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DETERMINANTS OF INFRASTRUCTURE SECTOR PROJECTS IN INDIA: A STATE AND SECTOR LEVEL ANALYSIS

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Abstract

The study examines the determinants of infrastructure project participation across sectors and sub-national levels in India from 2000-01 to 2017-18, focusing on the number of projects under both public and PPP modes. Using descriptive statistics and Poisson regression, the analysis reveals that while transport projects show similar trend across both modes, the PPP participation is very marginal in water and sanitation sector. The political factors such as term year and political alignment between the centre and state significantly influence private participation, whereas economic and social factors such as public investment, industrialization and population size drive public project participation. Therefore, in order to ensure a balanced infrastructure development, governments should enhance institutional frameworks and ensure macroeconomic stability to attract private participation in underrepresented sectors like water and sanitation, while maintaining consistent public investment in high demand areas.

Keywords: Public-Private Partnerships, Infrastructure Projects, Investment, Industrialization, India.

JEL Codes: H41, H54

1. Introduction:

The rapid urbanization and migration have significantly increased global infrastructure demand, with investment needs projected to reach $40 trillion by 2040, which is about 3.7% of global GDP annually (Global Infrastructure Outlook, 2017). In India, despite its large population and economic growth, infrastructure development remains insufficient, posing a major challenge. The Indias basic infrastructure like transport and energy are not developed to an extent that is compared to its competitor countries. Within BRICS, PPPs account for around 50% of the total projects and investment value, largely dominated by China with 18% of the projects. Since the mid-1990s, China has consistently invested about 13.5% of its GDP in the development of infrastructure (Dao and Marisetty, 2016; Chong and Poole, 2013).

As per the estimations of the planning commission, India's investment requirements are estimated to be around $512 to $1000 billion which is around 8-9% of annual GDP order to meet the growing demand for infrastructure (Nagesh and Gayathri, 2014). Given the limited capacity of central and state governments to raise such funds, private investment becomes essential (Chatterjee, 2006). Additionally, many developing countries around the globe face severe infrastructural deficits and high public debt, leading to economic stagnation and low living standards, further driving the use of PPPS (Robert et al., 2014).

Several studies highlight that PPPs emerged as a middle path to address the limitations of both public and private modes of infrastructure delivery. The evidence shows that the government led projects often suffered from inefficiencies, weak institutional management and poor decision making. On the other hand, the pure privatization often prioritize profit leading to unequal access to services (Kwak et al., 2009; Hammami et al., 2006). Therefore, the use of PPPs helps to ease the fiscal pressure, improve efficiency through risk sharing and combine public accountability with private expertise to deliver greater value for money (Engel et al., 2014; Kaur and Malik, 2021).

While the use of PPPs in infrastructure development has steadily increased, its distribution remains uneven across sectors and states. Of this, roads account for the largest share at 53.4%, followed by urban development (20%), ports (8%) and energy with 7.4% (Kutumbale and Telang, 2014). In contrast, water and sanitation sectors attract minimal private participation, comprising with only 1% of projects number and 1.5% of investment value (Kaur and Malik, 2021). The state-wise distribution shows that Karnataka, Andhra Pradesh, Madhya Pradesh

lead in PPP numbers, with Andhra Pradesh and Karnataka notably developing strong institutional framework to support PPPs (INEF, 2013).

Against this background, the study examines the factors influencing the number of PPPs and public infrastructure projects at both sub-national and sector level. It focuses on three key sectors namely transportation, energy and water & sanitation[1] and 21 states[2].

The study draws on data from several sources such as infrastructure India, ECI, EPWRF, Census and the RBI handbook of statistics, categorising variables into political, economic and social factors. It makes key contributions by analysing the determinants influencing both public and PPP project participation in infrastructure development across sectors and states in India. While global studies on sectoral PPP determinants are limited, this is among the first in the Indian context to examine the political, economic and social factors driving the infrastructure projects both at sectoral and sub-national levels.

The paper is structured as follows, section 2 outlines the theoretical background, evolution of PPPs and literature on PPP and public determinants at both global and Indian context. Section 3 details about the data sources and section 4 presents the descriptive statistics on the distribution of PPP and public projects in India. Section 5 explains the variables and methodology, followed by results and discussion in section 6. Finally, section 7 concludes with policy implications and future perspectives.

2. Theoretical background:

The term Public-Private Partnership (PPP) is widely used in the literature, though its origins and definitions vary across countries and organizations. PPPs were first introduced in the UK to bring private capital into infrastructure development and address public sector limitations (Malek & Zala, 2022). These partnerships help mitigate risks and tackle persistent issues such as cost and time overruns (Umer et al., 2011). Over time PPPs have been adopted in both developing and developed countries. Despite definitional differences from country to country, the core features of PPP remain same across the countries. The PPP was primarily employed to enable private sector involvement in providing public services and facilities (Cheung et al., 2009). However, some scholars argue that the PPP adoption in developing countries accept

[1] The study excludes telecommunication and social and commercial sector due to limited number of projects.
[2] The study also excludes North eastern states, Jammu and Kashmir and Union territories (excluding Delhi), due to limited number of projects.

PPP policy as a condition to avail loans from international institutions ((Jamali 2004, Thomas et al. 2006, Appuhami et al., 2011).

Numerous studies emphasize that PPPs leverage the strengths of both public and private sectors, thus using private expertise and efficiency to ease budget constraints and enhance project execution (Percoco, 2014; Casady et al., 2019). The key advantages of using PPP include administrative cost savings, better risk allocation, access to private capital and enhanced innovation (Robert et al., 2014; Zheng and Tiong 2010). Recognizing these benefits, in addition to public sector involvement, post economic reforms in 1991, the Indian government has introduced several policy measures both at national and sub-national levels to promote private participation in infrastructure development (Patel and Bhattacharya, 2010).

