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Why Do Indian States Differ in Their Infrastructure Development?

Govinda R Timilsina
Pravakar Sahoo
Ranjan Kumar Dash

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Abstract

The literature suggests that one of the main factors behind the interstate inequality in economic development in India is the variation in the level of infrastructure development. However, unequal infrastructure development across the Indian States is less understood. This study empirically analyzes various factors (economic, fiscal, demographic, social, institutional, and political) to explain interstate infrastructure inequality using a panel data set for 18 states in India between 2004 and 2020. Employing the principal component analysis technique, three separate infrastructure indices are developed for physical, social, and financial infrastructures. The relationship of each index with its explanatory variables is estimated using System Generalized Method of Moments. The results show that economic factors—including economic performance, financial development, investment, and economic structure—are more influential on physical infrastructure. For social infrastructure, in addition to economic factors, fiscal and demographic factors are more influential. Meanwhile, economic and demographic factors are found to drive financial infrastructure. Financial development fosters physical infrastructure, while its impact on social infrastructure is weak.

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Govinda R Timilsina, Pravakar Sahoo, Ranjan Kumar Dash[2]

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[2]Govinda Timilsina (gtimilsina@worldbank.org) is a Senior Economist at the Development Research Group, World Bank, Washington, DC; Pravakar Sahoo (pravakarfirst@gmail.com) is a Professor at Institute of Economic Growth, Delhi University, New Delhi, India. Ranjan Kumar Dash (ranjandash67@gmail.com) is an Associate Professor, Symbiosis School of Economics, Symbiosis International (Deemed) University, Pune, India.

Why Do Indian States Differ in Their Infrastructure Development?

1. Introduction

The Indian economy has sustained an average growth rate of around 7 percent over the last three decades, until the start of COVID-19 in 2020, since economic reforms launched in 1991. However, economic growth varies substantially across the states (Rao et al., 1999; Mishra and Mishra, 2018). As evidenced by earlier studies, some of the major factors for the differential growth rates across states include initial levels of development, existing economic structure, and differential development of infrastructure (Rao et al., 1999; Ghosh and De, 2005; Majumder, 2012; Bandyopadhyay, 2012; Mishra and Mishra, 2018). The different levels of development in physical infrastructure (transportation, energy, information), social infrastructure (education, health), and financial infrastructure (financial institutions) help explain the variations in economic growth across the Indian states.

The contributions of infrastructure development to the overall competitiveness of the economy by improving factor productivities and reducing trade and transaction costs are well documented (World Bank, 1994; Roller and Waverman, 2001; Caldern and Serven, 2004; Sahoo and Dash, 2009; 2012). Apart from contributing to economic growth through increased productivity, infrastructure development also provides less developed regions and disadvantaged sections/individuals better access to economic and social opportunities, thereby reducing inter-spatial divergence in inequality and poverty (Estache and Fay, 1995; Calderon and Serven, 2014; Bajar and Rajeev, 2016).

While the existing literature focuses on establishing the relationship between infrastructure development and economic growth (Roller and Waverman, 2001; Caldern and Serven, 2004; Sahoo and Dash, 2009; 2012), little emphasis has been paid to determining factors responsible for the variations in the development of infrastructure itself. In the Indian context, some studies empirically examine the contribution of infrastructure development to economic growth and performance of the industrial sector (Ghosh and De, 2005; Nayyar 2008; Majumder, 2012; Bandyopadhyay, 2012; Mitra *et al*. 2002; Mitra *et al*., 2016; Ghosh, 2017). However, a very few studies have looked at the factors contributing to the disparities in infrastructure development which could be responsible for different levels of economic growth across the Indian states. Existing studies, such as De (2010), find that Asian countries with higher income, stronger institutions, better governance, and more open economies have higher

