Risk ranking and analysis in PPP water supply infrastructure projects: an international survey of industry experts

Abstract

Purpose: Public-private partnership (PPP) for water supply infrastructure services has seen continued growth over the past two decades, following public sector's budgetary constraints and inability to provide infrastructure-based water services efficiently and cost effectively. However, these projects are often subjected to major risks leading to failures. For this reason, this paper aims to identify and evaluate the most significant risk factors that strongly affect the implementation of PPP water supply projects.

Design/methodology/approach: Following extensive literature review and case study analyses, an international questionnaire survey was conducted with practising and experienced PPP experts to establish the significant risks in PPP water projects. Both the probability of occurrence and severity of 40 risks were evaluated by the expert panel in order to determine their significance and impact on water projects procured under PPP arrangement.

Findings: The paper presents a derived risk factor list, ranks the factors, and describes the 'top-ranked' risk factors as: poor contract design; water pricing and tariff review uncertainty; political interference; public resistance to PPP; construction time & cost overrun; non-payment of bills; lack of PPP experience; financing risk; faulty demand forecasting; high operational costs; and conflict between partners.

Originality/value: This factor list broadens PPP stakeholders' view of important project risks, rather than relying on culture-dependent studies—an area that has received less attention in PPP risk management research. The identified risk factors would provide governments and investors a useful tool in implementing constructive water PPPs by facilitating the development of risk mitigation strategies, particularly for developing countries with poor risk management practices.

***Keywords**: Public-private partnerships, water supply projects, risk identification, risk assessment*

1. Introduction

Since 1990s, the global water industry has seen a marked growth in public-private partnership (PPP) water supply projects, in response to the need to invest in public water infrastructure and the constraints on public financial resources, growing water demand (Nickson, 1996; Haarmeyer and Mody, 1998) and the numerous PPP benefits. Such advantages include value-for-money (VfM) through optimal risk allocation, managerial and technical expertise and innovation, reduced life-cycle cost, and improved service levels, efficiency and performance (Marques and Berg, 2011; Zheng and Tiong, 2010). PPP assumes many forms, such as private-finance initiative (PFI), water concessions, joint-ventures, etc (Henjewele et al., 2014). PFI – the popular model in the UK – is seen as the forerunner (Smyth and Edkins, 2007) and involves utilising private sector's financial resources, innovative and management skills, and capabilities in providing public infrastructure and services (Oyedele, 2013). HM Treasury (2012) noted that more than 700 projects have reached their financial close with private sector investment of around £55 billion. Despite its perceived advantages, such as substantial risk transfer, disciplined method of procurement, cost effectiveness and long-term thinking (Dixon et al., 2005), PFI has major flaws that include high transaction cost, inflexibility, lengthy procurement period, inexperienced public sector, waste, and lack of transparency (Carrillo et al., 2008; Dixon et al., 2005; HM Treasury, 2012). Following these shortcomings, the U.K. Government's new approach, Private Finance 2 (PF2), has been introduced for attracting private finance in public infrastructure and services delivery (HM Treasury, 2012). Briefly, PF2 primarily seeks to offer access to broader sources of debt and equity finance, increase transparency of liabilities of projects and equity returns of investors, offer increased flexibility in delivery of services, and expedite and minimise costs of the procurement process (HM Treasury, 2012). Thus PF2 will draw on private sector expertise and finance to provide public infrastructure and services while tackling the weaknesses of its predecessor, PFI.

PPP in the water sector "involves transferring some or all of the 'assets' [and]/or 'operations' of public water systems into private hands" (Palaniappan et al., 2006, pg. 10). This definition implies the basic characteristics of PPP, including ultimate public sector ownership and responsibility of (water) assets, risk allocation and responsibilities between public and private sectors, contribution of resources (financial, technology and human), and existence of a 'partnership' (HM Treasury, 1997). A partnership style approach to infrastructure and services delivery is seen as a key element in PPP (World Bank, 2003), prompting National Audit Office (NAO, 2001) to suggest that tightly specified contracts should have some flexibility in order to sustain contractual relationships in a spirit of partnership. This requires that public-private parties share a common vision of how best to work together in a project (NAO, 2001).

Well-structured PPP water supply projects have good market returns and continue to attract the private sector's interest at a time when governments are constrained in their willingness to add to the already high public debt (Chung et al., 2010). In response to this challenge, and following the Dublin International Conference on Water and Environment and the UN Conference on Environment and Development (held in 1992), many governments have adopted PPPs as a financial means to procure water infrastructure and services.

Moreover, with considerable acceptance of the PPP policy following its backing by The World Bank and Organisation for Economic Co-operation and Development (OECD) since 1993 and 1994, respectively (Chong et al., 2006), different models have been utilised in developing and developed economies regarding the extent of private and public sector participation in water services. Figure 1, based on The World Bank's database, shows that between 1990 and 2011, the level of investment exceeded 65,215 (US$ million) in 782 water projects in 62 low- and middle-income countries. The figure shows progress in terms of the number of projects and investments over the last two decades. The sector attracted much private capital in the 1990s, but investments began to shrink after 2000 following huge investment losses. See Ameyaw (2012) for a detailed discussion on water PPP trend.

[Please, insert Fig. 1 around here]

Despite its advantages, PPP involves risks and uncertainties in planning, implementation, and monitoring (Wibowo and Mohamed, 2010; Ameyaw, 2012) that vary according to country-specific and project circumstances (Zheng and Tiong, 2010), and external uncertainties occurring in the contractual relationships between the private and public sectors due to intrinsic differences in working practices and objectives (Ibrahim et al., 2006). Following a lack of relevant experience and expertise in several countries, these uncertainties and risks result to fatal problems and even failures in infrastructure-based water services.

Water-related projects are characterised by multiple risks because the sector accumulates risks that apply to infrastructure (OECD, 2009), distinguishing it from other infrastructure sectors. Ameyaw and Chan (2013) presented in detail these characteristics as summarised below:

(a) high capital intensity and huge sunk costs;
(b) multiple and conflicting public policy objectives;

(c) highly fragmented sector with diverse institutional setups;

(d) high asset condition uncertainty; and

(e) numerous sector performance objectives.

These characteristics define the complexity of the water sector. Also, extant literature suggests that the difficulties and controversies encountered in water PPPs initiated over the past two decades have emerged from poor understanding and underestimation of the risks associated with the sector (Orr et al., 2005; OECD, 2009). For example, the socio-political constraints of raising previously subsidized public water services to cost reflective levels were largely misunderstood and underestimated. Despite these constraints, water PPPs have come to stay. They do not only relieve governments of budgetary pressures (Haarmeyer and Mody, 1998), but also generate productive efficiency gains from market competition (Rivera, 1996).

