

# Optimal Capital Structure of PPP Projects: A Review of the Literature

Hu Xiang\*, Eliza Nor, & Chee-Wooi Hooy

*School of Management, University Sains Malaysia, Malaysia.*

*\*Email: [xiang@usm.my](mailto:xiang@usm.my)*

## Abstract

*Public-private-partnership mode helps to better solve the problems in financing, technology, and management of public goods by effectively utilizing the respective advantages of government and private sector. There are myriad researches on risk-sharing, benefit distribution, asset securitization, and capital structure of PPP projects these days. In this paper, we provide analysis and discussion for the research methods of selected literature which applied the most used method for measuring the optimal capital structure of public-private-partnership projects. By analyzing these studies, we can identify the potential problems of present research methods, and we can also provide research suggestions for future researchers to promote and enhance their research methods of optimal capital structure of public-private-partnership projects and make the methods more practicable and reality-adaptive.*

*Keywords: Public-private-partnership; Optimal capital structure; Measurement method; Literature review; Future research.*

*JEL Classification: H43; H54; H63*

## 1. Introduction

According to the United Nations Development Programme (1998), public-private-partnership (PPP) is a cooperative mechanism between the government and the private sector to finance, build and manage infrastructure facilities such as energy plants, ports, transportation systems and telecommunication systems. PPP model allows the government and private sector to share the benefits and risks of an infrastructure project, and the cooperation also enables government and private sectors to give full play to their respective advantages to improve project efficiency and achieve the best value for capital (World Bank, 2011).

The PPP model has been widely adopted in countries because it helps effectively relieve the financial pressure of government (World Bank, 2012). Compared with the traditional funding model, the PPP model has unique advantages to benefit the government such as leveraging private capital and spreading risk. However, the PPP model also has the problems such as higher financing costs and more interest conflicts due to the involvement of more stakeholders at some point. Since the capital structure is a reflection of the interests and obligations of each stakeholder of a project, a PPP-mode project requires a higher level of management skill on the capital structure to ensure the success of the project. A good capital structure can reduce the cost of capital and improve the efficiency of project construction, financing and operation, and this paper provides a comprehensive discussion on literature review (from both theoretical and empirical studies) of optimization of capital structure of PPP projects.

## **2. Theoretical Literature Review**

This sector introduces the public goods theory, contestable market theory and capital structure theory --- the theoretical basis for the optimization of PPP project capital structure.

### **2.1 Public goods theory**

Social goods can be simply divided into public goods and private goods as claimed by public goods theory (Samuelson, 1954). It is commonly believed that public goods are insufficiently profitable and not attractive to private capital. Therefore, public goods can only be invested, built, and managed by the government in order to meet public demand (Oakland, 1987). Emergency of the PPP model provides the chance for the government and private sector to work together on investing, building, and managing public goods, PPP model is usually applied in infrastructure projects with the goal of maximizing the benefits of all stakeholders (World Bank, 2012). Taking the highway construction project as an example, the government grants the concession to the private investor which invested in the construction project to charge for facility use of public during the concession period, the private party will transfer the ownership of the project to the government after the concession expires. Both government and private sector can obtain eligible benefits through the PPP project.

### **2.2 Contestable market theory**

Economists Baumol et al. (1982) have proposed the contestable market theory and argued that even in a monopolistic market, new entrants can bring competitive pressure to the existing firms thus stimulating the whole market to improve the efficiency of management and production. Contestable market theory can be applied to the PPP model as the government should create a competitive market and let the market play its role of resource allocation and fair competition so that the efficiency of resource usage can be improved and long-term economic growth can be achieved. From this perspective, a competitive market can replace the management of government to some extent, government should establish an effective competitive mechanism for PPP project solicitations in terms of competitive theory so as to improve the economic, managerial, and productive efficiency of PPP projects through competitions.