levels of infrastructure. Some of the other factors affecting infrastructure development are economic growth, capital expenditure, and access to finance (Ari and Toivanen, 2005; Billon, 2010; Cerra et al., 2017). While studies such as Chakraborty and Guha (2009), Bajar (2014), and Nallathiga (2015) discuss the nexus between variations in infrastructure development and economic performance across the Indian states, they do not empirically examine the factors responsible for differential development of infrastructure. The existing studies on infrastructure development at the state level mainly looked at three aspects viz., determinants of per capita infrastructure expenditure (Mohanty et al. 2017); drivers of public-private partnerships (PPPs) in the infrastructure sector (Anant and Singh; 2009; Kaur & Malik, 2020); divergence in infrastructure development and economic growth (Pillai, 2008; Pradhan, 2017; Rasul and Sharma, 2014; Umdor & Panda, 2007), etc. Overall, to the best of our knowledge, there is no study that empirically examined the drivers of differential development of infrastructure stocks at the state level in India. Therefore, it is imperative to understand the factors that explain the variations in infrastructure development across the Indian states. It would help understand why the different Indian states have attained different levels of economic development. The present study aims to help fill this research gap.

Our study empirically examines how economic, fiscal, demographic, social, institutional, and political factors have influenced infrastructure development across the Indian states. Unlike previous studies (Ari and Toivanen, 2005; Billon, 2010; Cerra et al., 2017; De, 2010) that have focused on a particular type of infrastructure or a relatively narrow range of infrastructure indicators, we consider a wider range of infrastructures (altogether 13 types of infrastructures). We group them into three categories – physical, social, and financial – infrastructure. Each of them is represented by an index that is built using principal component analysis (PCA) over annual stocks of relevant infrastructures. The physical infrastructure index includes road, rail, power, and telecommunication indicators. The social infrastructure index includes education and health infrastructure indicators. The financial infrastructure index covers access to finance and financial institutions. We use the latest panel cointegration and GMM systems to account for state-specific heterogeneity and endogeneity and empirically examine the potential factors determining these three types of infrastructure indices across states. The possible factors include economic factors (e.g., gross regional products or GRP and the ratio of gross capital formation to GRP), financial factors (e.g., interest rate, yields on bond markets, foreign direct investment, etc.), demographic and cultural factors (e.g., population density, cast structures, rate of urbanization, etc.), political/institutional factors (e.g., alignment

of central and state governments, governance/corruption, etc.). The period of analysis chosen for the empirical analysis is from 2005 to 2019.[3] Overall, we find significant differences in infrastructure development across the major Indian states though the inter-state disparity in infrastructures has moderated over the years. Our results reveal that economic performance, financial sector development, complementary infrastructures, political factors, capital, and social expenditure played a vital role in driving the performances of three categories of infrastructures. However, there exist significant differences in determinants of different categories of infrastructure.

The rest of the paper is structured as follows. Section 2 presents a brief review of empirical work in developing countries, including India. Section 3 reports the Methodology - Variables, Data, and Techniques - used for the empirical analysis. Section 4 analyses trends in infrastructure development across the major Indian states. Section 5 details the empirical analysis, and in the end, key conclusions and policy implications are presented.

2. Literature review

The impacts of infrastructure development on economic growth and income distribution have been well investigated and the impacts are mostly positive in the case of developing economies (Timilsina et al. 2021). However, the variations in infrastructure endowment across the nations, more specifically across sub-national economies (regions/states/provinces), have not been explained well in the literature. Even if some studies exist investigating this issue for some economies, studies for India are limited. In this section, we briefly review empirical studies that examine the factors determining infrastructure development in developing countries as well as India

2.1. The empirical literature for other developing countries

A few empirical studies exist analyzing the factors causing the variations in infrastructure endowment across countries and different regions (Cerra et al. 2017; Guarara et al. 2017; Dao, 2008; Banerjee et al. 2006)). Using a panel of 110 countries for the 1990-2013 period, Cerra et al. (2017) examine factors affecting the endowment of roads, power, and telecom infrastructure. They find that level of public expenditure is the primary factor. Besides,

[3] 2005 represents financial year (FY) 2004-05 and 2019 represents FY 2018-19.

