adjustment is 3 years, and the range of adjustment should correspond with the inflation rate. However, the actual adjustment frequency and range will be determined through the negotiation between the government and the water supply company. It is a policy choice. This package can show the simulating results of different policy choices regard to water selling price to assist decision making.

Water demand is considered from three main aspects: target population, average water demand per person, and the production capacity of water treatment plant. From the macroscopic view, the target population determines the upper limit of residential water demand. In the delineated area, if no alternative water resource is allowed for using, all the population have the need to use the water supply by the company. Therefore, the maximum residential water demand is the product of population and the average demand per person. In actual calculation, the number of connections is used to reflect population, and the demand is measured by per connection instead of by person. From the microscopic terms, the average water demand per connection will be affected by water selling price, willingness to pay, the habit of using water and many other factors. A multiple linear regression is conducted to analyze the interactions between water demand and these variables. In addition, water demand is also restricted to the production capacity of the water treatment plant. In long-term calculation, the population growth will lead to additional water demand, so it is required to estimate whether the production capacity can meet the requirement of the water demand in the long run.

Assume the bill collection rate is 100%, the quantity of water consumption is equal to water demand and equal to billable water demand. The first step is to calculate the number of connections. It is the product of service target ratio and potential connections. The potential connections will change year by year along with service extension. New connections will be calculated by the difference of two coterminous years. Then the demand will be calculated according to the growth.

As stated before, the daily water consumption per connection will be affected by many factors. A multiple linear regression is conducted to analyze the interactions between water demand and these variables. In this study, the information of 1000 household connections is randomly selected from the customer management system. The information for each connection includes the regular household population, whether they have alternative water resource, the family income level, and the water selling price applied to them. The regression model is constructed as follows:

$$D = \beta_0 + \beta_1 POP + \beta_2 WELL + \beta_3 IN + \beta_4 P$$

where,

β_0 is the intercept

β_1~β_4 are called slopes or coefficients

D is the monthly water consumption for a household connection

POP is the household population

WEL is a dummy variable indicate whether the household connection have alternative water resource, where 1 represent the connection does not have a well, and 2 represent the connection has a well.

IN is the income level, where 1 represent low level income, 2 represent middle level income, and 3 represent high level income.

P is water selling price

Table 6.3 shows the descriptive analysis results of the monthly water consumption for the 1000 connections. We can see that the highest density of consumption concentrated in 1 ton, then in 3 ton, 2 ton, and 5 ton per month. In addition, there is a notable portion of users that their monthly water consumption is zero. Table 6.4 shows the descriptive statistics of independent variables. For the samples selected, the mean value of family population numbers is 3.73 with a standard deviation 1.181. It means that generally a family has 2 to 5 persons. The mean value for assessing whether they have alternative water resource is 1.41. It means that 40% of the households have their own wells. The mean value of income level is 1.86. It indicates that more families belong to middle income level. The mean value of water selling price is 3.25, and the standard deviation is 1.298. It indicates that different water selling prices are applied to different type of users. In China statistic year book, the urban daily residential water consumption is 170 liter. According to the results of descriptive statistic, the amount of water consumption in the samples is comparatively low. To investigate the main effect variable, a correlation matrix of each variable against each other variable is calculated and shown in Table 6.5. The results show that the water demand is significantly related to two factors: one is the number of persons in the family and the other is that whether the household has alternative water resource. To find out the slopes of the predictor variables and construct the regression

model, stepwise method is selected. Table 6.6 summarizes the efficiencies of the variables. Regarding the results, the constructed function may be

$$D = 2.195 \cdot POP - 5.112 \cdot WELL + 1.236 \cdot IN + 0.904 \cdot P - 0.339$$

Table 6.3 Descriptive analysis of water consumed.

		Percentage	Valid Percentage	Cumulative Percentage
Valid	.00	5.0	5.0	5.0
	1.00	16.6	16.6	21.7
	2.00	11.6	11.6	33.3
	3.00	11.7	11.7	45.0
	4.00	5.0	5.0	50.0
	5.00	10.0	10.0	60.0
	6.00	4.2	4.2	64.2
	7.00	7.5	7.5	71.7
	8.00	5.0	5.0	76.7
	9.00	4.2	4.2	80.8
	10.00	5.0	5.0	85.8
	11.00	1.7	1.7	87.5
	12.00	4.2	4.2	91.7
	13.00	.8	.8	92.5
	15.00	.8	.8	93.3
	16.00	.8	.8	94.2
	17.00	.8	.8	95.0
	19.00	.8	.8	95.8
	20.00	.8	.8	96.7
	22.00	.8	.8	97.5
	25.00	1.7	1.7	99.2
	31.00	.8	.8	100.0
	Total	1000.0	1000.0	

Table 6.4 Descriptive Statistics of variables

Variable	Mean	Std. Deviation	Description
D	5.87	5.670	Actual water consumed (quantity)
POP	3.73	1.181	The number of persons in a family
WELL	1.41	.494	If they have well, 1=NO, 2=Yes
IN	1.86	.539	Family income
P	3.25	1.298	Water price

Table 6.5 Correlations

		D	POP	WELL	IN	P
Pearson Correlation	D	1.000	.490	-.478	.096	.117
	POP	.490	1.000	-.094	-.022	-.032
	WELL	-.478	-.094	1.000	-.097	.102
	IN	.096	-.022	-.097	1.000	-.261
	P	.117	-.032	.102	-.261	1.000
Sig. (1-tailed)	D	.	.000	.000	.148	.102
	POP	.000	.	.153	.405	.366
	WELL	.000	.153	.	.147	.135
	IN	.148	.405	.147	.	.002
	P	.102	.366	.135	.002	.

Table 6.6 Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta	B	Std. Error
1	(Constant)	-2.889	1.505		-1.919	.057
	POP	2.352	.385	.490	6.104	.000
2	(Constant)	4.899	1.814		2.701	.008
	POP	2.155	.337	.449	6.394	.000
	WELL	-5.009	.806	-.436	-6.211	.000
3	(Constant)	3.492	2.372		1.472	.144
	POP	2.165	.338	.451	6.415	.000
	WELL	-4.935	.811	-.430	-6.085	.000
	IN	.682	.739	.065	.922	.358
4	(Constant)	-.339	2.642		-.128	.898
	POP	2.195	.327	.457	6.711	.000
	WELL	-5.112	.788	-.445	-6.488	.000
	IN	1.236	.741	.118	1.669	.098
	P	.904	.308	.207	2.937	.004

Based on the mean function, we can determine the expected monthly water consumption for any connection as long as we know its number of family members, the status of alternative water resources, the income level, and water selling price. Among the variables, the effect of alternative water resource for households is strong, while the water selling price is weak. According to this mean function, a middle income three member family use water at 3.25 dollar

per ton, if they have a well in their house, the expected monthly water consumption will be 1.34 tons. If the family removes the well, there will be 5.112 tons increase in expected monthly water consumption. This model helps to predict the water demand form the microscopic view. From the macroscopic view, Gray prediction modelling (GM) will be adopted for demand prediction.

