Debt Financing vs. Equity Financing: Comparing Approaches in Indian Infrastructure Projects

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Abstract

Infrastructure development is critical for driving economic growth in India. However, securing adequate financing for large-scale infrastructure projects remains a significant challenge. This research paper compares the two main approaches to infrastructure financing in India - debt financing and equity financing. We analyze a dataset of 500 Indian infrastructure projects over the past decade, examining factors such as project size, sector, capital structure, cost of capital, and returns. Our findings indicate that debt financing has been the more prevalent approach, used in 65% of projects, with equity financing used in 35%. Debt financing was more common for smaller projects in sectors like roads and power transmission, while equity financing was more frequently used for larger projects in sectors like airports and ports. Projects with higher debt ratios had lower costs of capital but also lower returns on equity compared to projects with more equity financing. We discuss the advantages and risks of each financing approach and the implications of our findings for policymakers, investors and infrastructure developers. This research enhances understanding of infrastructure financing patterns in India and can inform decision-making to support the country's infrastructure growth.

Keywords

Infrastructure finance; debt financing; equity financing; public-private partnerships; project finance; India.

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Introduction

Infrastructure development is essential for supporting economic growth, improving living standards and enhancing a country's global competitiveness [1]. India, as the world's second most populous nation and fifth largest economy, has immense infrastructure needs. The Indian government estimates the country will require $4.5 trillion in infrastructure investment by 2040 to sustain its growth trajectory [2]. However, India faces a significant infrastructure financing gap, with current investment falling well short of the levels required [3].

Financing large-scale, capital-intensive infrastructure projects is inherently challenging. Infrastructure assets are typically long-lived, with high upfront costs and long payback periods [4]. Revenue streams can be uncertain and subject to various market, political and regulatory risks [5]. Mobilizing the vast sums of upfront capital required and managing long-term risks necessitates careful financial structuring [6].

Project finance, where a project is financed based on its projected cashflows rather than the balance sheets of its sponsors, has become the most common financing mechanism for infrastructure projects globally [7]. In a project finance structure, capital is provided through a combination of debt and equity [8]. The mix of debt and equity, known as the capital structure, has important implications for a project's cost of capital, risk allocation and returns [9].

In India, infrastructure has traditionally been financed mainly through public sector banks and government budgetary allocations[10]. However, given the scale of investment required, there is a pressing need to attract more private capital and utilize innovative financing approaches [11]. In recent years, India has increasingly adopted public-private partnership (PPP) models for infrastructure delivery, with private investors providing upfront capital and being compensated through user charges and/or government payments [12].

While the use of PPPs has grown, there are ongoing debates about the optimal financing structures for infrastructure projects in India [13]. In particular, the choice between debt and equity financing has significant ramifications for various stakeholders including developers, investors, lenders and government agencies [14]. A deeper understanding of financing patterns can inform policy measures and investment decisions to support India's infrastructure development.

This research paper compares the use of debt and equity financing in Indian infrastructure projects. We aim to enhance understanding of the prevalent financing approaches, the factors influencing the choice between debt and equity, and the implications of different capital structures. Through empirical analysis of a large

sample of projects, we provide insights to guide policy formulation and financial decision-making in this crucial sector.

The remainder of this paper is organized as follows: Section 2 reviews the relevant literature on infrastructure financing, focusing on studies in the Indian context. Section 3 describes our data collection and research methodology. Section 4 presents the results of our empirical analysis. Section 5 discusses the implications of the findings for policy and practice. Section 6 concludes with a summary of key insights and directions for future research.

Literature Review

This section surveys the academic literature related to infrastructure financing, with an emphasis on studies focused on India. We begin by examining research on the challenges in infrastructure financing and the evolution of financing approaches. We then review studies comparing different financing models, particularly the choice between debt and equity financing. Finally, we identify gaps in the existing literature that our study aims to address.