The conjecture of the current paper is that risk factors underlie the huge investment losses and failures in most PPP water supply projects. Hence, if relevant risks and uncertainties are understood properly, the betterment of risk allocation and proactive risk management is expected to occur in PPP water services delivery (Chung et al., 2010). The authors aim to explore the following critical questions: in PPP water supply projects (i) what are the actual risk factors encountered, and (ii) which of these risk factors concern the direct project partners (private water investors and host-governments) the most? By answering these questions, this paper seeks to conduct a more up-to-date assessment of the critical risk factors in PPP water projects, by drawing on international PPP experts with direct involvement in these projects. Thus the authors explore the domain of objective risk or epistemic approach to risk (Charette, 1989), which allows industry experts to offer opinion based on their individual experience. It is hoped that the findings of this research will contribute to both practice and research in risk management for PPP water supply projects, at both country and international levels, by providing valuable information on critical risks for water operators who intend to invest in infrastructure-based water services.

The above research questions are explored in seven sections. Following on this introduction, section two reviews extant literature on PPP risk factors, and the knowledge gap and justification for the current study are provided in section three. The research methods adopted in this study are elucidated in section four while data analysis and results of the survey are presented in section five. Section six discusses the most critical risk areas in PPP water projects. Finally, conclusions and future research enquiry are presented in section seven.

2. Literature survey: risk identification and assessment

The literature on risk and risk assessment in PPP projects is vast, because PPP risk factor research has been (and continues to be) of interest to both academics and practitioners (Ke et al., 2009). Risks and risk management – risk identification and classification, risk assessment, risk allocation, and risk management strategies – are the most active research topics in the PPP arena.

Risk identification is a systematic and continuous process of understanding, identifying, and classifying potential risks associated with a project (Bajaj et. al., 1997). Risk assessment is the evaluation of how identified risk factors can affect the success of a project and its outcomes by determining their significance (i.e. probability and consequence). Research into risk identification is directed toward enumerating risk factors specific to projects in specific infrastructure sectors or countries through review of extant literature, interviews and surveys with experts, case studies, expert judgment, brainstorming, and Delphi technique (Ameyaw and Chan, 2013). Lubka (2002) investigated the role of risk identification in the total risk management process (RMP) and concluded that its significance is linked to the necessity of knowing all risks facing a project. Many authors (UNIDO, 1996; Ameyaw and Chan, 2013; Xu et al., 2011; Ng and Loosemore, 2007) have proposed comprehensive risk registers and taxonomies and assessed the respective impacts of those risks on PPP projects.

Drawing on 13 case studies, Schaufelberger and Wipadapisut (2003) observed that the major considerations in selecting a PPP financing strategy are project risks, funding availability and project conditions, with the most significant project risks in a financing strategy been market, political and financial risks. UNIDO (1996) suggested a build-operate-transfer (BOT) risk register and classified the risks into two categories as project-specific risks and general/country risks. Project-related risks include construction and completion risks, developmental and operating risks while country risks involve commercial, political, and legal risks.

Shen et al. (2006) studied the Hong Kong Disneyland Theme Park to establish the key risks affecting project performance. The significant risks were classified into 13 categories: industrial action, site acquisition, legal and policy, unexpected underground conditions, inexperienced private partner, changes in market conditions, financial, design and construction, operational, land reclamation, force majeure, and pollution to land and surroundings.

Ozorhon et al. (2007) presented the risk categories associated with a BOT hydropower plant project in Turkey as market, financial, political, legal, construction, and operation risks. Thomas et al. (2003) categorised BOT road project risks into four major project phases: development phase; construction phase; operation phase; and project life cycle phase, and Xenidis and Angelides (2005) also offered practical insights into 27 financial risks in generic BOT projects. Lam and Chow (1999) surveyed the impact of financial risks in BOT projects on different stages of procurement process and concluded that currency exchange restrictions was moderately significant in the operational stage while time overrun was extremely significant in the construction phase.

Hardcastle and Boothroyd (2003) and Li et al. (2005) suggested a checklist of risks for private PFI/PPP projects in the UK. Li et al. defined 66 risk factors and suggested a meta-classification method based on three categories of risks as macro (exogenous), meso (endogenous), and micro risks. Grimsey and Lewis (2002) identified nine risks and further suggested two broad categories based on the developmental (e.g., design and construction risks) and the operational (which includes risks such as revenue, wages, asset operation, maintenance and insurance risks) phases of a project. Some researchers have focused on evaluation and management of foreign exchange and revenue risks (Wang et al., 2000a, b) and political risks (Sachs et al., 2007; Voelker et al., 2008).

Thomas et al. (2006) offered a risk probability and impact assessment framework based on Delphi technique and fuzzy-fault tree and established delay in financial close, traffic revenue risk, demand risk and delay in land acquisition as the critical risks on BOT tollroads. Ke et al. (2011) conducted a two-round Delphi survey with practitioners to assess the key risks in Chinese PPP projects. The established ‘top-ten’ risks according to their mean scores are: government’s intervention; poor political decision making; financial risk; government’s reliability; market demand change; corruption; subjective evaluation; interest rate change;

immature juristic system; and inflation. Voelker et al. (2008) identified and assessed political risks in Indonesia's PPP power projects by drawing on the perception of government officials, investors, lenders and insurers. The authors observed that political risk perception for Indonesian power projects is relatively high following the country's legal and regulatory risk and government breach of contract.

Risk-induced factors are industry-specific and significant risk variables established in other industries cannot be generalised to the water sector, given the sector's unique characteristics afore-mentioned. In the context of the water industry, Ameyaw and Chan (2013) observed that empirical research into risk identification and assessment for PPP water supply projects is scanty, despite the growing private interest in public water infrastructure services. From Ameyaw and Chan's extensive literature survey, water PPP risk factor research is summarised here as follows. First, some authors have focused on general risks in the water sector (e.g., ADB, 2009), risk criticality and allocation in water PPPs (Cheung and Chan, 2010; Wibowo and Mohamed, 2010; Xu et al., 2011; Haarmeyer and Mody, 1998), and barriers to water PPPs (Choi et al., 2010). Second, few researchers have explored the risks associated with specific PPP modalities for water projects, notably BOTs (Zeng et al., 2007). The reason is that the BOT model is widely applied in the water sector and involves a plethora of risks right from project identification through transfer. The most commonly cited risks from the foregoing literature include uneconomic water tariffs, water pricing uncertainty, financing, tax policy change, interest rate volatility, water resources price instability, government breach of contract, weak host-country banking capacity, completion, government interference, and public resistance.