Gray prediction modelling (called as GM (1, 1) model) is fairly suitable for water demand forecasting among all applicable prediction methods. In gray theory, gray prediction modelling is an essential part to model a dynamic system with less history data. It features high computing efficiency and high accuracy for modelling monotonically increasing or decreasing data. Therefore, it is fairly effective to apply gray theory to water demand prediction.

Basically, GM (1, 1) prediction model can be formulated by a first-order differential equation. Least squares method is frequently utilized to determine model coefficients. The essential part of GM (1, 1) prediction model is generating an accumulated sequence based on the initial data. Mathematically, the initial data is expressed as the following time series.

$$X^0 = (x_1^0, x_2^0, ...x_n^0) \tag{6.7}$$

Accumulate Eq. (1), we can obtain:

$$X^1 = (x_1^1, x_2^1, ...x_n^1) \tag{6.8}$$

where $x_t^1 = \sum_{n=1}^{t} x_n^0; t = 1, 2, ..., n$.

Based on the gray theory, GM (1, 1) equation is expressed as follow:

$$\frac{dX^1}{dt} + aX^1 = u \tag{6.9}$$

Let $A = \begin{pmatrix} a \\ u \end{pmatrix}$, $Y_n = BA$. Least squares method is adopted to obtain the approximate solution:

$$\hat{A} = (B^T B)^{-1} Y_n = \begin{pmatrix} \hat{a} \\ \hat{u} \end{pmatrix} \tag{6.10}$$

where:

$$B = \begin{bmatrix} -\frac{1}{2}(x_1^1 + x_2^1) & 1 \\ -\frac{1}{2}(x_2^1 + x_3^1) & 1 \\ \vdots & \vdots \\ -\frac{1}{2}(x_{n-1}^1 + x_n^1) & 1 \end{bmatrix}, \text{ and } \quad y_n = \begin{bmatrix} x_2^0 \\ x_3^0 \\ \vdots \\ x_n^0 \end{bmatrix}$$

Substitute (6.10) to (6.9), thus:

$$x_{t+1}^1 = (x_1^0 - \frac{\hat{u}}{\hat{a}})e^{-\hat{a}t} + \frac{\hat{u}}{\hat{a}} \tag{6.11}$$

$$x_{t+1}^0 = (e^{-\hat{a}} - 1)(x_1^0 - \frac{\hat{u}}{\hat{a}})e^{-\hat{a}t} \tag{6.12}$$

Posterior variance test is adopted to evaluate the effectiveness of prediction, which is formulated as follow:

$$\bar{x} = \frac{1}{n}\sum_{t=1}^{n} x_t^0$$

$$\bar{\varepsilon} = \frac{1}{n}\sum_{t=1}^{n} \varepsilon_t$$

$$s_1^2 = \frac{1}{n}\sum_{t=1}^{n} (x_t^0 - \bar{x})^2$$

$$s_2^2 = \frac{1}{n}\sum_{t=1}^{n} (\varepsilon_t - \bar{\varepsilon})^2$$

Posterior variance is defined as:

$$C = \frac{s_2}{s_1} \tag{6.13}$$

$$P = P(|\varepsilon_t - \varepsilon| < 0.674) \tag{6.14}$$

For a good and effective prediction, C is required to be small enough, which demonstrates vibration of forecasting error is weak. P is required to be large enough, which demonstrates that the probability of small error is high.

Water demand prediction is crucial for water project management and decision making. With fast economic development, water demand for industrial production, public consumption and household's consumption increase exponentially. Table 6.7 shows the historical data of water consumption in *City N* from year 2007 to 2012, which presents the fast growth trend of water demand.

Table 6.7 Gross Water Consumption (GWC) from year 2007 to 2012, in *City N, China*

Year	2007	2008	2009	2010	2011	2012
GWC /ton	651525	903220	1061077	1127542	1519369	1789936

Based on the GM (1, 1) prediction model, gross water consumption for 10 years is predicted, all data is tabulated in Table 6.8. Both initial data and all forecasting data are plotted in Figure 6.10. Conducting Person analysis, we can get the R square is equal to 0.9813. It indicates the forecasting data fit well with the actual data, therefore the prediction is reliable.

Table 6.8 Prediction of GWC from year 2007 to 2012, in *City N, China*

Year	2007	2008	2009	2010	2011
Prediction (ton)	651,525	859,540	1,029,041	1,231,969	1,474,914
Year	2012	2013	2014	2015	2016
Prediction (ton)	1,765,768	2,113,978	2,530,856	3,029,942	3,627,449

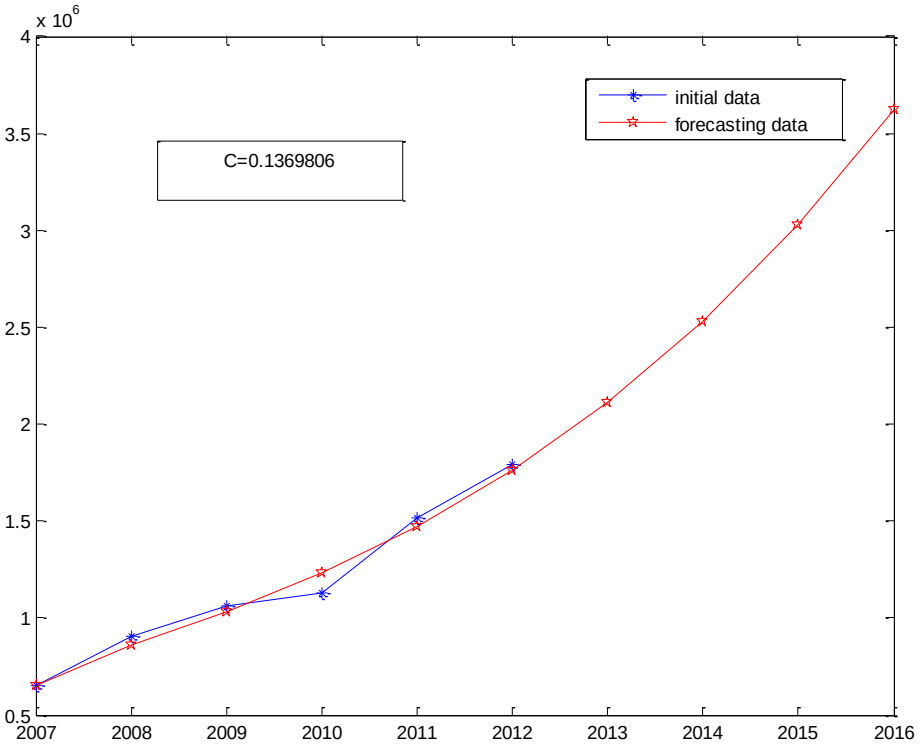

Figure 6.10 Forecasting data from year 2007 to 2016

For long-term costs, there are eight component should be considered. Among them, electricity fees, chemical costs and maintenance cost are related to material cost and the quantity of water produced (*Q*). The long-term material cost will be calculated with regard to inflation rate. And for risk case, 2% volatility is added with normal distribution random function. The quantity of water production (*Q*) is related to water demand (*D*), the *designed production capability* of the water plant, and *leakage percentage*. Water demand (*D*) is calculated in the revenue, and can be used directly. Leakage percentage is managed by the decision-makers, so it is a policy choice factor. The relationships between them are and should subject to

$$D/(1 - \text{leaking percentage}) = Q < \text{Designed Production Capacity}$$

Other expenses including salary, welfare and insurance, business entertainment fee, traveling expenses, and administrative expenses will change along with inflation rate with 2% volatility added. They are also adjusted regarding the increase of connection numbers. To achieve the pre-set working efficiency, new staff will be enrolled when service target increases.