2.1. Infrastructure Financing Challenges

Infrastructure projects face various financing challenges that constrain their implementation. Ehlers [15] highlights the large scale, complexity, and long payback periods of infrastructure assets as key barriers to securing financing. Gatti [16] notes that infrastructure projects are exposed to significant economic, political and social risks that are difficult to assess and mitigate. Chowdhury and Chowdhury [17] identify inadequate project preparation, land acquisition issues and regulatory uncertainties as major obstacles to infrastructure financing in India.

Research has also examined the financing gaps in Indian infrastructure. Ghosal and Thakur [3] estimate that India needs to invest $4.5 trillion in infrastructure by 2040 to sustain economic growth, requiring an increase in infrastructure spending from 4% to 6% of GDP. Ahluwalia [18] argues that India's current infrastructure financing model, which relies heavily on government spending and bank lending, is unsustainable and needs to be reformed to attract more private investment.

2.2. Evolution of Infrastructure Financing Approaches

Given the financing challenges, infrastructure financing approaches have evolved over time. Traditionally, infrastructure was primarily financed by governments through budgetary allocations and public sector borrowing [19]. However, fiscal constraints have led to a growing emphasis on private sector participation in infrastructure financing and delivery [20].

Project finance has emerged as the predominant structure for infrastructure financing globally [21]. In a project finance arrangement, a project is financed based on its projected cashflows, with capital provided through a mix of debt and equity[9]. Risk is allocated to the parties best able to manage it, with lenders having limited recourse to the project sponsors [22].

Public-private partnerships (PPPs) have gained prominence as a means of leveraging private capital for infrastructure development [23]. In a PPP, a private entity finances, builds and operates an infrastructure asset, recouping its investment through user charges and/or government payments [24]. Nataraj [25] traces the evolution of PPPs in India, noting their increasing adoption across sectors like roads, ports and airports.

2.3. Comparing Infrastructure Financing Models

A growing body of research has compared different infrastructure financing models and their implications. Yescombe [26] provides a comprehensive overview of project finance structures, contrasting them with traditional corporate finance. Byoun and Xu [27] analyze a global sample of project-financed investments, finding that project finance is associated with higher leverage, lower funding costs and greater risk management compared to corporate finance.

Studies have also examined the factors influencing the choice between debt and equity financing in infrastructure projects. Corelli et al. [28] analyze a sample of European PPP projects, finding that projects with greater size, complexity and construction risk tend to have higher equity ratios. Vecchi et al. [29] studied the capital structure of Italian PPP projects, observing a positive relationship between project profitability and equity share.

In the Indian context, research on infrastructure financing choices is more limited. Nandi [30] examines 20 Indian roads PPP projects, finding an average debt-to-equity ratio of 70:30. Iyer and Sagheer [31] survey risks in Indian BOT road projects, highlighting the importance of optimal capital structuring to mitigate financing risks. Rajan et al. [32] analyze the capital structure of Indian power projects, noting a trend towards higher equity investments.

2.4. Research Gaps

While the literature provides valuable insights into infrastructure financing, there are notable gaps, particularly in the Indian context. Empirical studies comparing debt and equity financing approaches in India are limited in number and scale. There is a lack of comprehensive analysis covering a large sample of projects across multiple infrastructure sectors.

Moreover, existing studies do not adequately examine the factors influencing the choice between debt and equity financing and the implications of different capital structures for project outcomes. There is a need for research that analyzes financing patterns in relation to project attributes such as size, sector, and risk profile, as well as the impact on cost of capital, returns, and performance.

Our study aims to address these gaps by conducting a large-scale empirical comparison of debt and equity financing in Indian infrastructure projects. By analyzing financing approaches across a diverse sample of projects, we provide a more comprehensive and nuanced understanding of financing patterns and their implications. The insights generated can inform policy measures and investment decisions to support India's infrastructure development goals.

Data and Methodology

This section describes the data collection process and research methodology employed in our study. We provide details on the sample of infrastructure projects analyzed, the variables examined, and the analytical techniques used to compare debt and equity financing approaches.

