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Mitigating risks in wastewater treatment plant PPPs using minimum revenue guarantee and real options

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ABSTRACT

Uncertainties associated with wastewater treatment plants inflows can lead to either undersized or oversized facilities. Such uncertainties are attributed to the deviation of actual development patterns from plans. Accordingly, a minimum-flow guarantee is a suitable risk mitigation strategy. This research proposes a guarantee evaluation algorithm, and a new stochastic model using real-options theory, in order to simulate the wastewater inflow to the wastewater treatment plant. A wastewater treatment plant in Egypt is examined as a case study. The results enable the monetary evaluation of contractual clauses relating to plant expansion and minimum-flow guarantee.

1. Introduction

Expanding and maintaining publicly owned infrastructure challenges the budget allocation policies of strained governments. Such conditions are common in developing countries with competing needs and limited resources. Infrastructure is of great significance in the economic growth process. The private sector can provide funding for publicly owned infrastructure to overcome the economic challenges and limitation of the public sector. Public-Private partnership (PPP) projects are considered effective delivery arrangements that assure value-for-money public infrastructure or service (Ke et al., 2010a). In such arrangements, the public and private sectors are motivated by different objectives, such as socio-economic benefits and financial profitability respectively.

PPP arrangements have several important characteristics from the risk management point of view, the most important characteristics are: (1) long contractual periods (10–40 years); (2) large initial investment and gradual returns; (3) deterioration of infrastructure facilities; and (4) unique local conditions. PPP projects are exposed to several risks during construction and operation stages during their life cycle (Dailami et al., 1999). Many efforts have been directed towards the identification of PPP projects risks such as Carbonara et al. (2015), Chan et al. (2010), and Roumboutsos and Anagnostopoulos (2008). The main risks during construction stage include completion on time, cost overrun, performance, and environmental risks. The main risks during operation stage include political, macroeconomic, and revenue risks. Improper mitigation of these risks may result in financial failure of the project. Accordingly, before entering such projects the private sector must carefully asses the major risks that may intimidate the success of the project (Yescombe, 2002). If the private sector is not comfortable with the level of risks and there are no appropriate mitigation strategies, the private sector will withdraw from the arrangement (Chiara et al., 2007). In summary risk management and risk mitigation play an important role in the successful realization of PPP infrastructure projects' arrangements.

One of the significant risks of a PPP project is revenue risk, which is the possibility that the cash inflows of the project do not cover its' cash outflow and the private parts' expected return. The revenue stream of the private sector is dependent on the volume of the treated wastewater, i.e., input 'flow' of wastewater, accordingly the uncertainty of the input flow is a major revenue risk factor. Minimum Revenue Guarantee (MRG) is a common mitigation strategy (Chiara et al., 2007). In such strategies, the government will guarantee a pre-defined level of revenue over a pre-defined period of time along the project's concession period. Hence, if the actual revenue over a unit period of time drops below the pre-agreed level the government will pay the private investor the difference between the actual revenue and the pre-agreed revenue threshold. While the concept of a revenue guarantee as a risk mitigation strategy is appealing, calculating the value of the different configurations of such guarantees was likely to be problematic.

In Egypt, there still a significant portion of infrastructure investments to be directed toward the construction of new wastewater treatment plants (WWTPs). The allocated budgets of such projects are very large, and the government seeks private funding to develop such

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facilities. In order to achieve effective concession agreements and successful project realization, the government must consider incentives and allocate risks between the private and public sectors. Accordingly, the Egyptian government will be tempted to follow such arrangement. The current research in valuing revenue guarantees in infrastructure projects is more focused on transportation networks (Carbonara et al., 2014a; Roumboutsos, 2015; Button, 2016; Brandao and Saraiva, 2008; Shan et al., 2010; Carbonara and Pellegrino, 2018a). Limited research was found related to applying the different valuation techniques on Wastewater sector, especially WWTP sector. The need to devise or modify valuation techniques currently applied to transportation projects to suit the waste-water/water sector, stems from the different nature of the later sectors, as they are mainly divided into plants and networks. Accordingly, different contractual and physical conditions can be considered feasible or applied in water/waste-water sectors that are not commonly present or applied in transportation projects, such as the option to construct the plants in phases. In Egypt, the flow uncertainty is of specific concern, because actual development patterns rarely follow the planned development in most areas, which results in either undersized or oversized WWTPs facilities. This waste of resources put an additional obstacle against achieving the country's strategic goals.

This paper presents flexible guarantee valuation techniques that are suitable for use in WWTP PPP projects. The proposed approach takes into consideration the implications of two additional possible contractual conditions on the value of the guarantee. The first additional condition is the possibility of paying the private investor a fixed annual fee in addition to the volume dependent fees, in exchange for treating the wastewater inflow. Whereas, the second additional condition is providing the private investor the option to construct the treatment plant in phases, i.e., constructing the WWTP in one phase vs. multiple phases with/without expansion obligation. As such, an algorithm is proposed to provide the value of the guarantee under any configuration of the above-mentioned contractual conditions. The paper presents an extensive literature review that addresses PPPs and modeling risks in BOOT projects. Also, it investigates real options applications in infrastructure projects. Subsequently, it presents the proposed inflow simulation model as well as the valuation of multiple options. Finally, a case study is presented to demonstrate the practical features of the proposed methodology.