Net present value (NPV)

The net present value (NPV) of a time series of cash flows is defined as the sum of the present values (PVs) of the individual cash flows of the same entity. It measures the excess or shortfall of cash flows above the cost of funds in PV terms throughout economics, finance, and accounting area. NPV is a central tool in discounted cash flow (DCF) analysis, and is a standard method for using the

time value of money to appraise long-term projects. It compares the PV of money today to the PV of money in the future, taking inflation and returns into account. Each cash inflow/outflow is discounted back to its PV. Then they are summed. Therefore NPV is the sum of all terms

$$NPV(i,N) = \sum_{t=0}^{N} \frac{C_t}{(1+i)^t}$$

where

t - the time of the cash flow

N - the total number of periods

C_t - the net cash flow (the amount of cash, inflow minus outflow) at time t.

i - the discount rate (the rate of return that could be earned on an investment in the financial markets with similar risk.); the opportunity cost of capital.

The rate used to discount future cash flows to the PV is a key variable of this process. The selection of the discount rate is dependent on the user's purpose. If the intent is simply to determine whether a project will add value to the company, using the firm's weighted average cost of capital may be appropriate. If trying to decide between alternative investments in order to maximize the value of the firm, the IRR would probably be a better choice. In this package, IRR is adopted.

Given a collection of pairs (time, cash flow) involved in a project, the NPV is a function of the IRR. IRR is a rate of return which makes this function equal to zero. Given the (period, cash flow) pairs (n, C_n) where n is a positive integer, the total number of periods N, and the net present value NPV, the IRR is given by i in:

$$NPV(i,N) = \sum_{t=0}^{N} \frac{C_t}{(1+i)^t} = 0$$

It can also be defined as the discount rate at which the PV of all future cash flow is equal to the initial investment or in other words the rate at which an investment breaks even. IRR calculations are commonly used to evaluate the desirability of investments or projects.

An investment is considered acceptable if its internal rate of return is greater than an established minimum acceptable rate of return or cost of capital. The higher a project's IRR, the more desirable it is to undertake the project. In a scenario where an investment is considered by a firm that has equity holders, this minimum rate is the cost of capital of the investment which may be determined by the risk-adjusted cost of capital of alternative investments. This ensures that the investment is supported by equity holders. In general, if IRR of an investment exceeds its cost of capital, it adds value for the company.

There are many numerical methods that can be used to estimate *i*. For example, using the secant method, *i* is given by

$$i_{n+1} = i_n - NPV_n \left(\frac{(i_n - i_{n-1})}{NPV_n - NPV_{(n-1)}} \right)$$

where i_n is considered the n^{th} approximation of the IRR. This *i* can be found to an arbitrary degree of accuracy. The convergence behaviour of the sequence is governed by the following:

If the function NPV(i) has a single real root i, then the sequence will converge reproducibly towards i.

If the function NPV(i) has n real roots i_1, i_2, ..., i_n, then the sequence will converge to one of the roots and changing the values of the initial pairs may change the root to which it converges.

If function NPV(i) has no real roots, then the sequence will tend towards $+\infty$. Having $i_1 > i_0$ when $NPV_0 > 0$ or $i_1 < i_0$ when $NPV_0 < 0$ may speed up convergence of i_n to i.

6.3.4 Results

Basing on the assumptions, all the calculations have been done according to the methods stated previously. The long-term variations for some main factors are shown in Figure 6.11-6.14. Variations in both risk case and no risk case are given. Table 6.9 shows the consolidated calculation results for a project. However, if policy choices change, the results will be different.