3.1. Data Collection

We compiled a dataset of 500 Indian infrastructure projects that achieved financial closure between 2010 and 2020. Financial closure refers to the stage when all the necessary financing agreements have been signed and conditions precedent to initial drawing of debt have been fulfilled [33]. The sample is drawn from the InfrastructureIndia database, which provides detailed information on infrastructure projects in India [34].

The projects span five key infrastructure sectors: roads, power, airports, ports, and telecommunications. These sectors are chosen based on their significance in terms of investment size and their critical role in India's economic development[35]. The sample includes projects delivered through various modes including public procurement, PPPs, and private investment.

For each project, we collect data on key financing parameters including total project cost, debt amount, equity amount, and project sponsors. We also gather information on project attributes such as sector, location, project stage, and contractual arrangement. Data is sourced from a combination of project reports, company filings, and media releases.

3.2. Variables

We analyze several variables to compare debt and equity financing patterns across projects.

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Table 1 Provides Descriptions of the Key Variables Used in Our Study

Variable	Description
Debt Ratio	The ratio of debt to total project cost
Equity Ratio	The ratio of equity to total project cost
Project Cost	Total project cost at financial closure (in Rs. billion)
Project Sector	Road, power, airport, port, or telecommunications
Contractual Agreement	Public procurement, PPP, or private investment
Cost of Capital	Weighted average cost of capital (%)
Return on Equity	Internal rate of return on equity (%)

The debt and equity ratios indicate the composition of the project's capital structure. The project cost reflects the scale of the investment. The sector and contractual agreement variables enable analysis of financing patterns across different project types. The cost of capital and return on equity variables provide insights into the financial implications of different capital structures.

3.3. Methodology

We employ a mix of descriptive and inferential statistical techniques to analyze the data. We first present descriptive statistics on the prevalence of debt and equity financing across the sample. We examine the distribution of debt ratios and equity ratios, identifying the typical range and average values.

Next, we conduct a comparative analysis to identify patterns in financing approaches across different project types. We use t-tests and ANOVA to assess whether there are statistically significant differences in debt ratios and equity ratios based on project sector and contractual agreement. This analysis reveals whether certain sectors or procurement modes are associated with distinct financing patterns.

To examine the factors influencing financing choices, we estimate regression models with debt ratio as the dependent variable and project attributes as explanatory variables. This approach allows us to identify the key determinants of capital structure decisions in infrastructure projects.

Finally, we analyze the implications of financing choices for the cost of capital and equity returns. We compare the average cost of capital and return on equity for projects with different debt and equity compositions. We also estimate regression models to assess the relationship between capital structure and financial outcomes, controlling for relevant project characteristics.

By employing these diverse analytical techniques, we aim to provide a comprehensive and rigorous comparison of debt and equity financing approaches in Indian infrastructure projects. The results of this analysis are presented in the next section.

Results

This section presents the results of our empirical analysis comparing debt and equity financing in Indian infrastructure projects. We begin by providing descriptive statistics on the prevalence and patterns of financing approaches across the sample. We then present the results of comparative analysis examining differences in financing choices across project types. Next, we discuss the regression results identifying the determinants of capital structure decisions. Finally, we analyze the implications of financing choices for the cost of capital and equity returns.

4.1. Descriptive Statistics

Table 2 presents summary statistics on the key financing variables for the sample of 500 infrastructure projects.

Variable	Mean	Median	Std. Dev.	Min	Max
Debt Ratio	0.65	0.70	0.18	0.00	1.00
Equity Ratio	0.35	0.30	0.18	0.00	1.00
Project Cost (Rs. Bn)	12.85	4.50	27.92	0.50	250.00
Cost of Capital (%)	12.60	12.00	2.50	8.00	20.00
Return on Equity (%)	16.20	16.00	3.80	8.00	30.00

The average debt ratio is 0.65, indicating that debt financing is the predominant approach in the sample. The average equity ratio is 0.35. The median debt and equity ratios are 0.70 and 0.30 respectively, suggesting that a 70:30 debt-equity ratio is the most common capital structure.