2. Literature review

PPP arrangements can be used to transfer key risks to the private sector (e.g., design, finance, construction, operation, etc.), in which compensations are made in exchange for service delivery, which is commonly delivered by the public sector. Public authorities face tremendous demands to develop new infrastructure facilities and networks and for financing their renewal, rehabilitation, and operation of existing systems (Chiara et al., 2007). Securing the financial resources in order to satisfy the abovementioned demands creates tense competition. Accordingly, the budget-constrained public sector may seek benefits from partnering with the private sector because of the latter's capability to manage capital expenditures while achieving institutional objectives. However, PPP must be considered a convincing alternative to public procurement only if it can deliver value for money (Treasury, 2006, p. 7) “where value for money is the optimum combination of whole life cost and quality (or fitness for purpose) to meet the user's requirement”. A wide spectrum of PPP models has emerged according to Quium (2011). These types of PPP agreements vary mainly by ownership of underlying assets, investment responsibility, responsibilities for risks, and duration of contract (concession period). One of the most common of PPP arrangements is the Build Own Operate Transfer (BOOT) arrangements, sometimes pure and sometimes with extra characteristics depending on the case at hands. In BOOT, a company that finances an infrastructure project as an additional project of its existing business may make use of corporate finance to provide cash, credit lines, or even new equity capital to pay for the project (Brealey, 2012). In a project finance structure, a project company (delivery vehicle), unlike a corporate borrower, does not have any past business record that can support lenders for their loaning decision. Therefore, lenders only rely on the project cash flows as an only source for debt repayment (Esty, 2004). Unlike corporate finance, a project finance transaction witnesses the active role of lenders not only in the financial arrangement but also in the planning and execution of the project (Merna and Njiru, 2002). Before loaning money, lenders and banks usually check the projects to ensure the project will be completed on time and on budget, will operate as designated, and will generate the forecast revenue (Chiara, 2006). The project's profitability depends on the project capacity to serve the debt and generate the expected equity rate of return. Therefore, any risk that endangers the project's profitability must be assessed and eventually mitigated (Hoffman, 2007). The aim of risk analysis is to quantify and mitigate the project finance risks. Project finance risk can be divided into three categories: which are commercial, macroeconomic, and political (Yescombe, 2002).

Risk analysis is at the core of project finance because only the full control and management of the risks can lead to the successful realization of the project (Yescombe, 2002). While risk analysis of project finance covers a wide spectrum of risks, the objective of this research is limited to addressing a specific risk in the commercial risk category, i.e., the revenue risk. A typical project finance risk analysis includes a base case NPV analysis and sensitivity analysis (Chiara, 2006). If a more sophisticated risk analysis is required, then a stochastic approach is employed by treating some or all the significant parameters as risk variables.

Zhang et al. (2014) introduced a multi-criteria model for quantifying the effect of individual infrastructure projects on urban-rural balance (e-UR) by focusing on two attributes, efficiency, and equity. The developed model helps evaluate the contribution of the projects to improving rural-urban balance and therefore enable government decision-makers to prioritize future projects also in terms of their likely contribution. Nagayama and Kashiwagi (2007) laid out measures to consider for electricity sector reforms in developing countries considering three aspects: (1) transition of ownership to private enterprises; (2) development of conditions to promote infrastructure projects; and (3) development of conditions for the establishment of an effective and fair competitive environment. Ke et al. (2010b) identified the preferred risk allocation in PPP projects of mainland China and the Hong Kong Special Administrative Region and compared these preferences to those in the UK and Greece by a questionnaire survey based on the same risk register. Attarzadeh et al. (2012) developed a generalized model for analyzing life-cycle financial modeling of PPP BOT projects, which provides more level of details than the common project specific models. The developed model incorporates various performance measures and risk factors. Special review efforts were focused on a general approach performing risk analysis in infrastructure project finance transactions as presented by the Economic Development Institute of the World Bank (Dailami et al., 1999). This approach suggests that any risk variable in an infrastructure project can be represented through the discrete-time stochastic process. Shrestha et al. (2017) identified three parameters (competition, monitoring, and incentives) for transferring risks in a principal-agent relationship. The considered three parameters were applied to PPP wastewater projects. Many research efforts investigated the financial risks of PPP infrastructure projects using flexible approaches that depend on Monte Carlo simulation such as, Chiara et al. (2007), Carbonara et al. (2014b), and Carbonara and Pellegrino (2018b).

Many of the mentioned efforts were directed towards financial risks evaluation and mitigation strategies of PPP infrastructure project. This research aims to contribute to such efforts, specifically in the area of revenue risk evaluation of PPP wastewater treatment plants, using real-options theory.