3. Knowledge gap and justification for current study

Though prior literature has contributed to the knowledge on PPP water project risk factors, the two questions posed in the Introduction have not been adequately addressed. Although some risk factor lists exist in published literature (e.g., Ameyaw and Chan, 2013; Cheung and Chan, 2011; Xu et al., 2011), there is still a lack of or limited consensus on the key risk factors that adversely impact on water PPP success across countries. Some of the water sector-specific studies are relatively dated (e.g., Moody and Haarmeyer, 1998) and vary in scope and detail to offer an avenue for a systematic risk identification and management. Most of the risk lists have been obtained based on limited samples (e.g., Ameyaw and Chan, 2013;

Choi et al., 2010) and were not based on research methods designed to derive reliable rankings (e.g., Xu et al., 2011; Moody and Haarmeyer, 1998; ADB, 2009; Xenidis and Angelides, 2005). More importantly, published risk factor lists were limited by geographical scope, without cross-cultural perspectives (e.g., Cheung and Chan, 2010; Zeng et al., 2007; Wibowo and Mohamed, 2010; Xu et al., 2011). That is, these lists are biased by those countries' experience and maturity in water PPP programmes and risk management propensity. Most of these studies were based on China because of its active role in using PPP to develop its water infrastructure (Chen and Messner, 2005). This study therefore seeks to contribute to lessening the country-specific bias, and to widen readers' view of risk factors and their ranking by surveying practitioners from different socioeconomic and cultural settings.

4. Research methodology

To meet the research objectives a four-stage approach was carried out mainly through establishment of risk factors, identification of PPP experts, discussions and international survey, and data analysis and reporting (Fig. 2).

[Please, insert Fig. 2 around here]

4.1 Identification of risk factors

The current study aims to establish an authoritative risk factor list, and to validate which of those factors are the most significant in PPP water projects. The initial factor list is qualitative and subjective, because it draws on related studies and past project cases that were accessed from academic and institutional literatures. This effort forms part of a wider research study that aims to establish a risk allocation model for PPP water supply projects (see Ameyaw and Chan, 2013). The identified risks were further reviewed by three academics/practitioners with experience in PPP procurement, which led to a 40–factor list.

4.2 Composition of the expert panel

Following that the required information demands sound experience and in-depth knowledge about the water industry and risks in PPP projects, a purposive sampling approach was used to select the panelists. To ensure variation in expert respondents' background, an expert panel was formed by soliciting participation from practitioners with many years (≥5) from different cultural and socioeconomic settings (see Table 2) through mixed approaches: (i) searching websites of targeted institutions, (ii) authors of journals and books on the topic, (iii) formal requests to selected institutions to nominate their most qualified practitioners, and (iv) semi-snowballing approach, by opportunistically asking initially-identified participants to suggest qualified experts.

In this study, an expert refers to a person with special knowledge/skills evident by his/her leadership in a professional organisation, or a person who has held or is holding a higher office in a professional institution, a presenter at important national conferences, or a primary/secondary writer of peer-reviewed journals (Cabaniss, 2002) in the PPP discipline. This definition together with the following pre-defined criteria guided the identification and invitation of the suitable respondents:

- ✧ Having extensive working experience from the water industry, with a good knowledge of water sector risks;
- ✧ Having recent hands-on experience in PPP water projects; and
- ✧ Having in-depth knowledge of the concepts of PPP risk management (including authors of peer-reviewed journals and/or books in the PPP discipline).

A total of 326 potential experts were identified and qualified according to their experience and cultural background, and emailed enquiring whether they were available and willing to complete an email-based questionnaire survey for this research. The invitation email explained the purpose, requirements and scope of the research. Subsequently, 35 experts expressed willingness and availability to participate the survey. This sample size is explained by the following reasons: (1) majority of the e-mail addresses were outdated and therefore the invitation e-mails were not delivered; (2) some of the respondents declined following their commitments to other duties, and lack of and/or limited experience in water PPPs. This was a panel of “certified” PPP experts who reflect current knowledge and diverse viewpoints, but not partial to the outcome of the study (Jairath and Weinstein, 1994).

Furthermore, they were a fair representation from the sectors and institutions with interests and involvement in PPP water projects, and from different categories and levels of expertise and knowledge. These institutions are a mix of public, private, international and academic organisations from which diverse experts were selected.

4.3 Questionnaire survey

Questionnaire survey is widely used in risk management research (e.g., Choi et al., 2010; Cheung and Chan, 2011; Wibowo and Mohamed, 2010), because questionnaire is an effective tool to measure practitioners' opinions and is capable of gathering data that reveals relationships among their opinions (Spector, 1994). Following the knowledge derived from the literature review, case study analyses and expert review of the identified risks, the questionnaire was designed and further amended based on the suggestions of four academics. To assess the significance of the established risk factors, an email-based ranking-type questionnaire survey containing 40 risk variables was conducted between 28 January and 03 March 2013. Email is a "push" technology that permits a researcher to directly communicate with target respondents (Andrew et al., 2003), irrespective of geographical location.

The assessment of the significance of PPP risks is a complex issue shrouded in imprecision, such imprecise terms are not avoidable because risk managers find it simpler estimating the probability and severity of risk factors in qualitative linguistic terms (Wang et al., 2004). For purposes of reliability and preciseness (Wang et al., 2004) of the email-based questionnaire survey, the experts were asked to rate both the probability of occurrence and severity of each risk according to a seven-degree rating system (1=extremely low and 7=extremely high). This scale renders the data suitable for different statistical analyses. Each risk was defined at the beginning of the questionnaire to ensure that experts' ratings are based on a common understanding of the risk variables.

Valid responses of 32 were received, which represented a response rate of 91.4%. Despite the small sample size, the findings are still significant because the panelists occupy senior positions in their respective organisations and have hands-on experience in PPP water projects (as shown in Table 1), and are from 15 countries (Table 2). These were experts who were willing and able to make meaningful contribution to knowledge and information.

Furthermore, the experts have different categories and levels of expertise and knowledge: academic and research institutions[1] (51.5%); international development banks (The World

[1] This category of experts comprised book and peer-review journal authors with industry experience.

Bank, African Development Bank, Inter-American Development Bank) (21.2%); international consulting firms and water operators (18.2%); international water non-governmental orgainsations (WaterAid-UK) (3.0%); and public sector agencies (6.1%). The experts have averages of 17.7 and 11.8 years of industrial and hands-on PPP experience, respectively while 48.5% hold senior managerial positions (e.g., senior water specialists, lead economists, infrastructure advisory leads, etc), 27.3% are professors and 24.2% are Ph.D holders in their present institutions. This rich experience of the experts guarantees the reliability of their feedbacks for the study.

Comparatively, this sample size is bigger than those used in previous related studies, including: 27 (Sachs et al., 2007), 19 (Choi et al., 2010), 31 (Wang et al., 2004), and 17 (Voelker et al., 2008) respondents. Finally, all the experts demonstrated immense interests in our research and most have requested for the final research report. The experts' background information is given in tables 1 and 2.

[Insert Table 1 around here]

[Insert Table 2 around here]

5. Data analysis and results

The feedback collected from the questionnaire survey was analyzed using various statistical methods by the Statistical Package for Social Sciences (SPSS) 21.0. Prior to conducting the statistical analyses, the internal consistency and reliability of the factors was assessed through the Cronbach's alpha model (Cronbach, 1951) to ensure validity. The alpha-value ranges between 0 and 1. Values of Cronbach's alpha for risk probability and risk severity are 0.942 and 0.954, respectively, which are above the recommended threshold of 0.70 (Hair et al., 2010). This suggests a high degree of uniformity on the survey instrument and a high level of consistency regarding correlation amongst the 40 risk factors.