### **2.3 Capital structure theory**

Capital structure is the consequence of financing decisions of a firm. There are many different definitions of capital structure, but the most used definition of capital structure is the relationship between total liabilities and owner's equity. The capital structure of PPP projects explained in this study can be represented as the composition of the equity fund, debt size, etc. Capital structure has undergone substantial researches since its introduction in 1952, many theories such as MM theory (Modigliani and Miller, 1958), modified MM theory (Modigliani and Miller, 1963), trade-off theory (Kraus and Litzenberger, 1973), pecking order theory (Frank and Goyal, 2011) have been developed. The present-day researches on capital structure are focusing on two aspects --- "influencing factors" and

“optimal capital structure”. This paper introduces the researches on the optimal capital structure of PPP projects. The consensus of most researches is that every capital structure has optimal point, but in practice, the optimal capital structure is difficult to achieve and the capital structure is more often adjusted to an acceptable level which is near the optimal level instead of the optimal level. The objective of optimizing capital structure is normally to maximize the market value of a firm or a project, and the optimization method is usually to calculate the minimum cost of capital or the maximum return on equity capital, etc.

## **2.4 Principal-agent theory**

The principal-agent theory was first proposed by Jensen and Meckling in the 1970s (Jensen and Meckling, 1976), the principal-agent theory states that the ownership (principal) and control (agent) of an asset should be separated to avoid interest conflicts between two parties and achieve maximum operational efficiency and asset value. In the 1960s and 1980s, economists such as Ross (1973), Mirrless (1975), Holmstrom (1979), and Grossman and Hart (1983) had continued research on principal-agent problem by considering the issues such as information asymmetry and economic incentive. Liu and Jiang (2006) pointed out that the principal-agent theory is an extension of the agency theory and follows the same logic: The principal hires an agent to act on behalf of the principal, however, the agent (has more information) may not always act in the principal's best interest when activities which are costly to the agent due to the existing of information asymmetry. Therefore, the principal must establish an effective mechanism (contract) to regulate, restrain, and motivate the agent's behavior so as to solve the agency problem. In a PPP project, a principal-agent problem may exist because numerous stakeholders are involved in the project such as shareholders, project managers, project suppliers, etc. How to construct a reasonable equity structure of a PPP project to reduce the cost of the principal-agent problems and achieve the best interests of all parties is an important issue to be addressed.

## **3. Empirical Literature Review**

### **3.1 Using net present value (NPV) and internal rate of return (IRR) to measure the optimal capital structure of PPP projects**

Optimizing the capital structure is important in improving the operational efficiency of a PPP project. Most of the existing methods used for calculating the optimal capital structure of a PPP project involve the net present value (NPV), internal rate of return (IRR), and return on equity (ROE) of the project. Using the discounted cash flow (DCF) to forecast the future cash flows of a project, and then appraise the proportional reasonableness of various capitals by evaluating their NPV and IRR. Dias and Ioannou (1995) firstly determined the optimal debt ratio of a PPP project by setting an objective function to maximize the return on equity (ROE) of the PPP project. Ye et al. (2000) pointed out that the NPV forecasting of PPP projects should take the project features and project risks into account, they thus proposed the NPV-at-risk evaluation method, which combines the weighted average cost of capital (WACC) and Expectancy Method to estimate the profitability of a PPP project from the investor perspective. Bakatjan et al. (2003) considered that a reasonable debt-to-equity ratio

is the key to a successful PPP project, they used NPV, IRR, and debt-service coverage ratio (DSCR) to build a linear programming model of optimal capital structure of PPP projects from the perspective of equity holder. The optimum share of private ownership (optimal capital structure) of PPP projects based on the assumption of "lower costs than in sole private investments and lower capital cost of the government" can be useful for evaluation. This formula is shown as below:

$$P(x, q) = \frac{f(q)}{x} + p(x, q)$$

$P(x, q)$  is the demand function for a given quality of service  $q$ , where  $f(q)$  denotes the fixed costs and  $p(x, q)$  denotes the variable costs. However, this method maybe not extensively applicable owing to its assumption that government has the share of ownership of the PPP projects because most governments are supporting the PPP projects with financial assistance or concessional loans rather than purchasing shares.

NPV and IRR are the basic indicators for evaluating the investment income of a project. However, PPP projects are characterized by long production and recovery period with increased uncertainties during the period. The estimation of a project's investment value based solely on the DCF method (NPV and IRR) may underestimate the value of a project when the current economic environment is not optimistic, some valuable projects may be rejected in this case (Hodder and Riggs, 1985).