income levels, urbanization rate, population density, fertility, access to finance, and the rule of law are also critical for accumulating infrastructure stocks. Similar findings are reported by Randolph et al. (1999) when analyzing the factors affecting investment in transportation and communication infrastructure in 27 low and middle-income economies for the period 1980-86. They show that economic development, urbanization rate, trade openness, government expenditure, and labor force participation rate significantly impact the per-capita infrastructure spending. Banerjee et al. (2006) find increasing importance of private finance to accumulate infrastructure stocks. Using panel data from 40 developing countries during the 1990-2000 period, it shows factors that are necessary for attracting private investment (e.g., property rights, strong and fair judicial system, strong regulatory system, better contract enforcement, and a low risk of expropriation of assets) are also instrumental for those infrastructures where the private sector can play a bigger role (e.g., power generation, telecommunication, toll roads). Dao (2008) further explains the complementarity between the private and public investment in infrastructure through a study using infrastructure data from 27 developing countries. It finds that public investment complements private investment. However, public expenditure on education is found to compete with spending on telecommunication and water resources. In low-income countries, however, physical infrastructure with the exception of cellular telephone systems, is primarily provisioned by the public sector (Guarara et al. 2017). Grants and concessional loans from development partners also played an important role in infrastructure funding in such countries. Analyzing the macroeconomic risks associated with infrastructure booms in 105 advanced and emerging economies, Walsh *et al.* (2011) find that economic growth and availability of financing (e.g., developed capital market and institutions), affect infrastructure investments.

In the case of Latin American countries (LACs), Cerra et al. (2016) find a large variation in infrastructure development. Some of the factors contributing to the variations are different levels of public investment in infrastructure, different degrees of private sector participation, interdependence among types of infrastructure, large gaps in per capita income, rate of urbanization, the disparity in access to finance and institutional capacities to enforce rules and regulation. They also find that fiscal policies and institutions play a critical role in improving the infrastructure network. Similarly, Lora (2007) assesses the impact of the state of public finances on public infrastructure investment (PII) in seven LACs. The results indicate that increase in public debt leads to increases in PII, while exogenous debt (exogenous is

defined as debt changes that are not the result of public investment in infrastructure) does not reduce PII.

In South Asia, with a focus on Bangladesh, India, and Sri Lanka, Jha and Arao (2018) find that both total and private investment in infrastructure depends on the country's level of economic development, market size, access to finance, and quality of institutions. The study suggests that the promotion of infrastructure investment requires greater leveraging of the private sector, which depends on the quality of public institutions and an effective regulatory framework for enforceability of contracts and resolution of insolvency. Public-private partnerships (PPPs) are the vehicles for private sector participation in infrastructure development in developing countries. Sharma (2012) examines the determinants of PPPs in infrastructure and finds that the size of the economy and per capita income are major determinants of PPPs in developing countries, along with macroeconomic stability, governance, and quality of regulation. In the Indian case, Jadhav and Choudhury (2019) examine the determinants of PPPs in the infrastructure sector for India, where they find that market size, macroeconomic stability, exchange rate, and governance are major determinants of PPPs in the infrastructure sector. Similarly, Nataraj (2007) finds that the private sector plays a major role in developing the telecom and energy sectors in South Asia, but it has a limited role in providing water and sanitation services because these services are considered the government's responsibility in the region.

There exist large variations in infrastructure provisions among the different African countries. While a few countries (the Seychelles, the Arab Republic of Egypt, Libya, South Africa, and Mauritius) are endowed with relatively higher infrastructure facilities, the rest of the region is considered poor in terms of infrastructure provisions (AFDB, 2018). Some studies attempt to understand the reasons behind the disparity in infrastructure development in African countries. Owusu-Manu et al. (2019) show that foreign investors contribute significantly to infrastructure development in the region, although they find a significant negative relationship between FDI and GDP. With an analysis of public external debt servicing on infrastructure expenditure in Zambia over the period 1970-2014, Kapindula (2019) finds that the total debt service has a significant and negative impact on construction value added in the long run. In contrast, gross domestic savings and government expenditure have a significant and positive effect on construction value-added in both the short-run and the long-run.

A few studies have attempted to understand the reasons for differential levels of infrastructure across different cities in developing countries. Arimah (2005), for example, uses the *United Nations Human Settlements Programme*'s global urban indicators database to investigate the determinants of infrastructure spending across cities in developing countries. It finds that investments in infrastructure are low for cities in Africa and Asia, moderate in the Middle East and economies in transition, and comparatively high in the LAC region. The intercity variations depend upon the macroeconomic environment, urban growth rate; quality of governance; and the financial capacity of city governments.

