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Capital structure optimization for Infrastructure PPP Projects: A Literature Review Approach

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ABSTRACT

Purpose: Public-Private Partnership (PPP) has emerged as an innovative mechanism in infrastructure development offering a collaborative approach between the government and private sectors. The objective of this study is to review the literature on capital structure optimization that balances the interests of various stakeholders, including the government, private investors, and lenders to make the project sustainable in the long run.

Design/Methodology/Approach: The study critically reviewed the literature, specifically focusing on optimizing capital structure of infrastructure PPP projects to gain deep understanding of significance of capital structure, evolution of its theories, factors that determine the financing decisions and different approaches to optimize capital structure.

Findings: The study highlights two primary domains of research in existing literature: 1) factors that influence capital structure, encompassing project-specific elements (such as contract type, investment volume, and sponsor configuration) and macro-level country-specific parameters (including GDP growth, inflation, and regulatory stability); and 2) approaches for optimising capital structure, where optimization models range from static frameworks to more sophisticated and adaptive methods such as linear programming, Monte Carlo simulation, and multi-objective optimisation.

Originality/Value: The study extends the current literature by performing an extensive review and offering a comprehensive perspective on the factors and various approaches used to optimize the capital structure of infrastructure PPP projects.

Paper Type: Review of Literature

KEYWORDS: Optimal Capital Structure | Public Private Partnership | Infrastructure | Critical Factors

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Introduction

Infrastructure is defined as the physical framework that delivers services to meet the economic and social requirements of a community (Singhal et al., 2011). Infrastructure encompasses two main categories: economic infrastructure and social infrastructure. Economic infrastructure includes the physical structures that facilitate economic activities, such as transportation, energy, utilities, and telecommunications. In contrast, social infrastructure pertains to facilities that support healthcare and education (Singhal et al., 2011). Infrastructure is a critical determinant of a nation's economic development, as it increases productivity by offering essential facilities that facilitate trade and enhance living standards (Kumari & Kumar Sharma, 2017). The influence of infrastructure extends beyond economic progress; it also provides social advantages by mitigating inequality, alleviating poverty, and promoting rural development through improved access to education and employment opportunities (Agrawal, 2020). The significance of infrastructure is particularly pronounced in developing countries such as India, where infrastructure development plays important role in nation's progress and enhancing global competitiveness. A projection by the McKinsey Global Institute (2013) indicates that a 1/100th increase in infrastructure expenditure to Gross Domestic Product (GDP) results in generating 3.4 million jobs in India. Furthermore, literature provides evidence supporting a unidirectional causality from infrastructure development to the country's output growth (Do, 2023).

Infrastructure development and its financing are interdependent, as it is widely accepted that quality and robust infrastructure cannot be achieved without effective financial planning. However, the public sector often faces significant constraints in this area, which can impede progress and efficiency. These constraints can be financial, operational, or regulatory, and they necessitate innovative solutions to overcome them. One of the primary constraints faced by the public sector in infrastructure development is financial. Governments often struggle to fund large-scale infrastructure projects. In public-private partnerships (PPPs), where the public sector seeks to leverage private sector investment to overcome these financial constraints. The need for substantial capital investments and the high uncertainties associated with infrastructure projects further exacerbate these financial challenges (Feng et al., 2017). Additionally, the public sector's reliance on traditional funding mechanisms limit its flexibility in financing infrastructure projects (Dong et al., 2011). The public sector generally is more bureaucratic and less efficient than the private sector which can lead to delays and increased costs in project delivery. This inefficiency is one of the reasons why governments are increasingly turning to privatization and PPPs as the private sector is believed to be more operationally efficient and capable of making timely decisions for better resource allocation. Furthermore, the complexity of managing large infrastructure projects which often involve multiple stakeholders with differing interests adds to the operational challenges faced by the government (Zhang, 2005).

In conclusion, the government faces numerous constraints in infrastructure development including financial limitations, operational inefficiencies, and regulatory challenges. These constraints necessitate innovative approaches such as increased private sector involvement through PPPs, to enhance infrastructure development. Therefore, Public-Private Partnerships (PPPs) have emerged as a significant mechanism in infrastructure development offering a collaborative approach concerning the private and public parties. This model may serve as a solution to issues of infrastructure financing, efficiency, and innovation. The significance of PPPs in infrastructure development is to leverage private sector investment and expertise, thereby enhancing the quality and sustainability of public infrastructure projects.