### **3.2 Using Monte Carlo simulation to measure the optimal capital structure of PPP projects**

The financial parameters of a project are fixed values, it may inappropriate to use these financial parameters and make a deterministic evaluation concerning a PPP project with a long-term concession period, the market risk, operational risk, financial risk, political risk, and other risks may occur during the period. Monte Carlo simulation can help to estimate scenarios with considerations of different potential risks and find the best capital structure of a PPP project. Songer et al. (1997) considered that Monte Carlo risk modeling provides more betterments to traditional investment studies of infrastructure projects, the betterments include probability distributions, correlations, sensitivity analysis, and external variables. Yun et al. (2009) simulated the risk factors of PPP projects using the Monte Carlo technique, they used a multi-objective optimization approach to construct an optimal capital structure model of PPP projects from the perspective of balancing the interests of lenders and special purpose companies (SPC). Du et al. (2013) used Monte Carlo simulation to draw the optimal capital structure of urban metro PPP projects with the objective function of minimizing the financial risks of key stakeholders.

### **3.3 Using option pricing model to measure the optimal capital structure of PPP projects**

It is impossible to obtain such detailed data in practice, and too many assumptions can make the research method difficult to exercise and make the research results less reliable. Chiara, Garvin, and Vecer (2007) used the Bermuda option pricing model (can be exercised one time

on given dates before expiration date) and the Australian option pricing model (which can be exercised multiple times on given dates before the expiration date) to estimate the value of PPP projects, which enable the project value can be calculated on the agreement dates. Also, they further used the multi-least-squares Monte Carlo technique to determine the fair value of this variety of real option. By using the real option model, Wang et al. (2019) investigated the optimal capital structure of the private sector under the circumstances of allowing capital restructuring and not allowing capital restructuring, respectively.

However, problems are existing in using real options to evaluate PPP projects. First, the assumptions are too strict to adapt the occasional events during the concession period (Fama and French, 2006). Second, the project statistics are difficult to obtain, simply using data from similar projects does not provide accurate evaluation result for present project. However, the real options method brings a new point of view to evaluate PPP projects, the method also solves the problem of insufficient data by using public industry data from the financial market, therefore, it may help researchers to turn eyes to the entire industry rather than a sole project.

### **3.4 Using capital asset pricing model (CAPM) to measure the optimal capital structure of PPP projects**

The CAPM can be used to describe the relationship between project risk and project expected return, so researchers applied it in forecasting the asset value of a project. Wibowo (2005) used the capital asset pricing model (CAPM) and the arbitrage pricing theory (APT) to value government-backed PPP projects instead of using the traditional DCF method. Dias and Ioannou (1995) tested the relationship between debt capacity and optimum financial structure for PPP projects based on the capital asset pricing model (CAPM). They found that the maximum NPV or ROE of a PPP project can only be reached when the project has debt less than its debt capacity. A project's NPV and ROE decline rapidly when the project's debt is in an attempt to reach the debt capacity level.

In using CAPM to derive the optimal capital structure of a PPP project, the NPV and ROE for a given project have to be calculated first, and then set ROE as the objective function to calculate the optimal proportion of debt and equity in the project capital structure. The equity value, debt value, and bankruptcy costs can be fully considered in this research method.

### **3.5 Using other methods to measure the optimal capital structure of PPP projects**

Akintoye (2003), Zhang (2004a; 2004b; 2005; 2006), and many other researchers have studied and proposed the best value approach, for example, Best-Value Source Selection (BVSS) method. The Best Value approach works by statistically analyzing a PPP project's life span, cost, design, operation, maintenance, management, safety, environmental impact, etc. based on a questionnaire survey of worldwide expert opinions, Best Value approach seeks to maximize the output of a PPP project. However, too many subjective weighted factors in evaluating a PPP project create restrictions in using the best value approach (Zhang, 2004b). The research results of Zhang (2004b) showed that for PPP projects, 59% of the respondents thought that the appropriate equity-to-debt ratio should be in the range of 20:80-35:65 and 46% of the respondents thought that the appropriate equity-to-debt ratio should be 30:70. There are some respondents who considered that the appropriate equity-to-debt of every PPP project is different and determined by respective conditions, and it can even be 0:100 for

low-risk projects, for instance, the Severn Bridge in the UK. The equity ratio should increase along with the risk level.