Quantitative feedback to the questionnaire survey were analysed using the mean score (MS) ranking analysis (Cheung and Chan, 2011), which were then ranked in order to establish the relative significance of the 40 risk factors. The MS was calculated using the following formula:

Academics without industry experience are excluded.

$$MS = \frac{7n_7 + 6n_6 + 5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{N}$$

where, MS = mean score of a risk factor; n = score given by expert respondents based on a seven-point scale from 1 to 7; and N = number of expert respondents that rated a risk factor (N = 32). The feedback has two groups of data, the probability of occurrence and magnitude of severity of each risk. The ranking of probability of occurrence and severity of the factors is directly based on the mean scores (as shown in Table 2).

Project risk is a joint function of probability of occurrence and severity and can be measured with the following formula:

$$Risk = f(probability, severity)$$

For example, Carter et al. (1994) and Ke et al. (2011) termed above method of risk measurement as expected value (EV) and risk significance index (RSI), respectively. By this method, it is possible to rank all the risk factors based on their RSI scores. A square-root of *RSI* gives a risk impact on a project, as shown in Tables 3 and 4.

Kendall's coefficient of concordance *(W)* was computed to measure the extent of agreement among the experts on their rankings for the risk factors. The *W*-values and the *p*-values for scored probability and severity rankings were 0.163 and 0.000, and 0.174 and 0.000, respectively. The low *W*-values indicate a very weak consensus among the expert panelists (Schmidt, 1997). However, because the respective *p*-values for probability and severity were less than 0.05, the findings are (statistically) significant, implying that all the experts' rankings were consistent (Rasli, 2006). It is worthnoting that it is difficult to achieve a high value of *W* (i) where 40 risk factors are assessed against a seven-point rating scale (ii) by 32 experts from 15 different cultural and socioeconomic environments.

6. Findings and Discussion

The survey results are presented in Tables 3 and 4. This section discusses the significant findings of the international survey based on the collective opinion of the expert panelists.

6.1 Overall ranking of risk factors for PPP water supply projects

On risk probability and severity (Table 3), the following observations are made; first, the mean index for the risk probability ranges from 2.81 to 4.50, which suggests that the likelihood of risk occurrence ranges from low to high levels. The mean scores of the risk severity ranges from 3.91 to 5.41, indicating that the risk severity ranges from moderate to high levels. Ultimately, the risk probability and severity ranges suggest that the variations in the experts' responses are relatively small, 1.69 and 1.50, respectively. Second, 19 out of the 40 risks have mean probability index $\geq$ 4.0, and 39 factors have mean severity index $\geq$ 4.0, which suggests that the panelists perceive 98% of the ranked risks within moderate to high severity range. The implication is that project managers would be more interested in the consequences of risk events.

The impact values of the risks range between 3.61 and 4.84 and the risk factors were divided into two impact groups: high impact (mean $\geq$ 4.50), and moderate impact (mean < 4.50) risk factors (Table 4). Overall, nine risk factors belong to the 'high impact' group while majority (31) of the risk variables have 'moderate impact' on PPP water projects.

[Insert Table 3 around here]

[Insert Table 4 around here]

Analysis of the rankings and comparison with earlier studies (e.g., Cheung and Chan, 2010; Zeng et al., 2007; Choi et al., 2010; Wibowo and Mohamed, 2010) provide some key insights. Given the changes in the water industries across countries over the last two decades, it is expected that, first, some risk factors have remained relatively significant. These factors include water pricing and tariff review uncertainty, political interference, public resistance, construction time and cost overruns, nonpayment of bills, etc (Choi et al., 2010), which mostly fall in the 'high impact' group. Second, most risks have declined in significance, perhaps due to sector reforms and better approaches to managing such risks. They largely belong to the 'moderate impact' group, including traditional political risks (e.g., political discontent & early termination, expropriation, political violence & government instability, currency convertibility and transferability), policy & legal frameworks, residual value risk, fall in demand, foreign exchange rate, procurement risk, etc. Third, because previous lists were limited by culture, this list contains some unique, significant factors that are not detected in many previous rankings, such as poor contract design, low quality of raw water, water asset condition uncertainty, corruption, raw water scarcity, water theft, and climate change risk which ranked 1st, 13th, 15th, 15th, 21st, 26th, and 39th, respectively. This list extends the coverage of some known risk items and further indicates that some important risks have emerged in the global water PPP market. For example, climate change risk and its associated consequences (raw water scarcity, low quality of raw water) are topical in today's water industry (Zwolsman et al., 2011). Therefore, drawing on country-specific studies may ignore and leave readers blind to some important factors.

Overall ranking for the risk factors — between moderate and high impact — suggests that the risk list is reliable and covers significant risk factors. Therefore, readers should note that most of the factors are situation-dependent; a moderate risk may be critical in a given environment.

6.2 Discussion of critical risks on PPP water supply projects

As indicated earlier, our approach makes it possible to generalise a 'top-ten' risk factors across different socioeconomic settings. First, this is due partly to space limitation. Second, unsurprisingly, these risk items comprise the nine 'high impact' factors with 'moderate' to 'high' probability mean indices and 'high' severity mean scores, and the tenth risk factor has a 'moderate impact', close to the 'high impact' level (Table 4). Also, given the importance assigned to relationship management (Zou et al., 2014) in the literature, 'conflict between partners' is discussed. These risks are believed to be critical in the water industry because they are recurring factors in some literature conducted across cultures and times. Possible sources and consequences of these risk factors are summarised in Table 5.

[Insert Table 5 around here]

6.2.1 Poor contract design

Overall, the ranking exercise corroborates that poor contract design is the factor the expert respondents perceived was most significant, ranking first. It is a factor that is missing in previous factor lists. The mean scores of the probability, severity and impact for this risk are 4.41, 5.31 and 4.84, respectively, with a significance index of 23.41. Meeting performance targets in a partnership is heavily dependent on how well the contract is designed (Cowen and Komives, 1998). The contract, which outlines rules and guides future behaviours of contracting parties, is a critical factor in ensuring successful implementation of a PPP. Subsequent conflicts and failure to meet contractual obligations is largely the outcome of faulty contract design in terms of, for example, how well an agreed-upon risk allocation is drafted into the contract, tariff setting and adjustment, incentives and contract terms, performance targets and measurement, and regulation. Several contractual designs, often with clear weaknesses and irregularities, have been applied in the water sector as a market test in diverse and challenging environments (Marin, 2009). The failed Cochabamba 40-year water concession in Bolivia (Nickson and Vargas, 2002) is a good example.