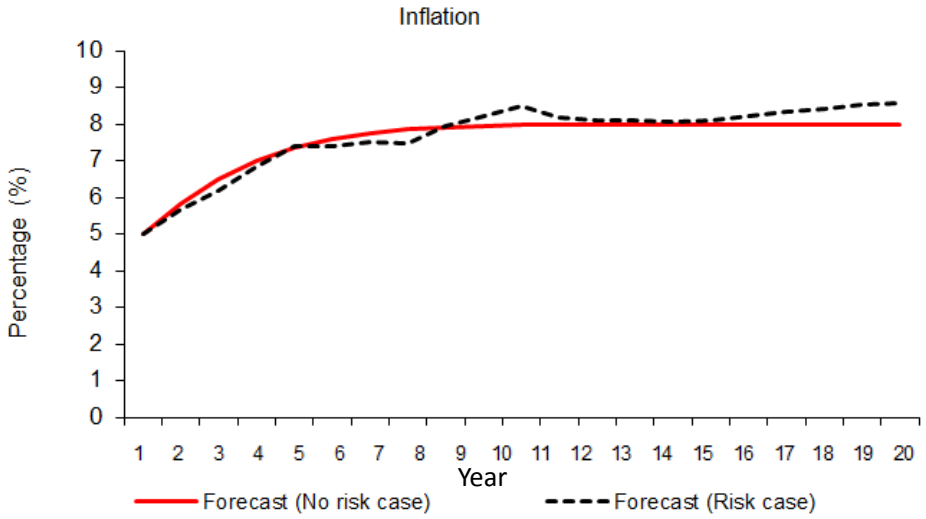

Figure 6.11 Inflation forecast

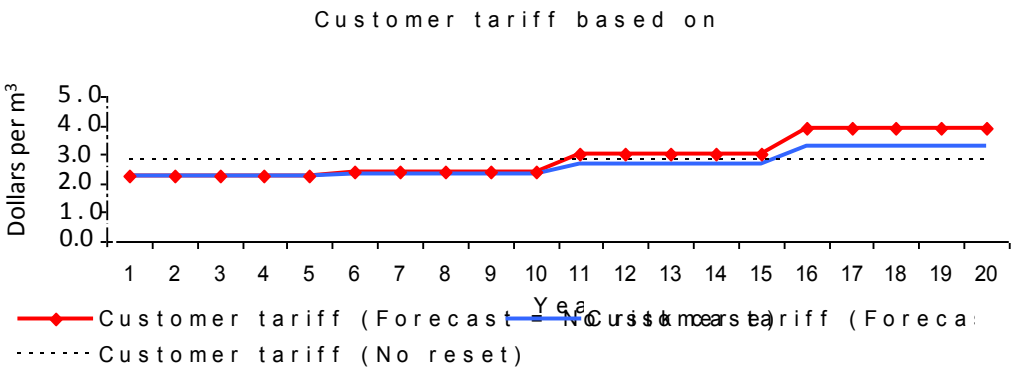

Figure 6.12 Water tariff required

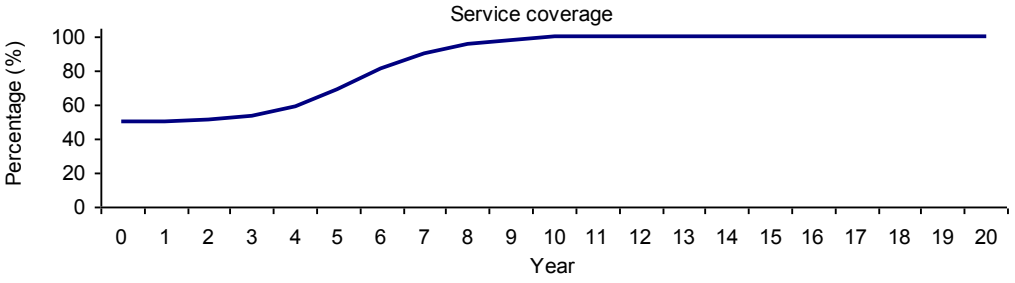

Figure 6.13 Development of service coverage

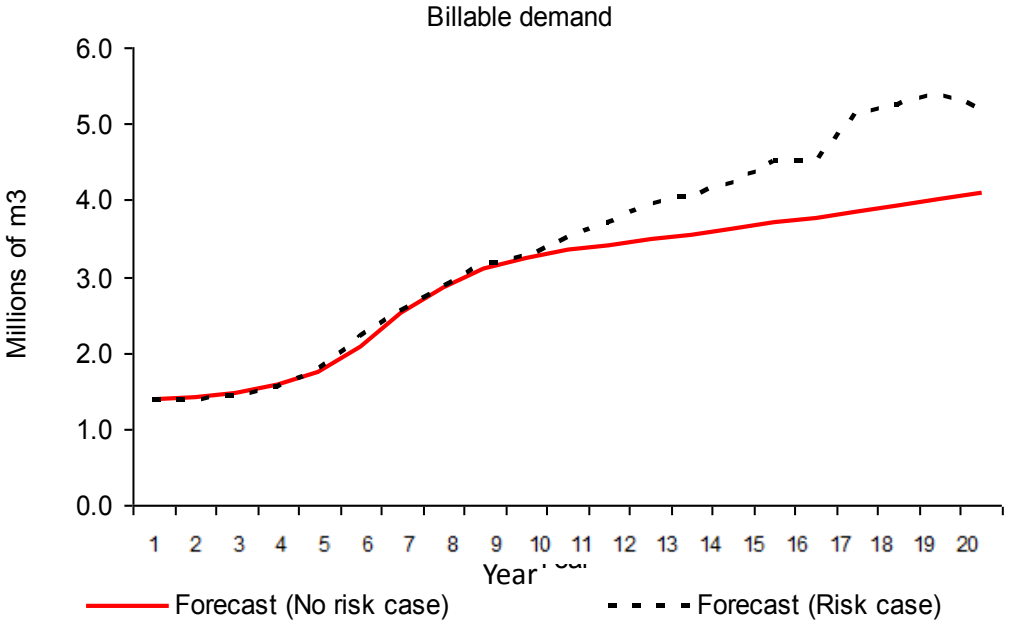

Figure 6.14 Water demand forecast

Table 6.9 A consolidated operation statement and cash flow for a water supply project

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Revenue		1,303,050	1,719,080	2,878,393	3,446,015	4,125,571	5,474,337	6,553,878	7,846,307	9,093,517	9,628,355	9,821,124	10,318,232	10,689,762	10,909,676
Price		2.00	2.00	2.80	2.80	2.80	3.10	3.10	3.10	3.18	3.18	3.18	3.20	3.20	3.20
Demand		651,525	859,540	1,029,041	1,231,969	1,474,914	1,765,768	2,113,978	2,530,856	2,861,634	3,029,942	3,090,604	3,229,336	3,343,590	3,411,135
Cost		2,145,186	1,971,030	2,189,547	2,395,491	2,599,677	2,403,901	2,560,407	2,735,241	2,871,524	2,941,656	3,139,215	3,202,438	3,254,110	3,284,668
Power charge		325,763	429,770	514,521	615,985	737,457	551,803	660,618	790,893	894,261	946,857	1,103,787	1,153,334	1,194,139	1,218,263
Chemical expense		26,061	34,382	41,162	49,279	58,997	44,144	52,849	63,271	71,541	75,749	88,303	92,267	95,531	97,461
Maintenance		52,122	68,763	82,323	98,558	117,993	88,288	105,699	126,543	143,082	151,497	176,606	184,533	191,062	194,922
Management Fee		600,471	669,986	722,829	760,159	785,111	801,154	811,205	817,399	821,175	823,464	824,845	825,677	826,177	826,478
Salary		688,432	768,129	828,713	871,511	900,119	918,512	930,035	937,136	941,466	944,090	945,673	946,627	947,200	947,545
Operating Surplus		**- 842,136**	**- 251,950**	**688,845**	**1,050,524**	**1,525,894**	**3,070,436**	**3,993,471**	**5,111,066**	**6,221,992**	**6,686,699**	**6,681,909**	**7,115,793**	**7,435,652**	**7,625,008**
Depreciation		1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000
Profit before Tax		**-2,342,136**	**-1,751,950**	**-811,155**	**-449,476**	**25,894**	**1,570,436**	**2,493,471**	**3,611,066**	**4,721,992**	**5,186,699**	**5,181,909**	**5,615,793**	**5,935,652**	**6,125,008**
Income Tax									772,989	1,180,498	1,296,675	1,295,477	1,403,948	1,483,913	1,531,252
Profit after Tax		**-2,342,136**	**-1,751,950**	**-811,155**	**-449,476**	**25,894**	**1,570,436**	**2,493,471**	**2,838,077**	**3,541,494**	**3,890,024**	**3,886,432**	**4,211,845**	**4,451,739**	**4,593,756**
Net Cash Flow		**-842,136**	**-251,950**	**688,845**	**1,050,524**	**1,525,894**	**3,070,436**	**3,993,471**	**4,338,077**	**5,041,494**	**5,390,024**	**5,386,432**	**5,711,845**	**5,951,739**	**6,093,756**