Despite various advantages and supportive measures, PPP participation remains limited and infrastructure delivery is still dominated the public sector. Although the public sector is still dominating, the descriptive statistics shows that the public sector projects are also becoming more concentrated in few states. on the other hand, more than half of the projects implemented using PPPs are concentrated in transport sector.

In this context, the study integrates theoretical perspectives with empirical literature to develop a comprehensive analytical framework for examining the key determinants influencing the attraction of both public and PPP infrastructure projects across sub-national and sectors in India.

Figure 1: Determinants of public and PPP project participation in infrastructure development:

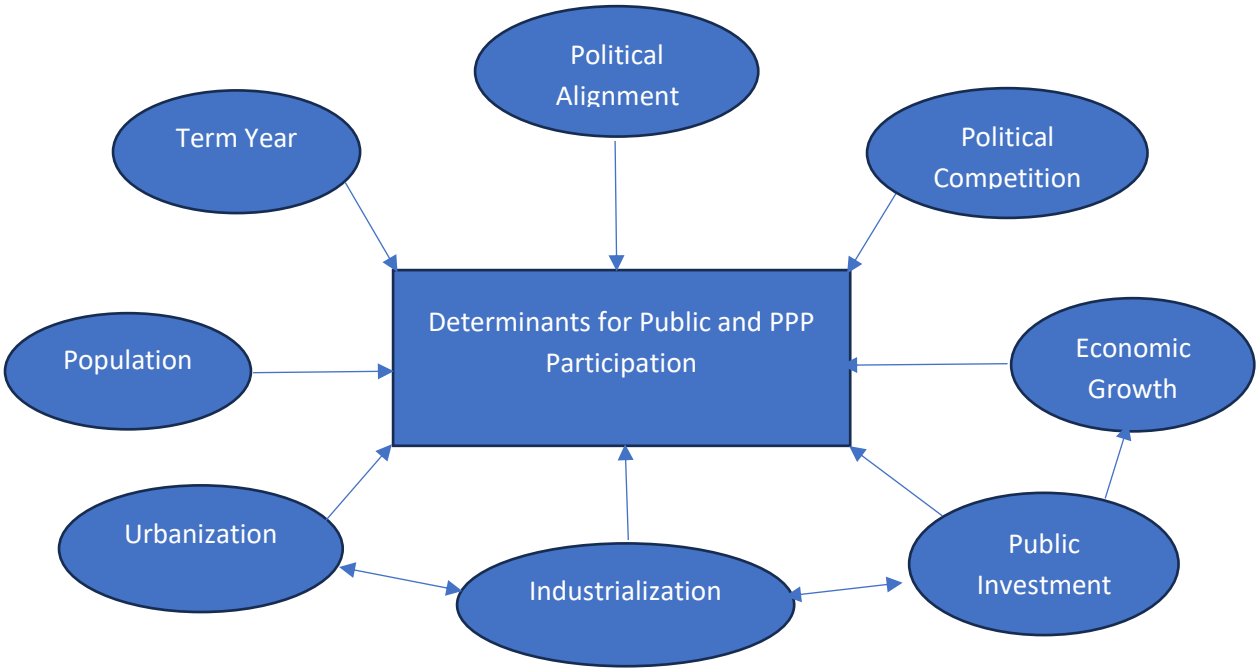


Figure 1 illustrates the key determinants influencing project participation through public and PPP modes across sub-national and sectors in India. Therefore, based on the literature several political and economic & social determinants have been identified as key drivers in attracting infrastructure projects across public and PPP modes.

Determinants of PPP and public sector participation in infrastructure development:

Several studies have emphasized the regional and sectoral disparities in infrastructure development. This study aims to identify some of the key determinants to these variations.

The concentration of PPPs varies across countries due to multiple factors. In this context, Hammami et al (2006) identify seven key determinants influencing PPP investment including the political environment, macroeconomic stability, legal and institutional quality, fiscal constraints and past experience with PPPs.

Macroeconomic conditions play a crucial role in attracting PPP investment. Many developing countries are constrained by weak economic performance and fiscal deficits, have reduced public spending on infrastructure. Therefore, in order to meet the growing demand, governments all around the world increasingly turning to private sector participation (Zhang et al., 2016; Lee et al., 2019; Kaur and Malik 2021). Privatization is also seen as a tool for macroeconomic stabilization, easing fiscal and monetary pressure (Resides, 2009). Hence the limited financing further highlights the importance of private capital in infrastructure development.

The PPP participation is generally higher in countries with larger market size and higher income levels (Kumar, 2019). A substantial market size improves the marketability of services, enabling the investors to recover costs and earn steady return, thereby attracting more PPPs and supporting further growth (Hammami et al., 2006; Sharma, 2012; Trebilcock and Rosenstock, 2015; Kaur and Malik, 2021). Additionally, the institutional quality significantly influences PPP adoption. The strong institutional quality marked by effective governance, rule of law and corruption control create a favourable environment for private participation by ensuring efficient use of available resources with improved regulatory mechanisms (Manu et al., 2017; Wang et al, 2019). A robust legal framework also boosts investor confidence (Yang et al., 2013; Asin and Munoz, 2021).

The literature also indicates that countries with prior PPP experience are more likely to attract private investment, as it enhances government expertise and reduces project uncertainties

(Hammami et al., 2006; Ng et al., 2012; Trebilcock and Rosenstock, 2015; Hyun et al., 2019). A country's existing infrastructure level also matters as low-income countries lack basic infrastructure facilities and often struggle to draw PPPs attention as a result leads to lower growth. On the other hand, a well- developed infrastructure supports economic growth and improves standard of living (Lakshmanan, 2008; Trebilcock and Rosenstock, 2015).