6.2.2 Water pricing and tariff review uncertainty

This risk is ranked second (RSI=22.03; impact=4.69), with the probability (4.41) and severity (5.00) scores ranking third and fourth, respectively. Adequate pricing of water services requires a precise approximation of demand-revenue ratio over a project's duration. This estimate commands future price of service and the development of pricing policy in line with local regulatory structures. A poor pricing strategy may result from false application of the estimation method of the demand/revenue ratio, strategic misrepresentation, wrong data for the estimation of the demand-revenue ratio (Xenidis and Angelides, 2005) and misapplication of the tariff formula. Economic pricing and tariff review policy remains a massive challenge for most water utilities in developing countries because water pricing has long been (and remains) volatile and politically sensitive (Dinar, 2000; Harris et al., 2012). Charging economic tariffs is often more about political opposition: most governments determine how much a service provider is allowed to charge consumers or hold down justifiable tariff increases for water services. This risk undermines service levels, results in revenue losses and increased hidden costs, and partly explains the poor profitability and inadequate financing in the water sector.

6.2.3 Political interference

Given that water has a political effect justifies the political interference (sometimes damaging) in areas such as tariff setting and reviews (Dinar, 2000). Political interference risk ranked third (RSI = 21.72; impact = 4.66), with the probability (4.34) and severity (5.00) scores ranking fifth and fourth, respectively. Political interference refers to the risk of government interfering in the activities of regulators and private operators, and violating contract provisions, such as opposing tariff adjustments. In China, following inadequate and inconsistent laws governing PPP activities, local governments can unilaterally change these laws without consultation with the investor or considering the consequences on the private partner (Zhang and Biswas, 2013). What is required to ensure successful partnerships is a political commitment/support rather than unjustified political interference.

6.2.4 Public resistance to PPP

Public resistance means a lack of or weak support for a water contract with private participation. Public resistance risk ranked fourth (RSI = 21.66; impact = 4.65), with the probability (4.50) and severity (4.81) scores ranking first and thirteenth, respectively. Public resistance is commonplace as far as PPP in water services is concerned (Hall et al., 2005; Hall and Lobina, 2012). Resistance has been vocal and remarkable, and successfully delayed or led to the revision of original agreements, reversal and termination of several PPP water projects. Public resistance in this sector encompasses vibrant interactions with political parties and systems such as legal and electoral apparatuses (Hall et al., 2005). From the water management literature, it stands to reason that factors for public opposition are similar across countries, notably: price hikes, job cuts, hefty profits of investors, opaque nature of some PPP processes, unmet service targets, and failed investment promises. There is continued public discontent with and resistance to PPP for water services (Kessides, 2004), even in developed countries, notably Italy, Spain and Greece (Hall and Lobina, 2012). The risk must be understood in a host country's context and carefully managed to ensure successful private participation.

6.2.5 Construction time & cost overrun

Construction time & cost overruns are among the most critical risks in PPPs (Lam and Chow, 1999; Shen et al., 2006). Unsurprisingly therefore, the construction time & cost overrun risk was ranked fifth (RSI = 21.31; impact = 4.62), with the probability (4.34) and consequence (4.91) ranking fifth and eighth, respectively. Water infrastructure is complex to design and construct. The [2]Tampa Bay Desalination Plant project which was six years behind schedule and over budget shows that timely completion within cost and quality is not guaranteed under PPP procurement. Delays, apart from causing a project to exceed its estimated schedule, is associated with consequences such as shortage of cash to settle operating costs with ensuing debts, delayed maturity period, and increased interest resulting from untimely loans settlement (Xenidis and Angelides, 2005). Pribadi and Pangeran (2007) observed that construction time overruns for PPP water projects relate to poor coordination of construction firms, delays in obtaining planning approvals and land-use rights.

[2] A design-build-own-operate-transfer (DBOOT) scheme between Tampa Bay Water and Poseidon Resources in the USA

Conversely, construction cost overruns at the engineering and construction phase requires additional substantial finances (ADB, 2000), which constraints profitability of a project through high tariffs that result in low demand in the operational phase (e.g., Yuvacik BOT water scheme in Turkey). Therefore, the elements of construction cost (costs of cooperation and co-ordination, site, imported material/equipment, raw materials, labour, insurance, etc) demand effective management to ensure reduced construction costs and high potential for profits.

6.2.6 Non-payment of bills

This risk ranked sixth, with probability, consequence and impact scores of 4.25, 5.00 and 4.61, respectively and a significance index of 21.25. Non-payment risk is one of the notable challenges in the water industry, particularly in developing countries (Auriol and Blanc, 2009). Chronic payment failure, which is partly offered as a reason to *'privatise'* public water services, is found to persist even under private management (Ameyaw and Chan, 2013). This raises the question of whether the private sector is likely to be any better at managing non-payment risk in water PPPs. Unaffordable tariffs, legal/political obstacles to service cut-offs, poor service levels, well-rooted habit of non-payment, and poor bill collection practices amplify levels of non-payment. In practice, payment risk is mitigated through strict collection policies, notably rigorous service cut-offs and (sometimes) court actions. However, an enforcement system depends on a host government's commitment, monitoring and legislative powers to penalise defaulting customers.

6.2.7 Lack of PPP experience

The probability (4.31) and consequence (4.91) of this risk ranked seventh and eighth, respectively, and overall, ranked seventh with a 'high impact' of 4.60. In countries where PPP procurement approach is new, it may be difficult to find local expertise to develop and implement PPP projects, without difficulties. Concerns about inexperienced public partners and incomplete designs (Cheung and Chan, 2011; Li et al., 2005; Loosemore and McCarthy, 2008) are sources of tendering difficulties. Advocates suggest that getting started with one or two projects is the first step, because experience is gained as more projects are launched. In the water sector, countries with interest but limited PPP experience can start with less ambitious models, such as service and management contracts at municipal and district levels, or engage external advisors in large-scale projects.

6.2.8 Financing risk

The financing risk has probability and severity scores of 4.28 and 4.19, respectively and also ranked eighth (RSI = 21.00; impact = 4.58). Availability of adequate funding (debt and/or equity) remains an issue for concern in most water projects (Marques and Berg, 2011), especially in low-income economies which have been tagged as risky investment destinations (MIGA, 2009 in Ameyaw and Chan (2013)). In 2002, the Beijing No. 10 water project which was won by a consortium of Mitsubishi Corporation and Anglian Water failed, following the consortium's inability to secure debt financing due mainly to lack of adequate financing policies and regulatory structures in China (Zhang and Biswas, 2013).

The capital intensive nature of water supply projects and affordability issues suggest that the challenge of financing and refinancing is to secure long-term funding at reasonable interest rates that match the lengthy payback periods linked to the huge financial commitments needed for building new infrastructure (Haarmeyer and Mody, 1998; Xenidis and Angelides, 2005). Given that the public sector is constrained in providing sufficient funding, the private sector is expected to bear this risk. However, an optimal combination of different funding sources (public and private) to establish a sound and flexible project financial structure and mitigate financing risk is likely to be the most effective approach.