2.2. Previous studies on determinants of infrastructure development in India at the state level

Existing studies examining the factors influencing infrastructure investments in India include Mohanty et al. (2017), Pradhan (2017), Rasul and Sharma (2014), Ghate (2008), Pillai (2008), and Umdor & Panda (2007). Ghate (2008) develops theoretical models and proves that the fixed cost of accessing the modern sector, the initial level of infrastructure, the wealth of median voters, and corruption explain variation in infrastructure investment across states. Therefore, reducing the fixed cost of accessing the modern sector and reducing corruption and appropriate credit policy will attract investment in infrastructure. Mohanty et al. (2017) analyze factors affecting per capita infrastructure expenditure in 14 major Indian states for the 1991-2010 period. They find different levels of resource mobilization, per capita income, and population density explain the differences in infrastructure levels in these states. However, other factors such as public investment, political stability, and interdependence in infrastructure spending among states are also important factors. The present study differs from Mohanty et al. (2017) in multiple ways. First, our study tries to empirically find out the drivers of infrastructure development in stock form for three categories of infrastructure – physical, social, and financial, whereas Mohanty et al. examine the determinants of per capita infrastructure (flow) expenditure on economic and social infrastructure. The outcome of per capita expenditure leading to the real stock of infrastructure differs from state to state, given the heterogeneity of states in terms of efficiency, governance, geographical location, etc. Second, we make a composite index of infrastructure development for physical, social, and financial infrastructure by multiple indicators to reflect the real level of infrastructure development. Third, we explore more control variables and carry out multiple functions for the robustness of the results.

The private sector increasingly plays an important role in infrastructure development in India, mainly through PPPs. Few studies looked at the drivers of PPPs at the state level. Anant and Singh (2009) analyze the differential participation of PPPs in road infrastructure projects across states. They find that more prosperous states are more successful in attracting PPPs and PPPs are successful for road projects connecting mega cities in richer states. Further, ceteris paribus, better governance attracts private investment in road infrastructure through PPPs. Kaur & Malik (2020), while examining the determinants of PPPs at the state level for the 2008-2017 period, find that fiscal compulsions, financial sector development, and institutional quality matter to PPPs to participate in infrastructure projects. However, they do not find any political factor influencing PPPs at the state level.

A few studies have also looked at the infrastructure development of individual states. Pillai (2008) analyses infrastructure development in Kerala over four decades, from 1960 and 2000. The study finds that the relatively higher (more than the national average) infrastructure development index of Kerala is mainly attributed to the perspective planning of the state focusing on improving the standard of living. The demand from the literate public for better infrastructures and higher government expenditure on the provision of public services, particularly social services, led to a higher social and economic infrastructure than the national level. Maparu et al. (2021) find long-term causality from urbanization to transport infrastructure for the Indian states from 1991 to 2011, thereby establishing that urbanization demands more investment in transport infrastructure.

Pradhan (2017) examines variation in infrastructure development across districts in Odisha over two points 1994-95 and 2011-12. The study concludes that infrastructure development is mostly concentrated in developed eastern coastal districts. Overall, there has been slow and uneven progress in infrastructure development across districts. Rasul and Sharma (2014) examine the factors influencing infrastructure provisions in Bihar and Uttar Pradesh. Umdor & Panda (2007) do the same for the Northeastern states. Both studies conclude that the lack of infrastructure is due to weak institutions, political and social instability, poor governance, and low public and private investment. Although the studies by Pillai (2008); Pradhan (2017); Rasul and Sharma (2014); Pradesh. Umdor & Panda (2007) look at infrastructure development at state and district levels and link it with economic performance, the analysis is merely descriptive exploration without any empirical validation. Overall, to the best of our knowledge, we don't find any study which empirically examines the drivers of differential development of infrastructure stocks at the state level in India.