In a democratic setting, the rapid growth in population increases the demand for infrastructure, prompting the governments to prioritize investments in densely populated areas to meet the public needs and political objectives. These disparities are often influenced by factors such as the degree of private participation, public investment, differences in per-capita income of the regions, level of urbanization, institutional capacity and the interdependence among infrastructure sectors (Cerra et al., 2016).

While urbanization typically drives infrastructure demand, high density and congestion in urban areas may discourage private investment, as a result the governments steps in to fulfil the necessary demand for the infrastructure services (Randloph et al., 1996). Additionally, the private investment is often concentrated in sectors like energy and telecommunication, whereas as essential services such as water and sanitation are taken care by public sector due to its obligations and governance challenges (Timilsina, 2022; Estache & Serebrisky, 2004). Further, water and sanitations sector face significant public resistance as the sector is highly dominated by very few private players, leading to a lack of trust in private players which ultimately results in lower private participation in the sector (Davis, 2005).

The political ideology also seen as a major determinant that significantly influence PPP adoption. The literature shows that the conservative parties are generally more supportive of private participation (Bell and Fageda, 2008). However, the impact of ideology depends on legislative professionalism, whereas its shift towards the liberalism may reduce the likelihood of PPP adoption and vice versa (Boyer and Scheller, 2018). The left or conservative parties often support PPPs as they retain public sector involvement, unlike in pure privatization, making them more acceptable. This way the PPPs appeal to both market oriented right-wing and public sector focused left-wing supporters (Mota and Moreira, 2015; Pena-Miguel and Cuadrado-Ballesteros, 2023).

The adoption of PPPs tends to rise in election years, suggesting they are focused strategically to gain voter support, but this momentum often declines after a new term begins (Pena- Miguel and Cuadrado- Ballesteros, 2023). Further, the political competition also plays a key role in

PPP implementation. Studies suggest that PPPs are more common in politically competitive governments as they offer a platform for cross-party cooperation (Pena- Miguel and Cuadrado-Ballesteros, 2023). However, high political competition can also shift government spending away from infrastructure towards populist policies like job creation and direct benefits, as a strategy to gain votes and limit opportunities for rent-seeking (Khemani, 2010).

Against this background, while many international studies have explored the determinants of PPP and public participation, limited attention has been given to sub-national and sectoral level factors. Therefore, this study aims to fill the gap by identifying the key determinants influencing PPP participation and contributing to the existing literature.

3. Data sources and variables:

The study has utilized state-level annual data from multiple sources spanning from 2000-2001 to 2017-18 for 21 states in India. The paper has used secondary data for all the variables considered. The detailed data sources and variable description for dependent and independent variables considered for the study are discussed in this section.

We find our dependent variable as the number of projects. The first and second models captures the year-wise total number of projects implemented in both public and PPP projects. The third and fourth models capture the year-wise total number of projects implemented at the sector level. The data for dependent variable has been obtained from infrastructure India database. The database covers 3 major project types, namely the projects purely developed by public sector, private sector and in combination of both public and private modes (Public-Private Partnerships)[3]. The database also provides the information related to sectors like: Transport, Energy, Telecommunication, Water and Sanitation, and Social and commercial infrastructure[4]. As a whole the study considers only 21 states[5].

The independent and control variables are collected from multiple sources and are majorly divided into two types: political and economic & social variables. For the political variables, data was obtained from Election Commission of India (ECI), while the data for economic and

[3] Due to limited number of projects, the study excludes the projects purely developed under private sector and considers only public and PPP types of projects.
[4] Due to limited number of projects, the study excludes telecommunication and social and commercial sectors.
[5] Due to limited number of projects, north-eastern, Jammu and Kashmir and union territories (except Delhi) are not considered for the study.

social variables were collected from Economic and Political Weekly Research Foundation (EPWRF) and RBI handbook of statistics on Indian economy and census.

In total there are 5869 projects of which the public projects and PPP projects constitute 4674 and 1195 projects across 21 states of India. The infrastructure data has been merged with the political, economic and social variables and created a panel data covering 21 states across 17 years.

Variable description:

We start with defining our main variables and their measurement in our analysis and then present the empirical specification used in the study.

Our independent variables are grouped into two broad categories: political and economic & social variables. The political variables consist of year of term, political alignment and political competition. The economic & social variables consist of gross state domestic product growth rate (GSDPGR), Industrialization, public investment and urbanization. The population of a state is used as a control variable. The detailed sources and variable significance and description is explained in the following table.

Table 1: Variable description and sources:

Variable	**Description**	**Source**
Gross state domestic product growth rate (GSDPGR)	We used lagged value of GSDPGR, which represents the fiscal capacity of the state. It serves as a measure of the state's economic growth.	EPWRF https://epwrfits.in/index.aspx.
Urbanization	Total urban population to the total population of the state	Census https://censusindia.gov.in/census.website/.
Total population	Log value of total population of the state	RBI https://www.rbi.org.in/Scripts/AnnualPublications.aspx?head=Handbook%20of%20Statistics%20on%20Indian%20States.
Term Year	The term year variable represents the current year of the incumbent government's term, which typically spans from 1 to 5 years. A value of 1 indicates the first year of the term, while 5 denotes the final year.	ECI https://www.eci.gov.in/.

Political Alignment	The political alignment represents whether the same party or allied parties in power at both the central and state levels. It is coded as 1 if there is alignment and 0 otherwise.	ECI https://www.eci.gov.in/
Political competition	The political competition represents the log value of the difference in seats between the winner and the runner	ECI https://www.eci.gov.in/
Public Investment	The public investment is measured as the percentage of GSDP, representing the capital expenditure incurred by each state government toward the development of long-term physical infrastructure (capital expenditure of each state).	https://www.rbi.org.in/scripts/AnnualPublications.aspx?head=Handbook+of+Statistics+on+Indian+States.
Industrialization	The percentage share of value added by the manufacturing sector in GSDP is used to measure the degree of industrialization taking place at the state level.	https://epwrfits.in/SDPTreeViewData.aspx.