6.2.9 Faulty demand forecasting (over-estimation)

Errors in forecasted demand mean that future demand is inconsistent with projections. Over-estimated water demand forecasts result in revenue shortfalls, renegotiations, and variations in original contracts (Lobina, 2005). In water concessions/BOT-type projects, demand is predicted over a considerable period, say 25 years. Therefore, an accurate demand projection is necessary to ensure viability and profitability of projects, but relies on reliable data and appropriate techniques. However, the difficulty of demand forecasting stems from the fact that factors influencing future demand (e.g., population growth, weather variations, alternative water sources, emergence of small-scale providers) cannot be predicted with certainty; good methods can only give average outcomes (World Bank, 2006). It ranked 9th with a high impact score of 4.52 and the probability (4.22) and severity (4.84) ranked 10th and 12th, respectively. This implies that demand prediction is a major challenge in long-term water PPPs (e.g., Chengdu No. 6 BOT water project in China).

6.2.10 High operational costs (cost overruns)

The water sector is unique in that operations are relatively complex and operational costs are unstable and difficult to predict. This is because costs of operating water services are linked to five functional areas, namely “acquisition [abstraction], treatment, power [energy] and pumping, transmission and distribution (including storage), and support services – the overall integrative responsibility of utility management” (Clark et al., 1977, p. 6). These functions are called the water supply value chain (Ameyaw and Chan, 2013) and the costs rising from each functional area are necessary for providing water services, either under public or private management.

In PPP procurement, operational cost overruns are attributable to the water operator’s responsibility, and external uncontrollable factors (Xenidis and Angelides, 2005). A private operator may submit *‘inaccurate’* estimates during the bidding stage as a deliberate attempt to win a contract. The winning bidder overstates the financial savings to the host government while underestimating the volume of work to operate and maintain the water infrastructure services. This tendency activates poor operating cost control which hampers successful service delivery and profitability (see the United Water concession in the U.S. (Public Citizen, 2003)). On the other hand, prevailing economic conditions in the operating environment, beyond the operator’s control, may raise operating costs. These pressing conditions include foreign exchange rate movement, inflationary pressures and high energy prices. The Maynilad Water Services’ experience (Phillippines) shows that external shocks, such as currency risks and regional economic crisis (the 1997 Asian economic downturn), could raise operating costs by 40% (OECD, 2009). Cost overrun risk is further exacerbated by low water tariffs and difficulties in collecting from customers (Harris et al., 2003). In many developing countries, governments have kept tariffs below costs and collection rates are low. Attempts at economic pricing and/or improving collection rates often result in widespread opposition from politicians and consumers (Harris et al., 2012; Nickson and Vargas, 2002; Harris et al., 2003). Cost overrun risk results in expensive services, reduced profits, jeopardized creditworthiness of project company, and poor services to customers. Consequently, the risk ranked 10th with a moderate impact (4.44), high severity of 4.75 and moderate probability score of 4.16, suggesting that private operators must concentrate on effective cost control strategies.

6.2.11 Conflict between partners (poor working relationship)

Given the emphasis placed on conflict between partners in the PPP literature (Oyedele, 2013; Smyth and Edkins, 2007; Zou et al., 2014), it is selected for further discussion. The risk ranked 12th, with moderate probability, high consequence and moderate impact scores of 4.03, 4.81 and 4.40, respectively, and a significance index of 19.40. Often, conflicts engulf water partnerships which subsequently affect performance of the public-private participants, waste time and resources and jeopardize the project's success (Trémolet et al, 2004). Conflicts primarily emanate from poor working relationship between the public client and the private consortium (Oyedele, 2013). Oyedele explained that this occurs when the public client is unwilling to endure performance failures in services delivery and work together with the private partner regarding performance shortcomings before effecting sanctions (such as payment deductions). To ensure a healthy working relationship, NAO (2001) recommended that parties should adopt a partnership approach to the project at an early stage, based on understanding of each other's business and a common vision to achieve a mutually successful project. This will drive on proactive relationship management (Smyth and Edkins, 2007) and its success factors, including commitment of senior executives, clearly-defined project objectives, well-designed contracts and effective risk allocation, and integration of the different divisions and a multidisciplinary team (Zou et al., 2014). Readers can consult Smyth and Edkins (2007) and Zou et al. (2014) for more on relationship management in PPP.

7. Conclusions and future research

Adequate risk assessment and development of countermeasures for PPP water projects necessitates an in-depth understanding of what the actual risk factors are, which of these risk factors significantly impact on such projects and require both investors' and public clients' attention, and how these risk factors differ across cultures. An empirical, email-based international questionnaire survey of PPP experts with direct involvement in PPP water projects, was conducted to address above risk issues. Because the initial list was based on a systematic procedure and the ranking was done by a multicultural panel of 32 of industry practitioners, the resulting factor list is authoritative, comprehensive and grounded. Analysis was conducted using the risk significance index–a well-established approach in decision theory–and the top-ranked risk factors in water PPPs based on their impact values were identified as (in order): poor contract design, water pricing and tariff review uncertainty, political interference, public resistance to PPP, construction time & cost overrun, non-payment of bills, lack of PPP experience, financing and refinancing risk, faulty demand forecasting (over-estimation), high operational costs, and conflict between partners (poor working relationship). Kendall's concordance analysis showed that the rankings of the 40 risk factors by the experts were consistent.

The ranking of probability of occurrence and severity of risks was directly based on the mean score indices. These risk factors relate to two risk categories: host-country risk, and project-related risk. A careful observation of Table 4, however, indicates that many risk factors in the former category have higher significant indices and impact values than those in the latter category. Therefore, risks must be understood in the context of a host country and a project's own right to ensure successful private participation in water services.

The findings from the current study are impactful to risk management in PPP projects with implications for both practice and academia, given the limited research studies of this nature. First, it provides a comprehensive risk factors that were carefully identified, filtered, and assessed by industry experts (actively involved in water PPPs) from 15 cultures of different maturity levels of PPP markets. Given its derivation approach, the current list has the advantage of been practical and comprehensive compared with previous studies that were constrained by cultural perspectives. Second, thus this factor list can assist international water investors and host governments to determine what risk factors would impact on water PPP projects and aid them in developing risk assessment and mitigation guidelines. Third, the study suggests which risk factors, over time, have declined in importance, are relatively stable, and have gained prominence in the global water PPP market. Both investors and governments should be aware of this dynamism and make conscious efforts to accurately analyse risk factors to prioritise risks for management purposes.

As with any empirical questionnaire survey, the following limitations must be noted: the risk factors were collected from projects cases reported in the water PPP literature and assessed by a limited number of practicing PPP experts. Therefore, for a specific project in a given cultural setting project stakeholders may need to add unique risk factor(s) to the above 40 factors, or certain low-ranked factors in Table 4 may need to be given much attention. However, the expert sample is relatively diverse, and the risk factor list has a wide coverage of possible risk factors in PPP water projects.