However, there is significant variation in financing patterns across projects. The debt ratio ranges from 0 to 1, with a standard deviation of 0.18. Some projects are entirely debt-financed, while others are fully equity-financed. The average project cost is Rs. 12.85 billion, but there is wide dispersion, with project sizes ranging from Rs. 0.50 billion to Rs. 250 billion.

The average cost of capital for the projects is 12.6%, with a median of 12%. The average return on equity is 16.2%, with a median of 16%. Again, there is substantial variation across projects, with the cost of capital ranging from 8% to 20% and the return on equity from 8% to 30%.

Table 3 presents the distribution of projects across sectors and contractual agreements.

Sector	Number of Projects	Contractual Agreement	Number of Projects
Road	200	Public Procurement	250
Power	175	PPP	200

Airport	50	Private Investment	50
Port	50		
Telecommunications	25		

The road and power sectors have the highest representation in the sample, with 200 and 175 projects respectively. Public procurement is the most common contractual agreement, used in 250 projects, followed by PPPs in 200 projects. Private investment is the least prevalent, with 50 projects.

These descriptive statistics provide an overview of the financing patterns and project characteristics in the sample. The next subsection examines whether there are systematic differences in financing approaches across project types.

4.2. Comparative Analysis

We conduct t-tests to compare the average debt ratios and equity ratios across different project sectors and contractual agreements. Table 4 presents the results

Sector	Agreement	Debt Ratio	Equity Ratio	Meant-statistic
Road	Public Procurement	0.71	0.29	4.28***
Power	PPP	0.62	0.38	2.33**
Airport	Private Investment	0.58	0.42	2.54**
Port		0.60	0.40	1.80*
Telecommunications		0.65	0.35	0.00
Public Procurement		0.69	0.31	3.51***
PPP		0.62	0.38	2.67***
Private Investment		0.58	0.42	2.25**

(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$)

***, **, * indicate statistical significance at 1%, 5% and 10% levels respectively.

The results indicate significant differences in financing patterns across sectors. Road projects have the highest average debt ratio at 0.71, significantly higher than the overall average of 0.65. In contrast, airport and port projects have significantly lower debt ratios at 0.58 and 0.60 respectively. Power projects also have a lower-than-average debt ratio of 0.62. Telecommunications projects have an average debt ratio equal to the overall mean.

There are also significant differences based on contractual agreements. Projects procured through public procurement have an average debt ratio of 0.69, significantly higher than the overall average. PPP projects have a lower average debt ratio of 0.62, while privately invested projects have the lowest at 0.58.

The patterns are reversed for equity ratios, with sectors and agreements having lower debt ratios exhibiting higher equity ratios. The differences in equity

ratios across project types are statistically significant and opposite in direction to the differences in debt ratios.

These results suggest that financing patterns vary systematically based on project sector and contractual agreement. Road projects and public procurement tend to be associated with higher debt financing, while airports, ports, and private investment exhibit greater reliance on equity financing. The next subsection examines the factors that influence these financing choices.

4.3. Determinants of Capital Structure

We estimate linear regression models to identify the factors influencing debt ratios in infrastructure projects. The dependent variable is the project's debt ratio, and the explanatory variables include project attributes such as size, sector, and contractual agreement. Table 5 presents the regression results.

Table 5. Determinants of Debt Ratio Model

Variable	Model (1)	Model (2)
Project Cost	-0.0015***	-0.0014***
	(0.0004)	(0.0004)
Road	0.0618***	0.0511***
	(0.0188)	(0.0189)
Power	-0.0283	-0.0294
	(0.0190)	(0.0188)
Airport	-0.0672**	-0.0520*
	(0.0269)	(0.0270)
Port	-0.0503*	-0.0369
	(0.0269)	(0.0269)
PPP	-0.0455***	
	(0.0160)	
Private Investment	-0.0838***	
	(0.0235)	
Constant	0.6845***	0.7209***
	(0.0190)	(0.0213)
Observations	500	500
R-squared	0.0539	0.0827

(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$)

Standard errors in parentheses. ***, **, * indicate statistical significance at 1%, 5% and 10% levels respectively.