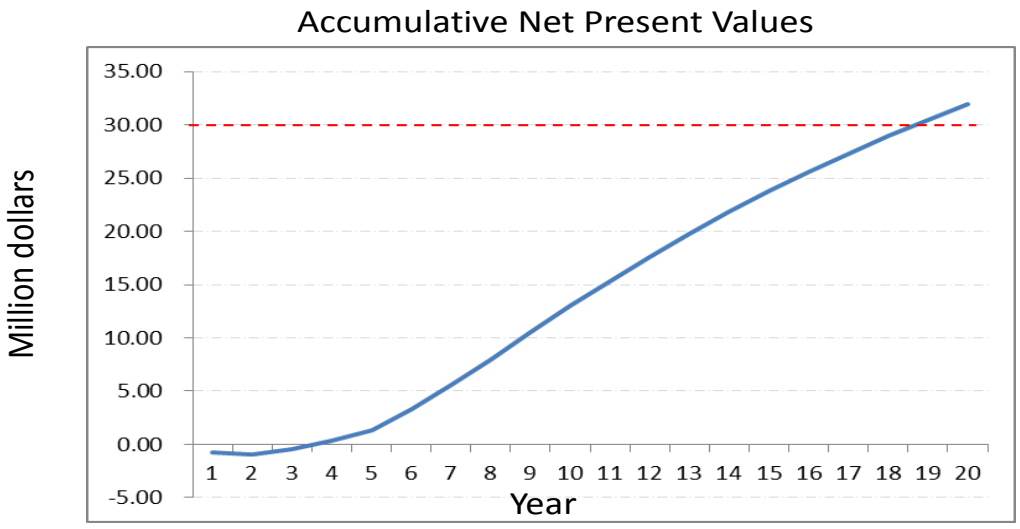

Figure 6.15 Net Present Value accumulation over the planning horizon

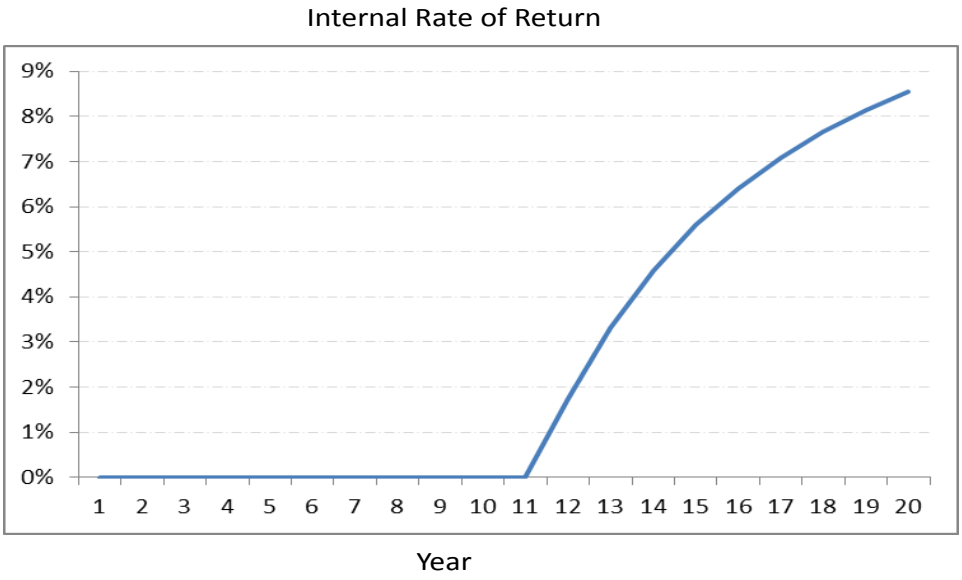

Figure 6.16 Internal Rate of Return over the planning horizon

The accumulative NPV and IRR over the planning horizon are plotted in Figure 6.15 and 6.16. The initial investment is 30 million dollars, and the acceptable baseline of IRR is set 8%, so the 20-year accumulative NPV is 1.9 million dollars. Although in this setting, the 20-year NPV is greater than zero, if the investor has higher expectation of IRR, the 20-year NPV will be negative. Policy choices have nonnegligible impact on project profitability.

6.3.5 Policy Choices

In this session, the focus is to discuss the impact of different policy choices on project profitability. We will analysis from four aspects: water tariff adjustment, the reliability of water supply, alternative water resource control, and government subsidy.

To make the problem simple, we can start the discussion from one year profit and cash flow estimation. The input assumptions are given in Table 6.10. Among the ten assumptions, the first seven are financial and operating assumptions. Once a project is selected, these assumptions will be defined. The last three assumptions are policy choice assumptions. When the policy choices change, the outputs of profit and cash flow will change accordingly. Comparing the outputs of profit and cash flow, the decision-makers can select their appropriate choices.

Table 6.10 Summary of initial inputs for a water supply project

	Assumptions	Initial Inputs
1	Total Investment ($)	30,000,000
2	Power Charge ($/t)	0.25
3	Chemical Charge ($/t)	0.02
4	Maintenance Cost ($/t)	0.04
5	Depreciation Cost ($/Y)	1,500,000
6	Salary ($/50P/M)	80,000
7	Other Expense ($/M)	70,000
8	Billable Demand (t/D)	5000
9	Rate of Uncounted for Water (%)	50
10	Water Selling Price ($/t)	2.00

Table 6.11 summarises the results of one-year profit and cash flow under three policy choices. In the initial status, this project has a 1,281,500 dollar loss in profit. In policy 1, the water selling price is adjusted to a higher level, which makes a profit of 178,500 dollars before tax. In policy 2, the billable water demand is increased, which brings a profit of 229,600 dollars before tax. In policy 3, the rate of uncounted for water is reduced to the maximum extension. However, policy 3 cannot make profit for this project. Basing one these results, the decision-makers can select their preferred policies and evaluate the feasibility of policies.

Table 6.11 Profit and cash flow of a water supply project under different policies

	Initial Status	Policy 1	Policy 2	Policy 3
Water Selling Price ($/t)	$2.00	$2.80	$2.00	$2.00
Billable Demand (t/d)	5,000	5,000	8,000	5,000
Rate of Uncounted for Water (%)	50%	50%	50%	0%
Profit before Tax ($)	-1,281,500	178,500	229,600	-715,750
Profit after Tax ($)	-1,281,500	133,875	172,200	-715,750
Cash Flow ($)	218,500	1,633,875	1,672,200	784,250

If the decision-make chooses policy 1 to adjust the water selling price to a higher level. The private sector has to provide the historical record of water selling price adjustment, the survey of water selling price in surrounds cities and cities in the similar level, and financing and operating statements. The public sector needs to consider the impact of inflation, and holds a hearing to investigate whether the majority of the community can accept the new price.

Policy 2 is to increase the billable water demand. It can be achieved through several approaches: to improve bill collection rate by strengthening management, and to develop new connections of users. However, the most effective way is to control the use of alternative water resources. Take the case study in Chapter five as an example. In that case, 40% connections have alternative water resources. These connections open wells to explore groundwater. It is mentioned in previous chapters that the ineffective control of ground water exploration will lead to health problem, environmental problem, and influence the revenue of tap water supplier. Therefore, both the public sector and the private sector have the motivation to have effective control on groundwater exploration. According to customer information analysis and the data from drainage treatment plant, if the use of ground water can be controlled effectively, the monthly amount of tap water consumption will reach 20,000 tons which will bring more profits for the project.