3. Methodology: Variables, Data, and Techniques

3.1. Identification of Dependent variables: Infrastructure Development Indices

Most of the earlier studies have considered one or a few individual infrastructure indicators separately as a proxy for infrastructure development (Straub, 2008; Calderon, 2009). In this study, we develop infrastructure indices using principal component analysis (PCA) procedure. The separate infrastructure indices have been developed, each for physical, social, and financial infrastructure. Both physical and social infrastructure indices use four types of infrastructure indicators, while the financial index uses three types of financial indicators (see Table 1 for details). Given these infrastructures are measured in different units and there exists a wide variation within States, variables are standardized for facilitating comparison. The standardized parameters were scaled down to make them unit free by using the following formula:

$$X_{scaled\ down} = \frac{X - \min^{*}(X)}{\max(X) - \min^{*}(X)}$$

where X = observed value for any parameter across the states, $\min^{*}(X) < \min(X)$, i.e., min* is less than the minimum value of the parameters across states and avoids zeros in scaling down, and max (X) is the maximum value of the parameter across the states.

Scaled-down parameters are used for index construction by applying the PCA method.[4] In this context, components having eigenvalues greater than unity have been retained for constructing three indices**:** Physical, Social, and Financial Infrastructure Indices. Once the principal components have been identified using the eigenvalue criteria, the factor loadings are multiplied with the corresponding values of the variables (scaled-down values) and summed up to produce the Infrastructure Index.

[4] In constructing PCA, we pool the data parameter-wise across time and state.

3.2. Identification of Potential Determinants of Infrastructure Development

The possible determinants of infrastructure development, based on both theoretical and empirical literature, can be broadly categorized as economic, fiscal, demographic, institutional, and political factors. Below we discuss some of the major determinants.[5]

Level of Economic Development (GSDP or Per capita GSDP): The level of economic development or economic growth contributes to infrastructure development from both demand and supply sides. On the demand side, higher per capita income leads to greater demand for infrastructural facilities, on the lines of Wagner's hypothesis.[6] The higher economic growth can improve living standards and, correspondingly, increase the demand for infrastructural facilities, such as transport, telecom, and power (Randolph et al.,1999; Vinogradova et al., 2015; Sharma, 2012; Jadhav and Choudhury, 2019). On the supply side, a higher economic growth results in higher tax and non-tax revenues for the government and profits for the private sector leading to more public and private investment in infrastructure (Randolph et al.,1999; Arimah, 2005). Additionally, higher economic development levels result in a more favorable business environment, which promotes greater investment and, thereby, a higher level of infrastructure facilities (Esfahani and Ramirez, 2003). The pattern of development, particularly the change in economic structure, also matters to the composition of infrastructure stocks. For example, the share of the manufacturing or degree of industrialization influences physical infrastructure development, whereas services-led growth contributes to the social and financial infrastructure. We consider per capita income for understanding the relationship between standard of living and infrastructure development. Alternatively, we also consider GSDP to examine whether the size of the economy (Sharma, 2012; Jadhav and Choudhury, 2019) matters to infrastructure development.

Investment Rate (Gross Capital formation as a ratio of GSDP)/ Public Capital Expenditure): A higher investment in infrastructure - like transport, communication, energy, health, education, housing, science, and technology- directly increases the supply of infrastructure

[5] Here we discuss only a few major determinants. Please see Table 1 for full list of potential variables used in the empirical analysis.

[6] Wagner's hypothesis suggests that the size of public sector or government expenditure is a function of increasing economic activity or growth. Increase in per capita income demands provision of public services thereby resulting in higher government expenditure on both social, economic and financial infrastructures.

facilities. Indirectly, an investment increases infrastructure demand through its multiplier effect on the economy by increasing aggregate demand (Ramey, 2020). Alternatively, we also consider public capital expenditure as government capital expenditure positively affects the provision of infrastructure facilities - transport, communication, energy, health, education, housing, etc. - and also attracts private investment into the infrastructure sector (Mallick, 2013a; Okolo et al. 2018). Further, government expenditure can correct regional imbalances and promote investment and infrastructure development (Mohanty et al., 2017). Therefore, states with higher investment or public spending on infrastructure are expected to have higher levels of infrastructure development.