Main advantage of PPPs in infrastructure development is to mobilize private capital which is crucial in contexts where public funding is insufficient. PPPs efficiently manage the distribution of risks and rewards between the private entities and public, which can lead to more efficient project delivery and management. For instance, in the USA, PPPs have already bridge funding gaps in transportation infrastructure, demonstrating their potential to attract private investment by offering a high rate 0f return or minimum internal rate 0f return (IRR) to private partners (Sharma et al., 2010). The dynamic nature of PPPs allows for adjustments in capital structures to address revenue uncertainties thereby, maintaining financial viability and project sustainability (Liu et al., 2020). However, effective PPPs require a well-defined capital structure that balances public and private interests, ensuring that both economic and non-economic benefits are considered (J. Du et al., 2018). A best capital structure poises the interests of various stakeholders, including the government, private investors, and lenders. The capital structure is important in determining the capital's cost and project's overall financial condition. A capital structure that is optimum reduces financing costs and improves the efficacy of project construction, financing, and operation (Hu et al., 2022).

Literature Review

Basic Concept of Capital structure

It refers to the composition of debt and equity sources of finance within corporate finance. This is a dynamic and intricate process that reflects both investor behaviour and corporate valuation (Myers, 1984). Capital structure has been the subject of extensive research since its introduction in 1952. Various theories have emerged, including *"Modigliani and Miller Theory (1958)"*, *"Modified Modigliani and Miller Theory (1963)"*, *"Trade-off theory (Kraus and Litzenberger, 1973)"*, and *"pecking order theory (Frank and Goyal, 2011)"*. However, more theories in context of capital structure merged thereafter also such as *"Agency Cost Theory", "Signaling Theory", "Corporate Control Theory"* and *"Industry Organization Model"*. Broadly we can divide the theories in three categories: Traditional Capital structure theories, Modern capital structure theories and New capital structure theories (J. Du et al., 2019).

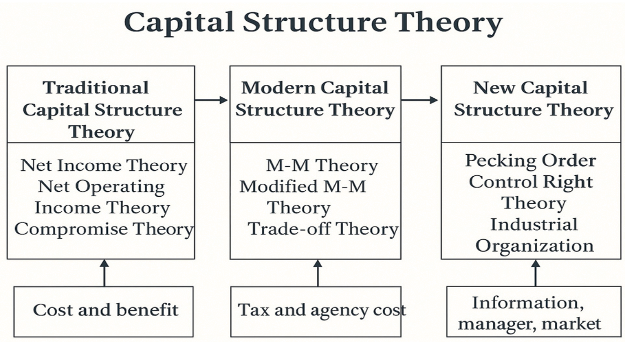

Figure 1: Evolution of Capital structure Theories
Source: As discussed by J. Du et al., (2019)

Figure 1 highlights a systematic classification of capital structure theories into three principal phases: Traditional, Modern, and New Capital structure theories, each representing the progressive comprehension of how firms establish their financing mix.

The Traditional theory highlights a cost-benefit analysis in financing decisions. The *"Net Income (NI) theory"* states that an increase in the share of debt within a firm's capital structure reduces the capital's cost attributed to the benefits accrued due to tax advantages associated with interest payments, thereby enhancing firm value. Conversely, *"Net Operating Income (NOI) theory"* presents a view that the value of a firm is unaffected by the financing decision with the cost of capital remaining constant irrespective of the debt-equity composition. The *"Compromise theory"* states integrating the advantages of debt, including tax shields with its increasing costs such as financial risk with the objective of minimizing WACC.

"Modern Capital structure" theory emphasizes rigorous assumptions and the implication of imperfections in financial analysis. *"Modigliani and Miller (M-M) theory"* asserts that under the supposition of perfect markets characterized by the absence of asymmetric information, tax, bankruptcy cost and financing structure decisions does not influence firm value. However, their Modified M-M theory states that the advantages (from tax) of debt contribute to a rise in firm value as a result of the interest tax shield associated with leverage. *"Trade-off theory"* states that firms seek an optimal capital structure by harmonizing the tax benefits of increased debt, compensating the escalating costs associated with financial distress and agency conflicts, acknowledging that excessive debt may result in suboptimal decision-making and risk-shifting behaviours.