Table 2: Summary statistics:

Variable	**Obs.**	**Mean**	**Std Dev.**	**Min**	**Max**
Dependent Variables:					
Total Projects	378	15.52	22.47	0	118
Public Projects	378	12.36	20.79	0	116
PPP Projects	378	1.91	3.79	0	43
Transport Public	378	5.14	11.28	0	93
Energy Public	378	3.90	8.44	0	63
Water& Sanitation Public	378	3.15	5.91	0	52
Transport PPP	378	1.91	3.79	0	43
Energy PPP	378	0.78	3.41	0	46
Water & Sanitation PPP	378	0.18	0.62	0	8
Independent Variables:					
Political Variables					
Term Year	378	2.99	1.40	1	5
Political Alliance	378	0.46	0.50	0	1
Political Competition	378	3.10	0.93	0	4.53
Economic and Social Variables					
Population	378	10.47	1.08	6.99	12.31
Urbanization	378	0.32	0.18	0.10	0.99
Economic Growth	357	7.38	4.65	-9.90	28.67
Public Investment	378	5.15	4.95	0.20	48.52
Industrialization	378	15.75	7.60	1.05	39.36

Source: Infrastructure India, ECI, EPWRF, Census and RBI handbook of statistics

The state level panel data on political and economic & social variables are collected for the period between 2000-01 to 2017-18. The data is collected for a total of 21 states. Table 2 shows the summary of all the variables (dependent and independent) constructed using these 4 different datasets. The mean value of dependent variable reflects the average number of infrastructure projects undertaken in each state during a given year, while minimum and maximum values indicate the range in project count across different states and years. For the independent variables, it is evident that the average term year of the government in power is 2.99 years while on average 46 percent of states have political alignment between the central and state government. The mean political competition between the runner and winner is about 3.10. The average growth rate of GSDP of a state is about 7.38 percentage. On an average, 32 percent of the population is living in urban areas. The states average public investment stands at 5.15% of the GSDP while manufacturing (industrialization) contributes about 15.75% of the overall output of the state.

4. Current status of public and PPP projects in India:

Table 3 presents the state-wise distribution of public and PPP projects for the period between 2000-01 to 2017-18. In terms of total projects (PPP and public together) Madhya Pradesh and Maharashtra shows highest share, followed by Karnataka, Uttar Pradesh, Bihar. However, if we compare across types, barring Maharashtra and Madhya Pradesh, the states like Bihar, Odissa, Jharkhand, Uttar Pradesh and West Bengal have larger share of public projects compared to PPP project type. On the other hand, Himachal Pradesh, Rajasthan and Arunachal Pradesh have a better share of PPP projects. While some states have similar distribution across project types, overall, states with fewer PPP projects tend to have a higher share of public projects and vice versa.

Table 3: State-wise distribution of public and PPP projects (2000-2001 to 2017-18)

Location	Public	PPP	Total
Andhra Pradesh	4.69	3.93	4.53
Arunachal Pradesh	0.98	10.46	2.91
Bihar	8.77	1.34	7.26
Chhattisgarh	2.91	0.67	2.45
Delhi (UT)	0.47	1.09	0.6
Gujarat	4.66	6.53	5.04
Haryana	1.52	1.17	1.45

Himachal Pradesh	1.03	8.54	2.56
Jharkhand	5.22	1.09	4.38
Karnataka	8.41	4.77	7.67
Kerala	1.73	1.59	1.7
Madhya Pradesh	9.46	13.47	10.27
Maharashtra	12.47	13.47	12.68
Odisha	7.21	2.18	6.19
Punjab	0.98	3.43	1.48
Rajasthan	5.58	11.8	6.85
Tamil Nadu	5.33	4.27	5.11
Telangana	1.93	1.76	1.89
Uttar Pradesh	7.92	4.69	7.26
Uttarakhand	1.8	1.76	1.79
West Bengal	6.93	2.01	5.93
Total	100	100	100
	4674 (79.63)	1195 (20.36)	5869 (100)

Source: Calculations based on Infrastructure Projects in India database.

Table 4 and Table 5 shows the sector-wise distribution of public and PPP projects across Indian states. Table 4 presents the sector-wise distribution specific to public sector. Of the total 4674 public infrastructure projects, Maharashtra accounts for the highest share with 12.47 percent, while Delhi has the lowest at just 0.47 percent. At the sectoral level, states like Madhya Pradesh, West Bengal and Maharashtra show a high concentration of projects across multiple sectors, indicating broader coverage across the sectors. Additionally, states such as Bihar, Rajasthan and Jharkhand exhibit a relatively significant presence in specific sectors like transport, energy and water and sanitation sectors indicating their focused infrastructure priorities.

Table 5 shows the sector-wise distribution of PPP projects across the states. Of the total 1195 PPP infrastructure projects, Maharashtra (13.47 percent), Madhya Pradesh (13.47 percent), Rajasthan (11.8 percent), Arunachal Pradesh (10.46 percent) accounts for highest share. Whereas, the states such as Bihar, Haryana, Chhattisgarh, Jharkhand, Delhi, Kerala and Uttarakhand have very marginal (less than 2 percent) participation of PPP.

As a whole, the distribution of infrastructure projects shows notable differences between public and PPP projects. the public projects are more evenly distributed across states and sectors, with highest concentration in transport (41.57%) followed by energy (31.6%) and water and sanitation and sanitation (25.5%). At state level, states like Maharashtra, Madhya Pradesh and Bihar have highest share. In contrast, the PPP projects are heavily concentrated in transport

sector (60.4%) and are highly skewed towards a few states, specifically Maharashtra, Rajasthan. While public projects are distributed across all sectors, which highlights the selective participation of PPP projects. This reflects the differences in participation patterns, feasibility and risk preferences between public and PPP projects. In addition, we employed Herfindahl-Hirschman Index (HHI) to assess the level of concentration of these projects across sectors and states.