Chang et al (2001) proposed a financial evaluation model based on the scenario analysis, the model can obtain indicators such as the net cash flow, net asset value, and distributed dividends of a project through inputting different sets of risk variables, so it can help to estimate the solvency and profitability of a project from the public and private sector perspectives, respectively. This model provides a research method for the public sector and private sector respectively to judge the financial feasibility of a project. Farajian and Cui (2011) proposed the multi-objective decision support system (MODSS) from two objectives -- maximizing project benefits and social benefits, MODSS calculates the utility function based on different interests of manifold stakeholders, for example, ROE of private investors, regional economic benefits and national long term benefits. Farajian and Cui used MODSS to make financing decisions and form the capital structure for five imaginary PPP projects.

Zhao et al. (2017) analyzed the optimal capital structure of PPP projects based on the fuzzy analytic hierarchy process (FAHP). FAHP can be used to help to make decisions in an uncertain and multiple-criteria environment. Sun and Li (2016) regarded used the game theory to study the optimal equity share of government and the public in the process of building and operating a new highway. Feng et al. (2017) constructed an equity allocation model which seeks the lowest social cost of the PPP projects with considering the interests of lenders, the private sector and the public sector. Chen (2018) regarded cost savings generated by the PPP model as the contribution to a project, he used Shapley value to determine the equity ratio of PPP projects. Shapley value is a solution concept in game theory, the working principle of Shapley value is to set functions of distributing gains and costs to stakeholders fairly.

#### **4. Future Prospects**

Summarizing the aforementioned researches, there are plentiful researches on the optimal capital structure of PPP projects, many researchers tried different research methods to calculate the optimal capital structure of PPP projects. However, there are still improvements that can be made in future research, for example:

- (1) The related research can shift from focusing on the pre-project stage to the post-project stage. Most of the existing studies have concentrated on assessing the rationality of capital structure of PPP projects at the pre-project stage from the perspective of project sponsors, the researches on capital structure adjustment at different stages of a project are very rare. Therefore, future research can put more focus on refinancing and capital structure adjustment at later stages of PPP projects.
- (2) Regarding the research method, most of the existing researches set unilateral benefit-maximizing as the optimal point of project capital structure to build objective models, too many assumptions make the results less reality-adaptive. Therefore, future research on the optimal capital structure of PPP projects should build the optimal capital structure model with consideration of the interests of more stockholders, the future research should intent to provide an optimal capital structure model with a comprehensive look at the interest of all stakeholders.

## 5. Conclusions

Public-private-partnership (PPP) refers to an arrangement between the government and private sector for the intention of delivering a public good or service. Although the PPP model only emerged in the late 20th century, it is now widely used by governments as a funding model of public goods and services. However, the research related to the PPP model is still in an ongoing stage. In this paper, we provide a review of the current literature on the optimization of PPP projects' capital structures over the last 30 years. By doing so, we can analyze and discuss the research methods of past researches on capital structure optimization of PPP projects, so we can contribute suggestions to future researches in this field.

The current researches on the optimal capital structure of PPP projects are productive to some extent. Most of the studies mainly used discounted cash flow (DCF) [net present value (NPV) and internal rate of return (IRR)], Monte Carlo Simulation, option pricing model, and capital asset pricing model (CAPM) to calculate the optimal capital structure of PPP projects. There are also many researchers who tried different methods to determine the optimal capital structure of PPP projects. However, most of the existing researches only focus on maximizing the interest of one stakeholder in a PPP project, but there may be more than two stakeholders involved in a PPP project such as the government, lender, facility user, etc. So the optimal capital structure model may not be able to reflect the maximum value of the entire project if the model only considers the interest of one stakeholder. Therefore, future studies should contemplate the interest of more stakeholders of PPP projects in a model setting. In addition, the research on the optimal capital structure of PPP projects should also be extended to the later stage of the projects, for example, the optimal capital structure at the project's different stages (preparation, construction, operation, etc.), the capital structure adjustment and refinancing.

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