The outcome of the current study has value for PPP in the water industry and researchers. The risk factors provide pointers to PPP initiatives across cultures, both mature and emerging PPP markets. While sector-specific empirical studies are essential to investigate particular countries, the research method and the established risk factor list can be used, and results compared to commence a broad knowledge base. Country-specific risk items can be added to reveal a wide coverage of critical risk factors for PPP water supply projects.

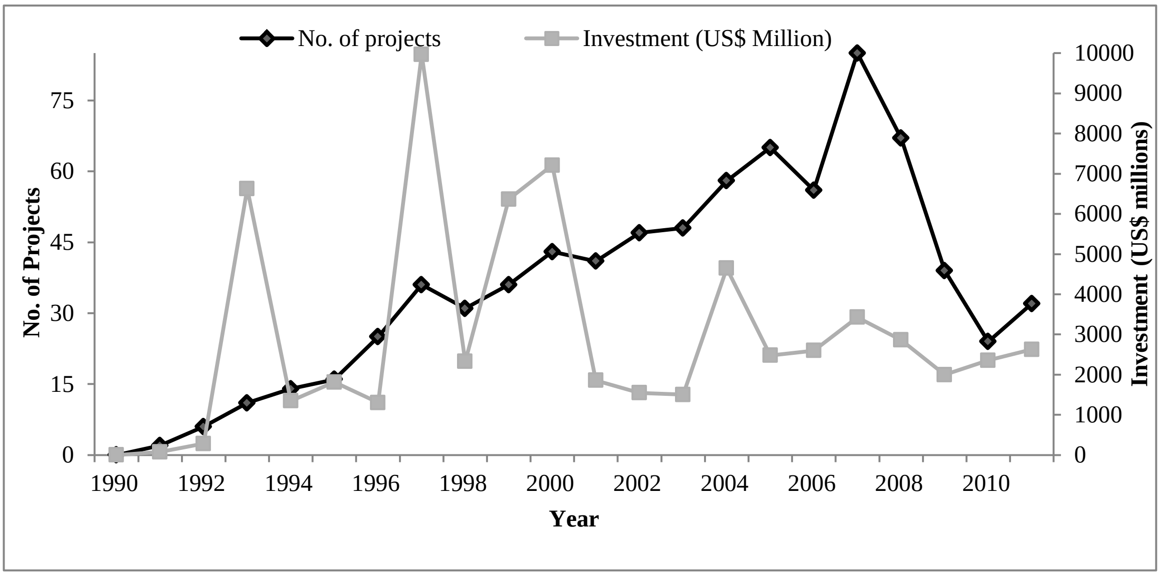

Fig. 1 Trends in water PPPs in developing countries (Source: World Bank database)

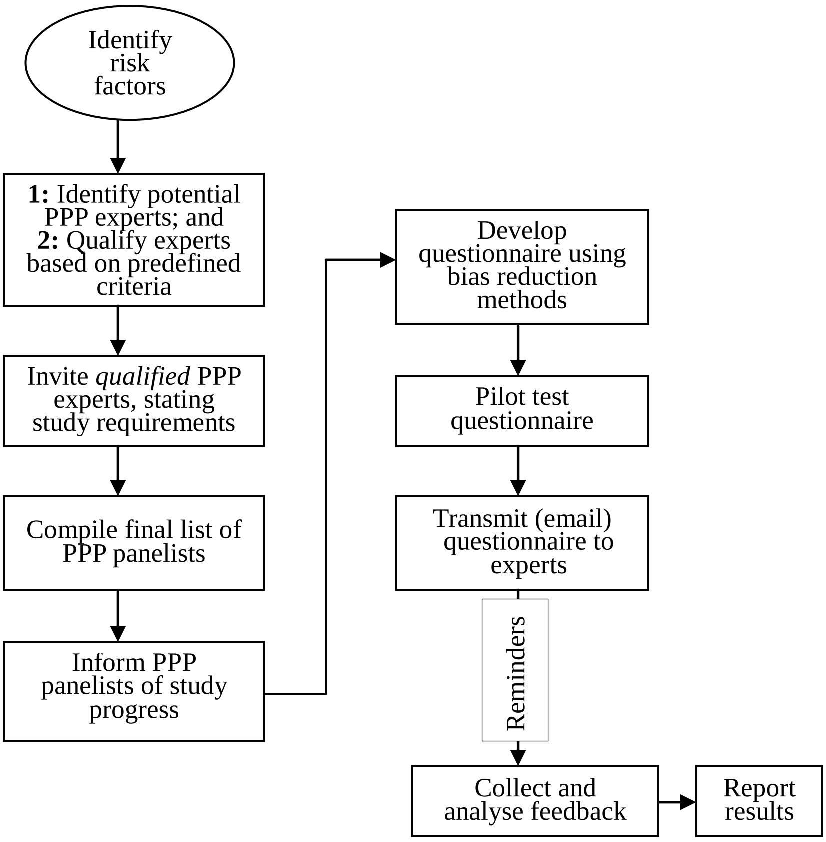

Fig. 2 Overall research process

Table 1 Background of Experts

Respondent Profiles	Categorisation	Count	Percentage (%)
Type of sector	Public	4	12.5
	Private	7	21.9
	Academic/ research	14	43.8
	Mix (of above)	7	21.9
Number of years of industrial experience	Less than 6 years	3	9.4
	6 – 10 years	4	12.5
	11 – 15 years	5	15.6
	More than 15 years	20	62.5
Number of years of PPP research/ experience	Less than 6 years	4	12.5
	6 – 10 years	12	37.5
	11 – 15 years	7	21.9
	More than 15 years	9	28.1
Number of PPP projects participated	Less than 3 projects	6	18.8
	3 – 5 projects	10	31.3
	Above 5 projects	16	50.0
Type of PPP projects participated	Lease/affermage	3	9.4
	Concessions/BOT-type	10	31.3
	Management contract	1	3.1
	Mix (of above)	18	56.3

Table 2 Geographical background of experts

Region	Country	No. of experts
Africa		**7**
	South Africa	3
	Nigeria	1
	Tunisia	1
	Senegal	2
Asia		**11**
	Hong Kong	2
	China	6
	Indonesia	1
	Bangladesh	1
	Korea	1
America		**7**
	USA	6
	Portugal	1
Europe		**5**
	Greece	2
	UK	2
	France	1
Australia		**2**
Total		**32**