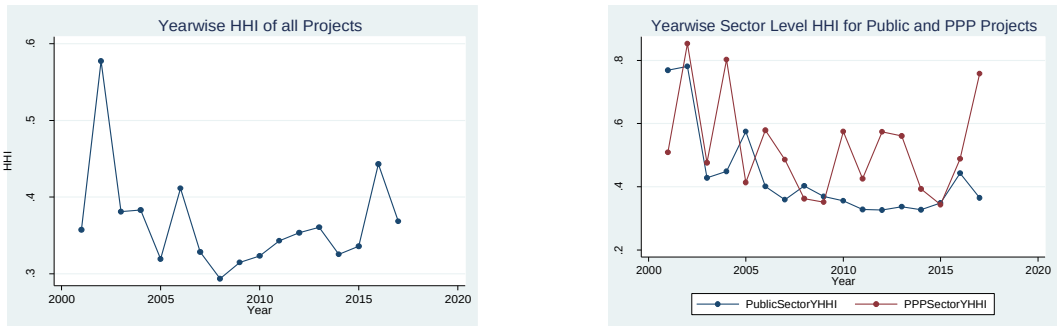
Concentration of PPP and public projects over time across sectors and states[6].

Sector level concentration of PPP and public projects

Figure 2 highlights the trend of year-wise sectoral concentration of projects across PPP, public and all projects implemented between 2000 to 2018. Figure 2(a) demonstrates overall (PPP and public) project concentration and reveals that the concentration has fluctuated overtime with a peak in 2001 and decline thereafter, indicating increasing diversification. The sector level HHI comparison shows that the PPP projects are significantly more concentrated in few sectors reflected by consistently higher HHI values. In contrast, the public projects demonstrate a more even and stable distribution across sectors highlighting broader government engagement. This highlights the selective nature of private participation in infrastructure development compared to public mode. To determine whether the observed skewness is driven by PPP or public projects, we conducted a separate analysis for each implementation mode individually (Public and PPP).

Figure 2: HHI calculations for PPP, public and all projects

(a) (b)



[6] Since the number of projects implemented was very low, this analysis focuses on data 2000 to 2018.

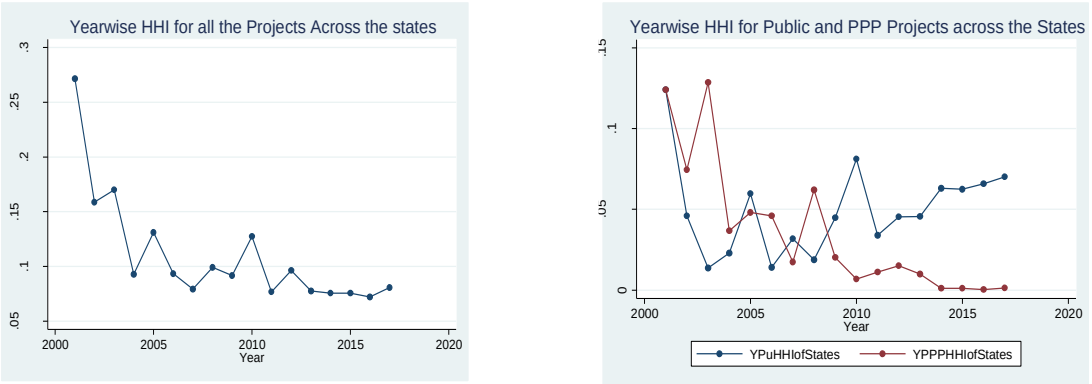
Source: Calculations based on Infrastructure Projects in India database.

Concentration of public and PPP projects at State level:

Figure 3 highlights the HHI concentration of projects at state level. Figure 3(a) represents the concentration for all projects (both PPP and public together) across the states, and Figure 3(b) represents the concentration of both PPP and public projects individually

Figure 3: HHI calculations for all projects at state level

(a) (b)



Source: Calculations based on Infrastructure Projects in India database.

Figure 3(a) the overall HHI across states shows a declining trend, indicating that infrastructure projects have become more evenly distributed geographically across the years. However, when disaggregated, PPP projects initially exhibited high concentration in few states but later became more dispersed. In contrast, the public projects started with a broader spread but have shown a slight increase in concentration in the recent years. Overall, this suggest that although the PPP participation remains lower, it has expanded to more states in recent years, whereas the public projects have become more relatively concentrated in certain states.

Therefore, the observed skewness in spatial and sectoral concentration of projects requires careful attention. In the following sections, we use econometric methodology to examine the factors influencing the concentration, composition of infrastructure projects in India.

5. Empirical Methodology:

Model Specification: $Projects_{it} = \alpha + \beta_1 Term\ Year_{it} + \beta_2 Political\ Alignment_{it} + \beta_3 Political\ Competition_{it} + \beta_4 Population_{it} + \beta_5 Urbanization_{it} + \beta_6 Economic\ Growth_{it} + \beta_7 Public\ Investment_{it} + \beta_8 Industrialization_{it} + \eta_i + \delta_t + \varepsilon_{it}$ (1)

Here from the equation (1), *i* represents the state and *t* represents the time period. $Projects_{it}$ is the total number of projects implemented in each state across the years. In the equation, α represents the constant term, η_i and δ_t represents the region and time-specific dummies. Finally, the ε_{it} is the error term.

To examine the occurrence of PPP and public infrastructure projects over the years, we estimated a panel data model incorporating several explanatory variables. The major concern in our estimation is the potential endogeneity between economic growth (measured through GSDP growth rate) and infrastructure project count. Infrastructure development or implementation can both influence and be influenced by the economic growth. Therefore, to mitigate this we used the lagged value of GSDP growth rate as an explanatory variable., which helps reduce simultaneity bias by ensuring that current project numbers are not influenced by current economic performance.