Policy 3 is to reduce the rate of uncounted for water. It is stated in previous chapters that the reasons for uncounted water include unauthorized water use, inaccurate metering tools, and leakage from decrepit water distribution pipelines. In a newly constructed and well maintained water distribution network, a 10% rate of uncounted for water is acceptable. However, in Table 6.11 we can see, even we can reduce the rate of uncounted for water to 0%, the project cannot make profit. In this situation, the private sector will have less motivation to invest to rehabilitate the network. Considering the reliability of water supply, the public sector can give some incentives to the private sector to encourage them to replace decrepit pipelines and build new pipelines. For example, the public sector can help to achieve the target of Policy 1 and 2. Also, the public sector can give some subsidy to the private sector to improve the project profitability to an acceptable level.

6.3.6 Summary

The proposed policy recommendation procedure clearly presents the impact of different policy choices on project profitability. For target water supply PPP projects, with these NPV results, the public sector can evaluate their strategy with regard to their actual capability. If they want to facilitate the success of PPP by improving project profitability, they can adjust water selling price, control the individual exploration of groundwater, improve the reliability of water supply, or to give subsidies to the private sector to meet their expectation. The private sector can also adjust their expected return of investment regarding the actual situation to facilitate the success of PPP. The recommendations provided through this procedure are the solid support and basis for decision-making, which makes it possible for decision makers to choose their favourable strategy. With these dada based evidences, the communication efficiency between the public and private sectors are improved, which also promote the success of PPP.

CHAPTER 7 CONCLUSIONS

This thesis has successfully created the DMF evaluation scheme for promoting sustainable development of PPP in water supply projects. The scheme is not only justified to remedy the insufficiency of existing evaluation methods in that it is capable to evaluate both the importance of DMFs and divergent viewpoints between sectors at the same time; it is also proved to contribute to categorize DMFs, and makes it possible for decision-makers to treat them differently. This scheme is applicable in any phase of the project. In preparatory phase, this scheme can be used as a tool for selecting suitable partner. In implementation and operation phase, this scheme can be enabled regularly to examine whether the partnership is forwarding to the concerted direction and make appropriate adjustment for promoting the cooperation.

Another major contribution of this thesis lies in the detailed formulation of the evaluation scheme. This scheme is constituted by seven steps, and the logical relationships between each step are closely interrelated. DMFs related to finance, economic, operation, environment, politics and regulation have all been included in the integrated checklist, which provides a platform for across comparing results among segment studies. The procedure for conducting Delphi Survey is constructed to get unbiased and consolidated evaluation results from experts. The criteria for examining data are clearly stated to ensure that the data collected are reliable and valid for further analysis. The analytical approach is illustrated in detail to guide the users to get a comprehensive analysis of the results.

In order to examine and justify the evaluation scheme, the author has successfully applied this scheme to a real PPP water supply project to evaluate its effectiveness. The results generated from the scheme discovered that one of the most important problems associated with PPP is the ineffective communication between partners. On one hand, public sectors always have long list of expectations toward PPP. However, these expectations may be disproportionate from the view of private sectors, and some expectations may lead to contradictory objectives. On the other hand, the expectations hold by private sectors may be different from public sectors. Due to information asymmetry, misunderstandings occur and may lead to negative influence of projects. To make precise communication, it is required to identify the divergent considerations of both partners. This application presents a benchmark for promoting healthy communication in PPP projects.

The thesis has also conducted a survey among 131 urban water supply companies to investigate their needs and problems encountered. The results show that approximately 80% water supply companies are operating under deficits. This situation is resulted from multiple reasons. Some issues are worthy of attention. The first is the uncontrollable groundwater extraction, 95.9% water supply companies identified it as an important problem. The second is low management efficiency. Government budget constrains is a severe problem because it will limit the development of water supply service. In many places, the water distribution networks are leaking and need repair or replace, but they cannot afford to do that. Low water tariff makes the situation worse. The water supply industry in China is running hard. 90% urban water supply companies believe PPP would be benefit to water supply service, however, only a small portion of companies showed the willingness of involving PPP.

The case study in this thesis is a typical one among hundreds of water supply projects, and shares similar problems with them. The successful application of PPP provides solid evidence that PPP is an effective model to finance, manage, and operate water supply service. These experiences can be generated to the whole water supply sector. It is discovered that in PPP projects, the private sector tends to attach more importance to most DMFs than the public sector does. The main concern of the public sector is to find reliable concessionaire and to secure social stability, whereas the private sector pays more attention to profitability, management, and investment environment. To attract the private sector, it is suggested that the government should take more responsibility for providing a more transparent and impartial environment.

The thesis has performed detailed analysis of the impacts on project profitability due to different policy choices. Water selling price adjustment, effective control of groundwater exploration, raising the rate of uncounted for water, and government subsidy are the parameters can be adjusted to improve project NPVs. Control of groundwater exploration is a more effective way, however, it calls for the cooperation with many government sections. The public and private sectors can negotiate based on the policy recommendations, and work out a most practical solution.

Overall speaking, the novel evaluation scheme proposed in this research is objective, practical and effective. Its application in the case study can be used as a benchmark for decision makers. The policy recommendations are manifest and workable. The research findings make good scientific contribution to understand the planning of PPP, and can facilitate communication between the public and private sectors so as to achieve a win-win result.

Urban water supply is an infrastructure work. Most of the water supply companies in China are operated by the government, and are facing similar problems including not enough funds for building new and rehabilitating existing water distribution networks, low efficiency in management and operation, and unsatisfied service quality. Although Public-private-partnership has been applied worldwide successfully in energy, transportation, and social services sectors to solve above mentioned problems, regarding the characteristics of water supply projects, the long contracting time, and the political regime and investment environment of China, the application of PPP in water supply projects in China is still limited. Future work should try to understand variations in different context of decision-making processes of PPP. More case studies are needed to examine the feasibility of applying these findings to other public services and in other regions. Previous researches related to decision-making factors always focus on a certain type of factors including risks, success factors, partner selection criteria, and driving factors of PPP projects; this leads to difficulties in across-comparing these research findings. The integrated checklist provided in this study just plays an intermediate role for comparison. However, more researches are desired under this framework to enrich the database, and make these evaluations more valid.