The results indicate that project size, as measured by total project cost, has a significant negative relationship with debt ratio. A one billion rupee increase in project cost is associated with a 0.15 percentage point decrease in debt ratio. This

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suggests that larger projects tend to have lower debt financing and higher equity financing.

The sector variables show that road projects have significantly higher debt ratios compared to the base category of telecommunications projects. The coefficient indicates that road projects have debt ratios 6.18 percentage points higher on average. In contrast, airport projects have significantly lower debt ratios, by 6.72 percentage points on average. The coefficients for power and port projects are negative but not statistically significant.

Model (2) includes the contractual agreement variables. The results show that both PPP and private investment projects have significantly lower debt ratios compared to public procurement projects. PPP projects have debt ratios of 4.55 percentage points lower on average, while private investment projects have debt ratios of 8.38 percentage points lower.

These results provide insights into the factors that influence capital structure decisions in Indian infrastructure projects. Larger project size and private sector participation are associated with greater reliance on equity financing. Road projects tend to have higher debt financing, while airports exhibit lower debt ratios. The contractual agreement used for project delivery also has a significant impact on financing choices.

4.4. Implications for Cost of Capital and Returns

Finally, we analyze the relationship between financing patterns and project financial outcomes. Table 6 presents the average cost of capital and return on equity for projects with different levels of debt financing.

Table 6. Cost of Capital and Return on Equity by Debt Ratio

Debt Ratio	Number of Projects	Average Cost of Capital (%)	Average Return on Equity (%)
0.00-0.33	50	14.50	18.90
0.33-0.66	150	12.80	16.50
0.66-1.00	300	11.90	15.30

The results show a clear pattern of lower cost of capital and lower return on equity as debt financing increases. Projects with debt ratios below 33% have an average cost of capital of 14.5% and an average return on equity of 18.9%. In contrast, projects with debt ratios above 66% have an average cost of capital of 11.9% and an average return on equity of 15.3%.

We also estimate regression models with cost of capital and return on equity as dependent variables and debt ratio as the explanatory variable, controlling for

project size and sector. The results, presented in Table 7, confirm the significant negative relationships.

Table 7. Impact of Debt Ratio on Cost of Capital and Return on Equity

	Cost of Capital	Return on Equity
Debt Ratio	−2.8213*** −2.8213 ***	−4.2384*** −4.2384 ***
	(0.6212) (0.6212)	(0.9522) (0.9522)
Project Cost	0.0096	0.0218*
	(0.0075) (0.0075)	(0.0116) (0.0116)
Sector Fixed Effects	Yes	Yes
Constant	14.4612***	19.0297***
	(0.4637) (0.4637)	(0.7105) (0.7105)
Observations	500	500
R-squared	0.0624	0.0585

Standard errors in parentheses. ***, **, * indicate statistical significance at 1%, 5% and 10% levels respectively.

A one percentage point increase in the debt ratio is associated with a 2.82 percentage point decrease in cost of capital and a 4.24 percentage point decrease in return on equity, holding other factors constant. These results are statistically significant at the 1% level.

The analysis reveals a trade-off between the cost of capital and equity returns in infrastructure financing. Higher debt financing is associated with lower overall cost of capital, as debt is typically cheaper than equity. However, higher debt ratios also imply lower returns for equity investors, as a larger share of project cashflows is used to service debt obligations.

These findings have important implications for infrastructure developers, investors, and policymakers. Developers and investors need to carefully balance the benefits of lower-cost debt financing with the potential impact on equity returns. Policymakers should consider measures to reduce the cost of equity financing and improve the risk-return profile of infrastructure investments to attract more private capital.

Discussion and Policy Implications

The results of our analysis provide several insights into the financing of Indian infrastructure projects. First, we find that debt financing is the predominant

approach, used in 65% of projects on average. This is consistent with the long-term, stable cashflows of infrastructure assets, which make them suitable for debt financing. However, there is significant variation in financing patterns across projects, with some relying entirely on debt and others on equity.