Urbanization: A higher level of urbanization generates greater demand for infrastructure facilities - such as transport, power, electricity, water supply, telecommunications networks, schools, and hospitals – which leads to higher infrastructure growth (Démurger, 2001 and LI, 2017; Maparu et al. 2021). Therefore, more urbanized States are likely to have more infrastructure facilities due to increased demand for such facilities. However, it is possible that urbanization could lower the per capita infrastructure facilities because of higher housing /population density in urban areas (Randolph et al.,1999).

Internal debt: The level and uses of internal debt – total government debt of the state governments - could have a positive or negative effect on infrastructure development (Aschauer, 2000; Aizenman et al., 2007). A larger debt leads to higher debt service obligations and pushes the interest rate, thereby affecting infrastructure investment (Winter, 2017). However, the debt incurred to finance productive investment results in infrastructure development in an economy (Aizenman et al., 2007).

Financial development: The financial development of an economy – developed banking sector, bond markets, and long-term financial institutions - are vital for infrastructure development as they mobilize savings, provide credits and diversify risks (Huang, 2010). Infrastructure projects are generally long-term projects and require long-term financing at reasonable interest rates. Therefore, a well-developed financial system is essential for financing infrastructure projects.

Population Density: Higher population density demands the provision of infrastructure facilities and ceteris paribus results in higher levels of infrastructure development (Glover and Simon, 1975). In a democratic setup, the political economy justifies providing infrastructure services in densely populated areas. Further, economies of scale associated with infrastructure

can result in higher optimal levels of infrastructure provisions in more densely populated areas (Randolph et al.,1999). However, it is possible that densely populated areas could lower the per capita infrastructure facilities. Therefore the impact of population density on infrastructure is ambiguous.

The proportion of Scheduled Castes (SC) and Scheduled Tribes (ST) in the Population: People belonging to marginalized castes and tribes tend to experience a high degree of economic and social deprivation, which limits their access to key infrastructure services (Throat, 2007). Given the generally low social and economic status of the SC/ST population, their demand for infrastructure, particularly for social and financial infrastructure, is lower. Moreover, individuals from such communities usually have lower representation in important political and economic decision-making processes, leading to the lower provision of public infrastructure for them (UNDP, 2010). Thus, states with a higher proportion of SC/ST population are expected to lag in infrastructure development.

Geographical factors like terrain (hilly states and states with high levels of forest cover) and access to the coastline could also influence the level and pace of infrastructure development, particularly physical infrastructure development. A preliminary test of the model (to be presented later) found a very weak relationship between physical infrastructure and geographical factors. Therefore, we did not consider the geographical factors to reduce the number of variables.

Complementarity among Infrastructures: The empirical literature suggests that there exists complementarity among different kinds of infrastructure services. The development of one set of infrastructure facilities can lead to the development of other types of infrastructure through positive externalities (Matous, 2017 and Cerra et al. 2017). For example, physical infrastructure development can increase demand for social and financial infrastructure and vice-versa.

Political factors/Institutions: India has a federal fiscal system where vertical fiscal imbalances exist as the central government has lucrative revenue sources, whereas states have more expenditure responsibilities. In a democratic setup like India, the governments at the center and states are governed by different political parties and also the same political parties. States which are governed by the same political party (or a coalition of parties) as in the center are better placed in terms of financial flows, coordination, and policy consistency. The reverse might be when different parties form governments in the states and the center. Some states that belong

to the 'special category' (Assam and HP) possess different fiscal arrangements with the central government and receive certain fiscal privileges such as 90% of expenditure covered by the central government on centrally sponsored schemes, preferential central funds, concessional excise duties, tax exemptions, a fund for infrastructure development. These fiscal supports are included in the corresponding variables, such as capital expenditure, investment, internal debt, and per capita income.