Table 3 Overall ranking of risk factors in PPP water supply projects

Risk Factor	Risk Probability		Risk Severity		Risk Significance Index	Risk impact*	Risk Rank
	Mean	*Rank*	*Mean*	*Rank*			
Poor contract design	4.41	3	5.31	3	23.41	4.84	1
Water pricing and tariff review uncertainty	4.41	3	5.00	4	22.03	4.69	2
Political interference	4.34	5	5.00	4	21.72	4.66	3
Public resistance to PPP	4.50	1	4.81	13	21.66	4.65	4
Construction time & cost overrun	4.34	5	4.91	8	21.31	4.62	5
Non-payment of bills	4.25	9	5.00	4	21.25	4.61	6
Lack of PPP experience	4.31	7	4.91	8	21.16	4.60	7
Financial and refinancing risk	4.28	8	4.91	8	21.00	4.58	8
Faulty demand forecasting	4.22	10	4.84	12	20.43	4.52	9
High operational costs	4.16	13	4.75	17	19.74	4.44	10
Design & construction deficiencies	4.16	13	4.72	18	19.61	4.43	11
Conflict between partners	4.03	18	4.81	13	19.40	4.40	12
Low quality of raw water	3.91	22	4.88	11	19.04	4.36	13
Change in government & political opposition	3.91	22	4.81	13	18.80	4.34	14
Quasi-commercial risk	4.00	19	4.69	20	18.75	4.33	15
Corruption	4.47	2	4.19	34	18.71	4.33	15
Water asset condition uncertainty	4.19	12	4.47	25	18.71	4.33	15
Land acquisition risk	3.91	22	4.78	16	18.68	4.32	18
Insufficient private operator performance (operation)	3.97	20	4.66	21	18.48	4.30	19
Foreign exchange rate	4.09	15	4.44	26	18.17	4.26	20
Raw water scarcity	3.53	34	5.09	4	17.99	4.24	21
Pipeline failures during distribution	4.09	15	4.31	29	17.65	4.20	22
Unfavourable local/ global economy	4.22	10	4.13	37	17.40	4.17	23
Regulatory risk (weak regulation)	3.91	21	4.38	27	17.09	4.13	24
Sovereign and contractual risk	3.66	30	4.66	21	17.02	4.13	25
Water theft	4.06	17	4.16	35	16.88	4.11	26
Fall in demand	3.56	33	4.72	18	16.81	4.10	27
Political discontent & early termination	3.72	29	4.50	23	16.73	4.09	28
Interest rate	3.66	31	4.50	23	16.45	4.06	29
Inflation rate volatility	3.78	27	4.31	29	16.31	4.04	30
Procurement risk	3.78	28	4.31	29	16.31	4.04	31
Supporting utilities risk	3.91	22	4.16	35	16.24	4.03	32
Absence of policy & legal frameworks	3.81	26	4.22	32	16.08	4.01	33
Force majeure	2.97	39	5.41	1	16.05	4.01	34
Expropriation/nationaslisation	2.81	40	5.41	1	15.21	3.90	35
Residual value risk	3.66	31	3.91	40	14.28	3.78	36
Political violence/ Government instability	3.19	37	4.34	28	13.85	3.72	37
Technology risk	3.28	35	4.06	39	13.33	3.65	38
Climate change risk	3.25	36	4.06	38	13.20	3.63	39
Currency convertibility/ transferability	3.09	38	4.22	32	13.05	3.61	40

*Impact = (Risk Significance Index) $^{0.5}$

Table 4 Risk classification and ranking of risk impact on PPP water projects

Risk Factor	Category	Risk Impact	Risk Rank	Criticality
Poor contract design	Project	4.84	1	High
Water pricing and tariff review uncertainty	Country	4.69	2	High
Political interference	Country	4.66	3	High
Public resistance to PPP	Country	4.65	4	High
Construction time & cost overrun	Project	4.62	5	High
Non-payment of bills	Country	4.61	6	High
Lack of PPP experience	Country	4.60	7	High
Financing and refinancing risk	Project	4.58	8	High
Faulty demand forecasting	Project	4.52	9	High
High operational costs	Project	4.44	10	Moderate
Design & construction deficiencies	Project	4.43	11	Moderate
Conflict between partners	Project	4.40	12	Moderate
Low quality of raw water	Country	4.36	13	Moderate
Change in government & political opposition	Country	4.34	14	Moderate
Quasi-commercial risk	Project	4.33	15	Moderate
Corruption	Country	4.33	15	Moderate
Water asset condition uncertainty	Project	4.33	15	Moderate
Land acquisition risk	Project	4.32	18	Moderate
Insufficient private operator performance (operation)	Project	4.30	19	Moderate
Foreign exchange rate	Country	4.26	20	Moderate
Raw water scarcity	Country	4.24	21	Moderate
Pipeline failures during distribution	Project	4.20	22	Moderate
Unfavourable local/ global economy	Project	4.17	23	Moderate
Regulatory risk (weak regulation)	Country	4.13	24	Moderate
Sovereign and contractual risk	Country	4.13	25	Moderate
Water theft	Project	4.11	26	Moderate
Fall in demand	Project	4.10	27	Moderate
Political discontent & early termination	Project	4.09	28	Moderate
Interest rate	Country	4.06	29	Moderate
Inflation rate volatility	Country	4.04	30	Moderate
Procurement risk	Project	4.04	31	Moderate
Supporting utilities risk	Project	4.03	32	Moderate
Absence of policy & legal frameworks	Country	4.01	33	Moderate
Force majeure	Project	4.01	34	Moderate
Expropriation/nationaslisation	Country	3.90	35	Moderate
Residual value risk	Project	3.78	36	Moderate
Political violence/ Government instability	Country	3.72	37	Moderate
Technology risk	Project	3.65	38	Moderate
Climate change risk	Country	3.63	39	Moderate
Currency convertibility/ transferability	Country	3.61	40	Moderate

Table 5 Sources and consequences of top 10 risk factors

Risk factor	Source(s)	Key consequence(s)
Poor contract design	Lack of public sector expertise in PPP contract design; Hurried pace of a PPP project	Ensuing conflict between project partners Failure to achieve performance targets Opportunistic renegotiations Abandonment of project
Water pricing and tariff review uncertainty	Poor pricing strategy Government breach of terms of contracts, or political opposition	Undermines private sector confidence Threatens profitability of water services Suspension of private investment (e.g., Aguas de Limeira, Brazil)
Political interference	Mainly political expediency	Undermines service delivery Government-led renegotiation, or termination of projects
Public resistance to PPP	Unresolved political and institutional issues	Stalls, or delays private participation in water services Abandonment of water PPPs
Construction time & cost overrun	Inefficient construction and cost control practices; Lack of coordination within construction firm and of subcontractors	Delayed operation and increased interest on loans Reduces profits High-priced water (e.g., Izmit water BOT, Turkey)
Non-payment of bills	Customer habit of non-payment; Poor bill collection practices	Disincentive to private sector Reduces operator's revenues
Lack of PPP experience	Public institutions' lack of technical expertise and academic experience related to PPPs	Projects implementation difficulties Gold-plated contracts to private partners High costs to taxpayers/ customers
Financial and refinancing risk	Private sector reluctance to investment in risky destinations; Global/regional financial crisis	Investment needs remain unmet Delayed private investments
Faulty demand forecasting	Aggressive bidding, or strategic misrepresentation; Unreliable data; inappropriate forecasting methods	Revenue shortfalls Renegotiations of original contracts Deferred private investments
High operational costs	Dive bidding (operator's responsibility); external shocks	Limits project profitability High-priced water services to customers

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