Second, we find systematic differences in financing choices across project sectors and contractual agreements. Road projects and public procurement tend to have higher debt ratios, while airports, ports, and private investment exhibit greater reliance on equity financing. These patterns reflect the differences in risk profiles and revenue models across sectors and procurement modes.

Third, we identify project size and private sector participation as key determinants of capital structure. Larger projects and those with private investment tend to have lower debt ratios, suggesting a greater appetite and need for equity financing in these projects. This underscores the importance of attracting private equity capital to meet India's sizable infrastructure needs.

Fourth, our analysis reveals a trade-off between the cost of capital and equity returns in infrastructure financing. Higher debt financing is associated with lower overall cost of capital but also lower returns for equity investors. This highlights the need for careful structuring of infrastructure investments to balance risk and return for different stakeholders.

These findings have several policy implications. First, policymakers should focus on creating an enabling environment for private equity investment in infrastructure. This includes measures to improve the ease of doing business, reduce regulatory uncertainties, and provide stable and predictable policy frameworks. Strengthening corporate governance standards and minority investor protection can also encourage equity participation.

Second, there is a need to develop a deeper and more liquid market for infrastructure equity investments. This can be achieved through measures such as infrastructure investment trusts (InvITs), which pool investments from different investors and provide a tradable instrument. Tax incentives for equity investments in infrastructure can also help attract capital.

Third, policymakers should also focus on reducing the cost of debt financing for infrastructure projects. This includes developing a deep and liquid bond market, particularly for long-term infrastructure bonds. Credit enhancement mechanisms such as partial credit guarantees and first-loss default guarantees can help improve the creditworthiness of infrastructure debt instruments and lower borrowing costs.

Fourth, there is a need for innovative financing models that optimize risk allocation and returns for different stakeholders. Hybrid annuity models, which combine elements of both debt and equity financing, have been used successfully in some sectors such as roads. Exploring new models such as asset recycling, where operational assets are monetized to fund new investments, can also help bridge financing gaps.

Finally, policymakers should also focus on improving the overall efficiency and sustainability of infrastructure projects through better project preparation, risk management, and contract enforcement. Enhancing the capacity of public institutions involved in infrastructure planning and delivery is crucial for attracting private investment and ensuring successful project outcomes.

Conclusion

This research paper provides a comprehensive analysis of debt and equity financing approaches in Indian infrastructure projects. Using a dataset of 500 projects across sectors, we find that debt financing is more prevalent, particularly for smaller projects in sectors like roads and power transmission. Equity financing is more common for larger projects and those with private investment, such as airports and ports.

We also find that financing choices have significant implications for project financial outcomes. Higher debt financing is associated with lower cost of capital but also lower equity returns, revealing a trade-off in infrastructure financing. Our results highlight the need for policy measures to attract more private equity capital, reduce the cost of debt financing, and develop innovative financing models that balance risk and return.

This study contributes to the limited empirical research on infrastructure financing patterns in India. By analyzing a large sample of projects across sectors and states, we provide insights that can inform policy formulation and financial decision-making. Our findings can help developers, investors, and government agencies structure infrastructure investments more effectively to maximize social and economic impact.

However, our study also has some limitations. Due to data constraints, we could not examine some potentially pertinent aspects of infrastructure financing, such as the terms and sources of debt, stage of project lifecycle and refinancing. Further analysis of these dimensions can provide additional insights. There is also scope for future research to examine the impact of financing choices on infrastructure project performance and service delivery outcomes.

Infrastructure development is critical for India's sustained economic growth and quality of life. Meeting the country's vast infrastructure needs requires mobilizing financing from both public and private sources in an efficient and sustainable manner. A deeper understanding of infrastructure financing patterns can help design policy frameworks and instruments that align the interests of different stakeholders and unlock the flow of capital.

By shedding light on the prevalent financing approaches and their implications, this study aims to contribute to the evidence-based discourse on infrastructure financing. The insights generated can help inform and guide policymakers and practitioners in their endeavors to finance India's infrastructure for the 21st century.

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