3.3. Data Sources, Model Specifications, and Econometric Methodology

Data Sources: A balanced data set covering 18 major Indian states over the period 2005 to 2019 has been used for this study.[7] Data has been compiled from various official sources such as the Reserve Bank of India, Centre for Monitoring Indian Economy, different Central Government Ministries, and Census, 2011. A detailed list of variables, definitions, period of study, and sources are presented in Table 1.[8]

Table 1: Variables Name, Definition, and Sources

Index/Variable	Definition	Period of Study	Sources
Physical Infrastructure			
Road density (sq. km (Road)	The ratio of the State's total road length to land area	2005 to 2019*	RBI
Rail density (sq. km (Rail)	The ratio of the State's total rail network to the State's land area	2005 to 2019	RBI
Telecom Density (TEL)	*Telephone* (fixed-line plus mobile) connections per 100 people	2005 to 2019	RBI
Per Capita Installed power capacity (KW) (POWER)	Installed power generation capacity per person	2005 to 2019	RBI
Social Infrastructure			
School Density (SCH)	School per 1000 people	2005 to 2019	CMIE
Teachers (TCH)	School teachers per 1000 people	2005 to 2019	CMIE
Hospital Beds (BED)	Hospital Beds per 1000 people	2005 to 2019	CMIE
Doctors (DOC)	Allopathic doctors registered with the State Medical Councils/Medical Council of India per 1000 people	2005 to 2019	Ministry of Health & Family Welfare
Financial Infrastructure			
Bank Accounts (AC)	Bank Accounts per 1000 people	2005 to 2019	RBI
Bank Branches (BB)	Bank Branches per million people	2005 to 2019	RBI
Post office (PO)	Post office per million people	2005 to 2019	Department of Post
Control Variables			

[7]The selection of states and time period are based on consistent data availability. The study is also fairly representative as it covers 18 major states that accounts for 88 percent of GDP and 93 percent of population in India.

[8]Although the roles of good institutions and favorable business climate play a critical role in promoting infrastructure development, we could not include them in this study due to unavailability of reliable and consistent data over the study period at the state level in India.

Gross State Domestic Product (GSDP)	Gross State Domestic Product (base 2011-12)	2005 to 2019	RBI
Per capita GSDP (PGSDP)	The ratio of Gross State Domestic Product to the total population (base 2011-12)	2005 to 2019	RBI
Urbanization Rate (UR)	The ratio of the urban population to the total population	2005 to 2019	RBI
Investment (INV)	Gross fixed capital formation as the ratio of GSDP	2005 to 2019	RBI
Capital expenditure[9] (CEXP)	Capital expenditure as a ratio of GSDP	2005 to 2019	RBI
Population density (PDEN)	Population density (per sq.km.)	2005 to 2019	Census, 2011
Internal debt (DEBT)	The internal debt of state government as the ratio of GSDP	2005 to 2019	RBI
Political Dummy (Dummy)	Dummy variable to capture whether both State and central govt. are from the Same party or in the same coalition	2005 to 2019	Authors' compilation
Share of Services sector to GSDP (SSER)	Share of Services sector to GSDP	2005 to 2019	RBI
Share of the manufacturing sector to GDP (SMNF)	Share of the manufacturing sector to GDP	2005 to 2019	RBI
Schedule Cast and Schedule Tribe people (SC/ST)	Percentage of Schedule Cast and Schedule Tribe people to the total population	20005 to 2019	Census, 2011

Source: Author's compilation.
*2005 to 2019 refers to Financial Year (FY) 2004-2005 to FY 2018-19. Therefore the estimation period includes 15 years of annual data.

Model Specifications: To identify the various factors that explain differential development of infrastructure (physical, social and financial) across states, the study uses the following three models:

$$PINFRA_{it} = \beta_0 + \beta_1 PINFRA_{t-1} + \beta_2 (GSDP/PGSDP)_{it} + \beta_3 (INV/CEXP)_{it} + \beta_4 UR_{it} + \beta_5 PDEN_{it} + \beta_6 CRE_{it} + \beta_7 SCST_{it} + \beta_8 SMNF_{it} + \beta_9 DEBT_{it} + \beta_{10} SINFRA_{it} + \beta_{11} D + u_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The expected sign of (β_1, β_2, β_3, β_4, β_5, β_6, β_8 and β_{10}) > 0, whereas the coefficient of β_7 and β_9 < 0.

$$SINFRA_{it} = \mu_0 + \mu_1 SINFRA_{t-1} + \mu_2 (GSDP/PGSDP)_{it} + \mu_3 (INV/CEXP)_{it} + \mu_4 UR_{it} + \mu_5 PDEN_{it} + \mu_6 CRE_{it} + \mu_7 SCST_{it} + \mu_8 SSER_{it} + \mu_9 DEBT_{it} + \mu_{10} PINFRA_{it} + \mu_{11} D + \varepsilon_{it} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

The expected sign of (μ_1, μ_2, μ_3, μ_4, μ_5, μ_6, μ_{10}) > 0, whereas the coefficient of μ_7 and μ_9 are < 0.