Additionally, in choosing between the fixed and random effects specifications, we conducted the Hausman test, which tests whether the unique errors are correlated with the regressors. The test results support the fixed effects model, indicating that unobserved heterogeneity is correlated with the explanatory variables. Thus, fixed effects is a more appropriate estimator as it controls for time invariant state specific characteristics. Further, infrastructure dynamics vary significantly across the regions and over time, potentially leading to heteroscedasticity and serial correlation. To account for this, we used robust standard errors clustered at the region and time level, which helps produce consistent and efficient standard errors in the presence of such heterogeneity.

Table 6: Hausman Test:

TS	C-S. S	C- S. d	Prob
Chi-square	46.57	8	0.0

Table 6 presents the Hausman test results. The results show a probability value of 0.0, which is lower than 5% indicating that the fixed effects model is the appropriate model specification to be used. Hence, we used FE panel data regression in our analysis.

As our dependent variable is number of projects implemented in a year and state, by using count regression approach (Poisson regression approach). Although initial testing revealed overdispersion in the data, we adopted the Poisson Pseudo Maximum Likelihood (PPML) estimator, which is robust to such dispersion. This method requires the conditional mean to be specified correctly and is achieved by correctly specifying the explanatory variables along with the region and year fixed effects. The equation is estimated using the robust standard errors (vce (robust)), which further ensures consistent inference even when the variance is mis-specified. Therefore, despite the presence of overdispersion, the use of PPML with robust inference allows us to obtain the reliable estimates for the determinants of PPP project implementation (Wooldridge, 1999). Additionally, the use of Panel data with fixed effects is crucial for controlling unobserved heterogeneity and time specific shocks. The PPML model conveniently accommodates both region and time/year fixed effects, making it well suited for panel datasets[7]. Therefore, incorporating fixed effects in standard Negative Binomial models is more complex and less straightforward. The formulation of the mean specification under PPML is given by.

$$\lambda_{it} = \exp(\beta x_{it} + \eta_i + \delta_t \quad (2)$$

from equation (2), λ_{it} represents the expected number of PPP projects in region *i* and year *t*, and x_{it} is the vector of explanatory variables, η_i denotes the region fixed effects and δ_t represents the year fixed effects.

6. Results and Discussion:

Table 7 presents the Poisson regression estimates for the number of infrastructure projects implemented, distinguishing between the total (public and PPP), public and PPP projects. The

[7] The primary estimation technique used in this paper is Poisson Regression, which is a Maximum Likelihood Estimation (MLE) method designed for count data (in our case number of projects) which does not rely on the assumption of stationarity in the same way OLS does. The Poisson models focus on the distributional characteristics of the dependent variable and are robust to some forms of non-stationarity, especially when fixed effects are used to account for unobserved heterogeneity. Therefore, while the stationarity tests are standard in time-series econometrics, they are not strictly necessary in this case due to the nature of dependent variable and the model specification.

results show that, public investment shows a significant and positive effect across all models, highlighting its central role in attracting project implementation. For PPP projects, political factors especially term year and political alignment shows positive and significance at 5%, indicating more PPPs are initiated near the election period or during the final years of the incumbent government (Pena- Miguel and Cuadrado- Ballesteros, 2023). The political alignment implies that there is a high possibility of implementing new projects if the parties at the centre and state are aligned or belonging to same political party. Whereas, the urbanization negatively affects PPPs, suggesting the private players may avoid highly urbanized or saturated areas and the problem related to land acquisition issues (Randloph et al., 1996).

In contrast, the population and industrialization significantly drive public projects, reflecting the government's role in meeting the rising infrastructure demands. Overall, while social and economic factors influence public projects, term year and political alignment play important role in attracting private participation in infrastructure development.

Table 7: Regression results of Poisson model for Project Type

	Project Type		
	(1)	(2)	(3)
VARIABLES	Total Projects	Public Projects	PPP Projects
Political Variables			
Term Year	0.056**	0.035	0.117**
	(0.026)	(0.027)	(0.048)
Political Alliance	0.173*	0.150	0.326**
	(0.090)	(0.092)	(0.133)
Political competition	0.044	0.024	0.075
	(0.042)	(0.046)	(0.060)
Economic and Social Variables			
Population	0.531***	0.777***	0.041
	(0.071)	(0.056)	(0.119)
Urbanization	-0.466	-0.411	-1.153***
	(0.336)	(0.412)	(0.404)
Economic Growth	-0.016	-0.013	-0.016
	(0.011)	(0.012)	(0.017)
Public Investment	0.074***	0.067***	0.085**
	(0.019)	(0.022)	(0.034)
Industrialization	0.010	0.027***	-0.024**
	(0.007)	(0.007)	(0.011)
Constant	-6.809***	-11.108***	-1.389
	(1.035)	(1.151)	(1.822)
Observations	357	357	357
Pseudo R2	0.63	0.72	0.31
Region	Yes	Yes	Yes
Year	Yes	Yes	Yes

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 8 presents the regression results of term year effects on the implementation of PPP and public projects. The results shows that PPP projects increase significantly in the final years of the term with significant and positive effect, indicating a political incentive to announce such projects towards the end of incumbent government's term. In contrast the public projects do not show a significant variation across term years. The public investment continues to positively influence all project types. This indicates that the private participation and PPP project implementation are more strategic, especially when the elections are closer.