"New Capital structure" theory broadens the framework by integrating real-world complexities including information asymmetry, managerial discretion, and market signalling. *"Pecking Order theory"* proposed by Myers and Majluf, says that a firm should choose internal source of finance over debt and resort to equity issuance only when necessary, owing to asymmetric information between managers and investors. This results in a financing hierarchy instead of an optimal structure. The Control Rights theory examines the impact of capital structure decisions on the retention of control within a firm highlighting that managers frequently refrain from external equity to prevent dilution of their control. The Industrial Organization theory synthesizes insights from market structure and competitive dynamics indicating that firms across various industries or competitive contexts may adopt distinct capital structures as a strategic response to external pressures.

This classification indicates the intellectual evolution in capital structure theory progressing from basic models centred on cost-benefit analysis to those that incorporate taxes and agency issues culminating in theories that account for strategic behaviour and information asymmetry.

However, the corporate capital structure is largely different from an infrastructure project's capital structure as project financing possesses distinct characteristics when compared with corporate financing. It demands creation of an independent project company utilizing a non-recourse or limited recourse debt financing framework. These characteristic turns project financing a risk-sharing activity for sponsors while imposing significant risks on lenders (Müllner, 2017). Therefore, it is essential to investigate the financing structure of the project to acquire a deeper comprehension of its financial performance.

Literature suggests that research on capital structure of infrastructure PPP projects emphasizes on two key aspects: influencing factors and optimum capital structure (Hu et al., 2022). The influencing factors for capital structure discusses those studies that are conducted to find out the factors that play important role in financing decisions. While an optimum capital structure reflects the study that developed a model to find best capital structure of PPP projects. A detailed discussion of these two aspects is presented in subsequent sections of this study.

Capital structure of Infrastructure PPP Projects - Factors Influencing Decision

A project or company's financing decision is affected by the various factors that influence how it finances its operations and growth through a combination of different financing sources (mainly equity and debt). Factors influencing decision of selecting capita1 structure refers to these various elements. This decision has an effect on the entity's operational efficiency as well as its financial stability. When it comes to Public-Private Partnership (PPP) projects, having a comprehensive understanding of these factors is important not only to maximise the effectiveness of financial strategies but also to guarantee the sustainability of the project.

The differentiation between project and country specific factors should be carefully considered while determining the capital structure. Project-specific factors include intrinsic characteristics such as investment, number of sponsors, and type of contract. These characteristics have a direct impact on the leverage ratio which is the share of total debt to total investment. In contrast, country-specific factors include the economic and financial environment of a country such as GDP, inflation, and market development. These factors have an indirect impact on capital structure because they influence risk and return profile of investments (Cai et al., 2019). The complexity of public-private partnership projects also makes it necessary to have a comprehensive understanding of both the internal and external factors involved. It is essential to incorporate internal factors such as the benefits, risks, and costs associated with the project. Additionally, external factors are support through government policies and the broader economic environment also play significant roles. Sources of funds available and their costs along with the risk taking abilities of lenders and investors influence on the capital structure (J. Du et al., 2018). Beyond these factors, the inherent unpredictability of project financing of Build-Operate-Transfer (BOT) projects further complicates selection of capital structure. A strategic financial planning is required in order to effectively manage the variability that is introduced by factors such as construction investment, operating costs, and market risks. In order to minimise risks and maximise financial outcomes this requires achieving a balance between equity and debt in capital structure of a project (Wang & Jin, 2019).

In addition to this, another essential component is the impact that sustainability has on the capital structure. When sustainability is considered during the decision-making process, economic, social, and environmental factors are incorporated. This helps to ensure that the capital structure not only satisfies the current funding requirements but also supports the long-term viability of the project. By taking this approach, the focus is shifted from purely economic factors to a more comprehensive evaluation that takes into consideration benefits, costs, and project conditions. This approach promotes life-cycle stability and positive societal impacts (J. Du et al., 2019). Collectively, these factors ensure that projects will be financially viable and sustainable throughout their entire lifecycle.

Approaches of Optimization

Public-Private Partnership (PPP) projects require the optimisation of the capital structure that is a difficult which harmonizes the diverse interests of various stakeholders. These stakeholders include the government, private investors, and lenders. Public-private partnership (PPP) projects typically involve upfront initial investments and lengthy recovery periods; therefore, it is crucial to minimise the cost and maximise the worth of project. There are different approaches to this challenge, each of which has its own methodology and areas of concentration.