APPENDIX I

Economic factors

Inflation:

Year0= Inflation_Cur

No risk case

Year1=Year0*EXP(Inflation_Speed*(Inflation_LT-Year0))

Year2=Year1*EXP(Inflation_Speed*(Inflation_LT-Year1))

Risk case

Year1=Year0*EXP(Inflation_Speed*(Inflation_LT-Year0)-Inflation_Vol*Inflatio n_Vol/2+Inflation_Vol*NORMSINV(RAND()))

Year2=Year1*EXP(Inflation_Speed*(Inflation_LT-Year0)-Inflation_Vol*Inflatio n_Vol/2+Inflation_Vol*NORMSINV(RAND()))

Consumer price index

Year0=100

Year1=Year0*EXP(Year1Inflation)

Year2=Year1* EXP(Year2Inflation)

Deflation factor

Year0=100%

Year1=Year0*EXP(-Year1Inflation)

Year2=Year1*EXP(-Year2Inflation)

Real exchange rate (RealExRate)

Year0=100

No risk case

Year1=Year0*EXP(ExRate_Growth)

Year2=Year1*EXP(ExRate_Growth)

Risk case

Year1=Year0*EXP(ExRate_Growth-ExRate_Vol*ExRate_Vol/2 +

ExRate_Vol*NORMSINV(RAND()))

Year2=Year1*EXP(ExRate_Growth-ExRate_Vol*ExRate_Vol/2 +

ExRate_Vol*NORMSINV(RAND()))

Nominal exchange rate:

RealExRate_Det*(1+Inflation_Det)

Discount factor:

Year0=100%

Year1=Year0*EXP(-DisRate_Cur)

Year2=Year1*EXP(-DisRate_Cur)

Consumption

Connections = INT(ServTarget_FC*PotentialConnections)

Potential connections

Year0= ServTarget_Exist

Year1= IF(Year<ServTarget_Year, ServTarget_Exist +

(ServTarget-ServTarget_Exist)

/(1+EXP(-(10/ServTarget_Year)*(Year-1-(ServTarget_Year-1)/2))), ServTarget)

Year2= IF(Year<ServTarget_Year, ServTarget_Exist +

(ServTarget-ServTarget_Exist)

/(1+EXP(-(10/ServTarget_Year)*(Year-1-(ServTarget_Year-1)/2))), ServTarget)

New connection s = MAX(Connection N- Connection (N-1),0)

Demand (L/connection/ day)

Year0=demand

Year1=Year0*EXP(Demand_Growth)

Year2=Year1*EXP(Demand_Growth)

Total demand (Millions M3) =

Demand (L/connection/ day)*Connections*365/1000/WaterDenValue

Costs & subsidies (Millions)

Operating costs

Fixed

(30) Domestic denomination:

Year0= (Opex_Fixed/MonDenValue)*(1-Opex_FixedForeign)

Year1= Year0*EXP(Opex_FixedGrowth)

Year2= Year1*EXP(Opex_FixedGrowth)

(31) Foreign denomination:

Year0= (Opex_Fixed/MonDenValue)*Opex_FixedForeign/ExRate_Cur

Year1= Year0*EXP(Opex_FixedGrowth)

Year2= Year1*EXP(Opex_FixedGrowth)

Variable

(33) Domestic denomination:

Year0= Opex_Var*(1-Opex_VarForeign)

Year1= Year0*EXP(Opex_VarGrowth)

Year2= Year1*EXP(Opex_VarGrowth)

(34) Foreign denomination:

Year0=Opex_Var*Opex_VarForeign/ExRate_Cur

Year1=Year0*EXP(Opex_VarGrowth)

Year2=Year1*EXP(Opex_VarGrowth)

Financing costs (millions)

Coverage extension costs =

Connections_New*InvestPerConnection/(DeflateFactor_Det*MonDenValue)

Amount financed by debt= Coverage extension costs *ServExt_Debt

Operator

Outstanding principal=

IF(Year<=Grace_Period,,INDEX(84:84,1,COLUMN()-Grace_Period))*IF(ServExt_LoanIntDen=lbl_Dom,1,RealExRate_Det)*ServExt_LoanPct

Principal repayment=

IF(Year<=Grace_Period,,INDEX(85:85,1,COLUMN()-Grace_Period))*IF(ServExt_LoanIntDen=lbl_Dom,1,RealExRate_Det)*ServExt_LoanPct

Interest payment=

IF(Year<=Grace_Period,,INDEX(86:86,1,COLUMN()-Grace_Period))*IF(ServExt_LoanIntDen=lbl_Dom,1,RealExRate_Det)*ServExt_LoanPct

Contracting authority

Outstanding principal=

IF(Year<=Grace_Period,,INDEX(84:84,1,COLUMN()-Grace_Period))*IF(ServExt_LoanIntDen=lbl_Dom,1,RealExRate_Det)*ServExt_CAPct

Principal repayment=

IF(Year<=Grace_Period,,INDEX(85:85,1,COLUMN()-Grace_Period))*IF(ServExt_LoanIntDen=lbl_Dom,1,RealExRate_Det)*ServExt_CAPct

No risk case:

Interest payment=

IF(Year<=Grace_Period,,INDEX(86:86,1,COLUMN()-Grace_Period))*IF(ServExt_LoanIntDen=lbl_Dom,1,RealExRate_Det)*ServExt_CAPct

Risk case:

Interest payment=

IF(Year<=Grace_Period,,INDEX(77:77,1,COLUMN()-Grace_Period))*IF(ServExt_LoanIntDen=lbl_Dom,1,INDEX(RealExRate_Risk,1,COLUMN()))*ServExt_CAPct

Tariff reset calculations

Asset base (nominal)

Initial existing asset base (A)

Year1=D0

Year2=D1

Depreciation (B)

Year1=A1*DepRate

Year2=A2*DepRate

(102) Maintenance costs (C)

Year1=D1-A1+B1

Year2=D2-A2+B2

Final existing asset base (D)

Year0: InitAssetBase/MonDenValue

Year1: A1*EXP(Inflation_Det)

Year2: A2*EXP(Inflation_Det)

(105) Initial new asset base （A）

Year1: D0

Year2: D1

(106) Investment （B）: = Coverage extension costs

(107) Depreciation （C）

Year1= (A1+B1)*DepRate

Year2= (A2+B2)*DepRate

Final new asset base （D）

Year0=0

Year1=A1 + B1 – C1

Year2：A2 + B2 – C2

Demand

(110) Discounted demand = IF(Year="",,BilledDemand_Det*DiscountFactor)

(111) Cumulative discounted demand: D=Year0 E= Year1

IF(Year="","",IF(OR(Tariff_Period=1,MOD(Year,Tariff_Period)=1),E110,D111+E110))

5 year discounted demand:

IF(Year>Contract_Length,"",IF(Year<INT(Contract_Length/Tariff_Period)*Tariff_Period,IF(MOD(Year,Tariff_Period)=0,INDEX(111:111,1,COLUMN()+Tariff_Period),),IF(Year=INT(Contract_Length/Tariff_Period)*Tariff_Period,INDEX(111:111,1,Contract_Length+4),)))

Return on new assets (real)

(114) Contracting authority

IF(Year="",,DisRate_Cur*SUM(E105:E106)*ServExt_CAPct)

(115) Operator

IF(Year="",,DisRate_Cur*SUM(E105:E106)*ServExt_LoanPct)

Depreciation (real)

(117) Contracting authority

IF(Year="",,E107*ServExt_CAPct*DeflateFactor_Det)

(118) Operator

IF(Year="",,E107*ServExt_LoanPct*DeflateFactor_Det)

(119) Maintenance costs (real)

IF(Year="",,E102*DeflateFactor_Det)