Table 8: Regression results of Poisson model for explaining the term year effect

	Project Type		
	(1)	(2)	(3)
VARIABLES	Total Projects	Public Projects	PPP Projects
Political Variables			
2.Term Year	-0.180	-0.141	-0.228
	(0.114)	(0.118)	(0.182)
3.Term Year	-0.080	-0.036	-0.190
	(0.142)	(0.148)	(0.208)
4.Term Year	0.129	0.141	0.106
	(0.116)	(0.117)	(0.228)
5.Term Year	0.123	0.030	0.381**
	(0.107)	(0.118)	(0.192)
Political Alliance	0.192**	0.161*	0.349***
	(0.089)	(0.091)	(0.129)
Political Competition	0.043	0.022	0.069
	(0.040)	(0.045)	(0.059)
Economic and Social Variables			
Population	0.526***	0.773***	0.039
	(0.068)	(0.054)	(0.116)
Urbanization	-0.488	-0.415	-1.169***
	(0.326)	(0.400)	(0.398)
Economic Growth	-0.014	-0.011	-0.017
	(0.011)	(0.012)	(0.017)
Public Investment	0.074***	0.068***	0.085***
	(0.019)	(0.022)	(0.032)
Industrialization	0.009	0.027***	-0.025**
	(0.007)	(0.007)	(0.011)
Constant	-6.624***	-10.990***	-1.027
	(1.010)	(1.130)	(1.759)
Observations	357	357	357
Pseudo R2	0.64	0.72	0.31
Region	Yes	Yes	Yes
Year	Yes	Yes	Yes

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

As a whole, Table 7 and 8 highlights the differing influences behind the PPP and public project implementation. Across both tables public investment shows a consistent influence across PPP and public projects. However, table 7 shows that PPPs or private participation is significantly influenced by political factors such as political alignment and term year, suggesting that such

projects are often timed around electoral cycles. Public projects on the other hand, are strongly influenced by structural factors like population growth and industrialization, reflecting a response to rising infrastructure demand. Table 8 focuses specifically on the disaggregated term year effects, further confirms that PPP projects are more likely to be initiated during the final years of the government's term, implying the political incentives. Overall, these results suggest that while public projects are primarily demand driven, PPPs tend to be more politically timed.

Table 9 and 10 present the Poisson regression results for the infrastructure projects of public and PPP approaches across three key sectors: transport, energy and water & sanitation. The findings of Table 9 reveal that political variables generally have limited influence, with the exception of political competition, which has a weak significant level at 10% in the water and sanitation sector. population shows a significant and positive impact across the sectors, reflecting a rising infrastructure demand with demographic growth. On the other hand, public investment significantly influences transport and energy projects, while industrialization has a positive and significant impact only for energy sector, implying its role in driving energy related infrastructure. Overall, public projects implementation at the sector level appears to be primarily driven by socio-economic factors rather than political factors.

Table 10 presents the results of PPP projects across the key sectors. The results indicate that the political factors significantly influence PPP projects across sectors. Term year positively effects the transport projects, implying that they are often initiated when the elections are near. On the other hand, the political competition drives PPPs in transport and water & sanitation sectors but negatively affects energy projects, while political alignment strongly supports energy sector PPPs. Among economic and social factors, population positively impacts transport and water and sanitation sector projects but negatively affects energy projects, reflecting regional concentration. Although urbanization has a negative effect in energy sector but positive in water & sanitation projects. The public investment is significant only in transport, the industrialization negatively affects energy projects. Therefore, these results suggest that the PPP implementation is shaped by both political motives and sector specific dynamics.

As a whole, Table 9 and 10 show that the public projects are mainly driven by social and economic factors like population, public investment and industrialization with a minimal political influence. In contract, the PPP projects are strongly influenced by political factors such as term year, political competition and political alignment significantly influence their

implementation, especially in energy and transport sectors. While public projects are more demand driven, PPPs are shaped by political timing and sector-specific factors.

Table 9: Public Projects at Sector Level

	Sector Type		
	(1)	(2)	(3)
VARIABLES	Transport	Energy	Water and Sanitation
Political Variables			
Term Year	0.051	0.028	0.031
	(0.038)	(0.049)	(0.047)
Political Alliance	0.107	0.151	0.173
	(0.142)	(0.134)	(0.147)
Political Competition	0.010	-0.027	0.166*
	(0.059)	(0.071)	(0.097)
Economic and Social Variables			
population	0.673***	0.927***	0.858***
	(0.075)	(0.085)	(0.128)
Urbanization	-0.087	-1.366*	-0.479
	(0.498)	(0.773)	(0.733)
Economic Growth	-0.009	-0.029	0.002
	(0.017)	(0.022)	(0.019)
Public Investment	0.056**	0.103***	0.005
	(0.028)	(0.033)	(0.030)
Industrialization	0.009	0.056***	0.022
	(0.011)	(0.013)	(0.014)
Constant	-11.685***	-27.647***	-12.098***
	(1.464)	(1.379)	(1.850)
Observations	357	357	357
Pseudo R2	0.67	0.60	0.45
Region	Yes	Yes	Yes
Year	Yes	Yes	Yes

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 10: PPP Projects at Sector Level

	Sector Type		
	(1)	(2)	(3)
VARIABLES	Transport	Energy	Water and Sanitation
Political Variables			
Term Year	0.123**	0.079	0.108
	(0.051)	(0.095)	(0.114)
Political Alliance	0.191	0.838***	0.419
	(0.144)	(0.258)	(0.282)
Political Competition	0.156**	-0.320**	0.340**
	(0.067)	(0.135)	(0.167)
Economic and Social Variables			
population	0.709***	-0.736***	1.081***
	(0.105)	(0.203)	(0.285)
Urbanization	0.202	-4.373***	2.122**
	(0.480)	(0.968)	(1.006)
Economic Growth	-0.008	-0.018	-0.009
	(0.019)	(0.032)	(0.050)
Public Investment	0.064*	0.045	-0.074
	(0.039)	(0.045)	(0.100)
Industrialization	-0.006	-0.054**	0.023
	(0.012)	(0.022)	(0.026)
Constant	-9.658***	6.579***	-30.201***
	(1.730)	(2.026)	(3.237)

Observations	357	357	357
Pseudo R2	0.36	0.59	0.24
Region	Yes	Yes	Yes
Year	Yes	Yes	Yes