Developing financial models that incorporate both theoretical and empirical research may be one method for optimising public-private partnership (PPP) projects. It is typically determined by these models through the utilisation of techniques such as discounted cash flow (DCF), net present value (NPV), and internal rate of return (IRR). By considering the risks involved, these methods intend to forecast future cash flows and evaluate the corresponding reasonableness of various capital components (Hu et al., 2022). The use of linear programming models, which have been shown to be effective in determining the optimal equity-debt mix for public-private partnership (PPP) schemes is yet another approach. Both equity holders and lenders have distinct points of view which are highlighted by these models that incorporates a variety of feasibility criteria and incorporate the role of the government (Chen et al., 2015).

In particular, as a response to the unpredictability of revenue during the operation of public-private partnership projects, dynamic capital structure optimisation is another significant area of research. It is suggested by this approach that capital structures ought to be flexible enough to accommodate alterations in project operations rather than decided at preparation stage of project. When dealing with the disparity between the anticipated and actual revenue, Monte Carlo simulation is frequently utilised in this context. This allows for dynamic adjustments with changing projects conditions (Liu et al., 2020). Furthermore, multi-objective programming models have been utilised in order to generate an optimal capital structure considering several factors, criteria, and constraints (J. Du et al., 2019). These models are designed to balance goals of stakeholders, such as maximising the benefits of private investment while simultaneously protecting the interests of the public.

The specific financial instruments and the impact they have on capital structure have been the subject of some studies specifically. In the context of project financing, for example, game models have been utilised to investigate the utilisation of external equity and the participation of external investors for drafting effective incentive contracts (J. C. Du et al., 2013). In addition, the sustainability perspective has been incorporated into the optimisation which also places an emphasis on the significance of life-cycle stable operations and the accomplishment of economic, social, and environmental benefits. When it comes to selecting the capital structure from a sustainability point of view, this method makes use of multi-objective programming and discounted cash-flow models (J. Du et al., 2019).

The optimisation of public-private partnership (PPP) projects financing structure requires a number of different approaches, each of which addresses a different aspect of financial management and the interests of stakeholders. Strategies that are focused on sustainability and dynamic adjustments are two examples of these methods. Traditional financial modelling and linear programming are also included in this category.

Conclusion

The review of literature looks at both the theoretical and practical sides of capital structure in the context of infrastructure projects. The study first talked about a thorough look at how capital structure theories have changed over time, showing a clear intellectual progression. It moves from older theories, like the Net Income and Net Operating Income approaches that focus on static cost-benefit trade-offs, to newer theories, like Modigliani and Miller's ideas and the Trade-off Theory. Eventually, this led to new capital theories like the Pecking Order and Control Rights theories, which deal with real-world problems like information asymmetry and strategic control. Theories from corporate finance provide a basic way to look at how to structure capital in big infrastructure projects.

PPP project financing is very different from corporate finance because it only looks at particular project. Public-private partnership (PPP) projects are different from corporate financing because they usually require the creation of a special purpose vehicle (SPV) that is funded through non-recourse or limited recourse debt. Because of this difference, lenders can share risks in a certain way in which they rely on the project's cash flows instead of the sponsor's balance sheet.

This study finds two main areas in the literature: 1) factors that affect capital structure, which include project-specific factors (like the type of contract, the amount of investment, and the sponsor configuration) and macro-level country-specific factors (like GDP growth, inflation, and regulatory stability); and 2) approaches to an optimum capital structure, which can be done with models that range from simple frameworks to more complex and flexible methods like linear programming, Monte Carlo simulation, and multi-objective optimisation. The optimisation models try to find the best way to lower financing costs while raising project value and managing risk at the same time.

The literature shows that it is becoming more and more important to include economic, social, and environmental sustainability principles in decisions about capital structure. Recent models that take into account life-cycle costs and externalities to make sure that businesses are profitable in the short term, viable in the long term, and have a positive effect on society. Aligning capital structures with sustainability goals makes stakeholders more satisfied and lowers risk exposure for the whole project, according to literature.

In conclusion, even though a lot of progress has been made in understanding and modelling capital structure in public-private partnerships, the field still needs strong, adaptable frameworks that involve many stakeholders.