(120) Domestic-denominated opex (real)

IF(Year="",,(E30+E33*BilledDemand_Det/(1-UFW_FC)))

(121) Foreign-denominated opex (real)

IF(Year="",,(E31+E34*BilledDemand_Det/(1-UFW_FC))*RealExRate_Det)

(122) Subsidies (real)

IF(Year="",,Man_Fee)

Revenue requirement (real)

Contracting authority

(126) Revenue requirement= SUM(E$114:E$114,E$117:E$117,-E122)

(127) Discounted revenue requirement= IF(Year="",,E126*DiscountFactor)

(128) Cumulative discounted revenue requirement =

IF(Year="","",IF(OR(Tariff_Period=1,MOD(Year,Tariff_Period)=1),E127,D128+E127))

Operator

(130) Revenue requirement= SUM(E$115,E$118,E$119,E120,E121)

(131) Discounted revenue requirement= IF(Year="",,E130*DiscountFactor)

(132) Cumulative discounted revenue requirement=

IF(Year="","",IF(OR(Tariff_Period=1,MOD(Year,Tariff_Period)=1),E131,D132+E131))

Discounted revenue requirement

(135) Contracting authority

IF(Year>Contract_Length,"",IF(Year<INT(Contract_Length/Tariff_Period)*Tariff_Period,IF(MOD(Year,Tariff_Period)=0,INDEX(128:128,1,COLUMN()+Tariff_Period),),IF(Year=INT(Contract_Length/Tariff_Period)*Tariff_Period,INDEX(128:128,1,Contract_Length+4),)))

(136) Operator

IF(Year>Contract_Length,"",IF(Year<INT(Contract_Length/Tariff_Period)*Tariff_Period,IF(MOD(Year,Tariff_Period)=0,INDEX(132:132,1,COLUMN()+Tariff_Period),),IF(Year=INT(Contract_Length/Tariff_Period)*Tariff_Period,INDEX(132:132,1,Contract_Length+4),)))

Revenue required per m^3

No reset

(140) Contracting authority

IF(Year="","",IF(SUM(110:110)=0,,SUM(127:127)/SUM(110:110)))

(141) Operator

IF(Year="","",IF(SUM(110:110)=0,,SUM(131:131)/SUM(110:110)))

5 year reset period

(143) Contracting authority

IF(Year>Contract_Length,"",IF(OR(Tariff_Period=1,MOD(Year,Tariff_Period)=1),IF(D112=0,,D135/D112),D143))

(144) Operator

IF(Year>Contract_Length,"",IF(OR(Tariff_Period=1,MOD(Year,Tariff_Period)=1),IF(D112=0,,D136/D112),D144))

Tariff indexation

(148) Indexation= IF(DeflateFactor_Det=0,,1/DeflateFactor_Det)

No reset

(150) Contracting authority= IF(Year="",,E140*TariffIndex_Det)

(151) Operator=IF(Year="",,E141*TariffIndex_Det)

5 year reset period

(153) Contracting authority = IF(Year="",,E143*TariffIndex_Det)

(154) Operator = IF(Year="",,E144*TariffIndex_Det)

Profit (millions)

Total revenue collected

(158) No reset

IF(Year="",,(E150+E151)*BilledDemand_Det*Collection_FC)

(159) 5 year reset period

IF(Year="",,(E153+E154)*BilledDemand_Det*Collection_FC)

Costs

(162) Operating costs = IF(Year="",,(E120+E121)/DeflateFactor_Det)

(163) Maintenance costs = IF(Year="",,E119/DeflateFactor_Det)

(164) Return on capital =

IF(Year="",,SUM(E114:E115)/DeflateFactor_Det)

(165) Depreciation = IF(Year="",,SUM(E117:E118)/DeflateFactor_Det)

(166) Subsidies = IF(Year="",,-E122/DeflateFactor_Det)

(167) Total = SUM(E162:E166)

Present value profit (real)

(170) No reset

(E158-E167)*DeflateFactor_Det*DiscountFactor

(171) 5 year reset period

(E159-E167)*DeflateFactor_Det*DiscountFactor

PV cash flows (millions)

No reset

(176) Contracting authority

IF(Year="",,(E150*BilledDemand_Det*Collection_FC-E95-E96-(E38-E39)*ServExt_CAPct)*DiscountFactor*DeflateFactor_Det)

(177) Operator

IF(Year="",,(E151*BilledDemand_Det*Collection_FC-SUM(E$162,E$163,E91:E92,(E38-E39)*ServExt_LoanPct))*DiscountFactor*DeflateFactor_Det)

5 year reset period

(179) Contracting authority

IF(Year="",,(E153*BilledDemand_Det*Collection_FC-E95-E96-(E38-E39)*ServExt_CAPct)*DiscountFactor*DeflateFactor_Det)

(180) Operator

IF(Year="",,(E154*BilledDemand_Det*Collection_FC-SUM(E$162,E$163,E91:E92,(E38-E39)*ServExt_LoanPct))*DiscountFactor*DeflateFactor_Det)

Debt service ratio

Cash flow before loan repayment

(185) No reset

IF(Year="",,E151*BilledDemand_Det*Collection_FC-SUM(E$162,E$163,E91,(E38-E39)*ServExt_LoanPct))

(186) 5 year reset period

IF(Year="",,E154*BilledDemand_Det*Collection_FC-SUM(E$162,E$163,E91,(E38-E39)*ServExt_LoanPct))

Debt service ratio

(188) No reset

IF(Year="",,IF(E92=0,"",E185/E92))

(189) 5 year reset period

IF(Year="",,IF(E92=0,"",E186/E92))

Stakeholder analysis

Water use & consumption

(194) Private household connection

IF(Year="",,Demand)

(195) Other sources

IF(Year="",,'Other assumptions'!E21)

Monthly cost

Private household connection

(198) 5 year reset period

IF(Year="",,ExistTariff_Connected*D$194)

(199) Existing tariffs

IF(Year="",,ExistTariff_Connected*TariffIndex_Det*D$194)

(200) Other sources

IF(Year="",,ExistTariff_Other*D195/DeflateFactor_Det)

Monthly coping cost

(202) Other sources

IF(Year="",,CopingCost/DeflateFactor_Det)

Willingness to pay

(204) Private household connection =

IF(Year="",,WTP_Connection*ExistTariff_Connected*D194/DeflateFactor_Det)

Other sources

(206) Monthly cost

IF(Year="",,WTP_Other*ExistTariff_Other*D195/DeflateFactor_Det)

(207) Monthly coping cost

IF(Year="",,(WTP_Cope*CopingCost)/DeflateFactor_Det)

Change in social welfare (real)

(209) Private household connection

IF(Year="",,IF(Year="",,(D$199-D198)*$D$17*DeflateFactor_Det*DiscountFac

tor/MonDenValue))

(210) Other sources

IF(Year="",,(D$206+D$207-D$200-D$202+D$204-D198)*Connections_New*

DeflateFactor_Det*DiscountFactor/MonDenValue)

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