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

7. Conclusion:

The major objective of the paper is to examine the determinants influencing the participation of both PPP and public infrastructure projects at the sectoral and sub-national levels. The preliminary analysis reveals a skewed distribution of projects across states and sectors. While the transport sector exhibits a similar trend under both PPP and public modes, the water and sanitation sector display greater skewness with lower private participation in the sector. Regression results indicate that public investment and macroeconomic stability are key factors for attracting infrastructure projects in both modes. For PPPs, political factors, particularly term year and political alignment significantly influence private participation. The final year of the governments term is positively associated with increased PPP activity, suggesting a shift towards populist policies to secure electoral gains. In contrast, population size, public investment and industrialization strongly impact the distribution of public projects., reflecting the governments emphasis on addressing public needs and political gains. Further, while industrialization positively influences public projects allocation, it has negative association with PPPs, possibly due to congestion and market saturation in highly industrialized areas that deter private investors.

At the sectoral level, population size has a positive and significant effect on the public infrastructure projects across all the sectors, reflecting the governments need to meet rising demand for basic services as population grows. Public investment is also a key determinant, particularly for the transport and energy sectors. in the case of energy sector, the increased industrialization drives demand, making it a significant factor in public sector investment. For PPPs, the political factors such as term year and political competition significantly influence private participation, especially in the transport and water and sanitation sectors. This suggests that rising political competition and population pressure encourage governments to pressure more populist infrastructure policies through private investment. However, urbanization shows a negative and significant effect on the energy sector under PPP mode, as a large share of projects are concentrated in only few states particularly Himachal Pradesh and Arunachal Pradesh due to geographic and physical advantages.

Therefore, the study concludes that the economic and social factors play a very important role in attracting the public projects. Whereas the political factors are instrumental in attracting the private participation.

Based on the results, the study proposes some policy implications. There is a greater need for the governments to decentralize PPP investment and help PPPs to expand beyond few geographically and economically advantaged states by providing the necessary incentives. Governments should leverage the population growth strategically and integrate the PPP strategies in sectors with growing demand. The government should also provide the balanced political incentives with long-term planning, since the PPP activity is influenced by political cycles. The governments at the state level should work on improving the institutional quality and regulatory mechanisms to attract more private participation. Given these differences across the sectors and sub-national levels, the future studies should look into the within sectoral differences and the determinants that play a role in attracting the private participation.

Appendix:

Table 4. Distribution of Public Projects across states and Sectors:

Location	Transport	Energy	Social & Commercial	Water & Sanitation	Total
Andhra Pradesh	2.42	5.69	6.56	7.04	4.69
Arunachal Pradesh	2.11	0.34	0	0	0.98
Bihar	11.79	10.36	3.28	2.18	8.77
Chhattisgarh	4.07	2.71	4.92	1.17	2.91
Delhi (UT)	0.87	0.2	0	0.17	0.47
Gujarat	3.14	5.82	4.92	5.7	4.66
Haryana	1.24	0.95	3.28	2.6	1.52
Himachal Pradesh	0.82	1.69	1.64	0.5	1.03
Jharkhand	8.54	4.06	1.64	1.42	5.22
Karnataka	9.42	4.81	14.75	10.9	8.41
Kerala	1.54	1.49	8.2	2.01	1.73
Madhya Pradesh	10.76	8.73	9.84	8.21	9.46
Maharashtra	9.01	13.54	6.56	17.1	12.47
Odisha	5.87	7.04	6.56	9.64	7.21
Punjab	1.34	0.41	6.56	0.84	0.98
Rajasthan	4.07	6.3	4.92	7.21	5.58
Tamil Nadu	4.12	5.89	4.92	6.62	5.33
Telangana	1.29	1.08	0	4.11	1.93
Uttar Pradesh	7.98	10.56	0	4.95	7.92
Uttarakhand	1.54	2.98	4.92	0.59	1.8
West Bengal	8.08	5.35	6.56	7.04	6.93
Total	100	100	100	100	100
	1943 (41.57)	1477 (31.60)	61 (1.30)	1193 (25.52)	4674

Source: Based on Infrastructure India Calculations

Table 5. Distribution of PPP projects across States and Sectors:

Location	Transport	Energy	Social & Commercial	Water & Sanitation	Total
Andhra Pradesh	5.96	0	2.83	1.45	3.93
Arunachal Pradesh	0.28	41.28	0	0	10.46
Bihar	1.66	0.67	1.89	0	1.34
Chhattisgarh	0.83	0	0.94	1.45	0.67
Delhi (UT)	0.83	0	0.94	8.7	1.09
Gujarat	9.83	0.67	1.89	4.35	6.53
Haryana	1.66	0.34	0	1.45	1.17
Himachal Pradesh	1.66	27.18	7.55	1.45	8.54
Jharkhand	1.39	0.34	1.89	0	1.09
Karnataka	6.23	0.34	3.77	10.14	4.77
Kerala	2.22	0.67	0	1.45	1.59
Madhya Pradesh	19.94	0.67	10.38	5.8	13.47
Maharashtra	12.88	15.77	11.32	13.04	13.47
Odisha	2.49	0	4.72	4.35	2.18
Punjab	4.02	2.01	5.66	0	3.43
Rajasthan	11.91	5.03	33.02	7.25	11.8
Tamil Nadu	6.37	0	0	7.25	4.27
Telangana	2.22	0	1.89	4.35	1.76
Uttar Pradesh	4.43	3.36	1.89	17.39	4.69
Uttarakhand	0.97	1.68	6.6	2.9	1.76
West Bengal	2.22	0	2.83	7.25	2.01
Total	100	100	100	100	100
	722 (60.41)	298 (24.93)	106 (8.87)	69 (5.77)	1195

Source: Based on Infrastructure India Calculations

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