Future Scope

One important area for future research on how to improve the capital structure of infrastructure PPP projects is considering the needs of many different stakeholders. Modern research often focusses on maximising benefits for one stakeholder, usually the equity holder. This can mean that the needs of other parties, such as the government, lenders, and facility users, are not considered. Future research should focus on making models that incorporate the different interests of all stakeholders in order to create a completer and more realistic optimisation framework. Future research could also look more into how capital structures change dynamically in response to changes in the economy and the environment. Future research could look into how to combine different optimisation methods to create models that are more complete and able to handle the problems that come up in public-private partnerships (PPPs) as they change.

In conclusion, we have made a lot of progress in understanding the best capital structure for infrastructure PPP projects, but there is still a lot of room for more research. Focussing on the interests of multiple stakeholders, making changes on the fly, and using new optimisation methods can make models stronger and more flexible in future studies. These improvements could make PPP projects work better and be more successful, making sure they meet the changing needs of both public and private stakeholders.

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Annexure 17.1.3

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Reviewers Memorandum

Reviewer's Comment 1: The paper presents a comprehensive review of the literature on capital structure optimization, effectively addressing the complex balance of interests among government stakeholders, private investors, and lenders to ensure long-term project sustainability. The authors have undertaken an in-depth and methodical analysis of the factors influencing corporate financing decisions, as well as the approaches to optimization, which enhances the intellectual rigor and practical relevance of the study. However, the conclusion section could be strengthened by offering a more explicit discussion of the broader implications of the findings. Specifically, the authors should clarify how their results advance the existing body of knowledge on capital structure theory and practice. Additionally, a reflection on the potential impact of the research on future studies, financial policymaking, or corporate strategic planning would provide valuable insight and amplify the study's significance.

Reviewer's Comment 2: This study makes a valuable contribution by offering a comprehensive review of capital structure optimization in infrastructure PPP projects. It effectively identifies a range of influencing factors, including project-specific variables such as contract type, investment size, and sponsor configuration, as well as macro-level country-specific factors like GDP growth, inflation, and regulatory stability. These determinants play a critical role in shaping financing decisions and risk-sharing arrangements in PPPs. The paper also outlines various optimization approaches, from simple analytical frameworks to more advanced methods such as linear programming, Monte Carlo simulation, and multi-objective optimization—each aimed at minimizing financing costs, maximizing project value, and managing risk. While the discussion is robust, the paper would benefit from a more structured synthesis of these factors and methods to enhance clarity and practical applicability for both researchers and policymakers.

Reviewer's Comment 3: The conclusion effectively highlights the progress made in understanding capital structure in infrastructure PPP projects and points to areas for further exploration, such as stakeholder integration, adaptability, and advanced optimization techniques. However, it could be improved by providing more precise and actionable insights. Specifically, the authors should clearly identify key research gaps, propose specific future methodologies, and discuss practical implications for policymakers and practitioners. Additionally, linking the findings more directly to the broader theoretical context would strengthen the paper's academic relevance. A more focused and forward-looking conclusion would enhance the overall impact and utility of the study.

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Editorial Excerpt

The article has 04% of plagiarism which is the accepted percentage as per the norms and standards of the journal for publication. As per the editorial board's observations and blind reviewers' remarks the paper had some minor revisions which were communicated on a timely basis to the authors (Nikhil and Ravi Sankar), and accordingly, all the corrections had been incorporated as and when directed and required to do so. The comments related to this manuscript are noticeably related to the theme "Capital structure optimization for Infrastructure PPP Projects: A Literature Review Approach" both subject-wise and research-wise. This manuscript presents a well-executed and relevant review that explore intellectual and thematic evolution of digital marketing strategies in the hotel industry. The authors successfully bridge fragmented literature across hospitality, marketing, and information systems, which is both innovative and necessary in today's market-driven environment. After comprehensive reviews and the editorial board's remarks, the manuscript has been categorized and decided to publish under the "Review of literature" category.

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The acknowledgment section is an essential part of all academic research papers. It provides appropriate recognition to all contributors for their hard work and effort taken while writing a paper. The data presented and analyzed in this paper by (Nikhil and Ravi Sankar) were collected first handily and wherever it has been taken the proper acknowledgment and endorsement depicts. The authors are highly indebted to others who facilitated accomplishing the research. Last but not least, endorse all reviewers and editors of GJEIS in publishing in the present issue.

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