[9] Capital expenditure consists of all possible items of investment.

$$FINFRA_{it} = \alpha_0 + \alpha_1 FINFRA_{t-1} + \alpha_2(GSDP/PGSDP)_{it} + \alpha_3(INV/CEXP)_{it} + \\ +\alpha_4 UR_{it} + \alpha_5 PDEN_{it} + \alpha_6 SCST_{it} + \alpha_7 SSER + \alpha_8 DEBT_{it} + \alpha_9 (PINFRA/SINFRA)_{it} + \\ \alpha_{10} D + \omega_{it} \quad \text{……..... (3)}$$

The expected sign of (α_1, α_2, α_3, α_4, α_5, α_7, and α_{10}) > 0, whereas the coefficient of α_6 and α_8 are < 0.

Where PINFRA is the physical infrastructure index, SINFRA is the social infrastructure index; FINFRA is the financial infrastructure index, GSDP is the gross state domestic product, PGSDP is the per capita GSDP, UR is the urbanization rate, INV is the investment as a ratio of GSDP, CEXP is the capital expenditure of states, PDEN is the population density (per sq.km.), Debt is the internal debt as a ratio of GDP, CRE is the per capita bank credit, SMNF is manufacturing GDP, SSER is services sector GDP and SCST is the percentage of SCST population. Dummy (D) is the dummy variable used to capture political factors (whether both state and central governments are from the same party or part of the same coalition government). D takes the value of 1 if the center and State governments belong to the same ruling or coalition party, while it is 0 in other cases. Lag levels of dependent variables are included to capture the dynamic aspects of the data.

The above three equations (Equations 1, 2, and 3) are estimated separately using the dynamic panel model (GMM System proposed by Arellano and Bond, 1998). Given that our dependent variable (infrastructure index) is dynamic and depends on its past values, a Dynamic model (System GMM) is appropriate and it has advantages over fixed, random, or GMM difference estimators. The literature suggests that there exists two-way causality between infrastructure and economic growth. For instance, studies such as World Bank, 1994; Straub, 2008; Calderon, 2009 empirically prove infrastructure positively affects economic growth. On the other hand, studies by Munnell, 1992; Gramlich, 1994 find that economic growth stimulates infrastructure development. Therefore, there is the possibility of a two-way dynamic relationship between the two. To avoid the potential endogeneity, our study applies dynamic panel estimates (GMM-system) proposed by Arelleno and Bond (1998), which considers the endogeneity problem and removes the weak instrumental problem of the GMM model. In addition, the GMM system not only controls potential endogeneity and heterogeneity but also improves the efficiency of estimates by including original levels instruments with the difference (Roodman, 2009). Further, unlike other estimators, the system GMM does not require any assumption about distribution (Verbeek, 2000). More importantly, when the cross-

section (N) is higher than the time series unit in panels (as in our case), the GMM system is more appropriate (Roodman, 2009).

4. Trends in Infrastructure Development across the Major Indian States

This section ranks 18 major Indian states based on each of the three infrastructure development indices - physical, social, and financial - over the 2005 to 2019 period. The states are also ranked based on selected infrastructure facilities, such as road, rail, telecommunication, and electric power under physical infrastructure; school density, number of teachers, hospital beds, and number of doctors under social infrastructure; and bank accounts, bank branches, and post offices under financial infrastructure (see Tables A1, A2, and A3 in Appendix A).

Physical Infrastructure: The rankings of the states concerning overall physical infrastructure development for three different points of time (2005, 2010, and 2019) are presented in Table 2. It is evident from the index score that there exist wide interstate variations in terms of the availability of physical infrastructure facilities even though the coefficient of variation (CV) marginally dropped over the period. For the year 2005, Punjab topped the rankings, followed by Kerala and Himachal Pradesh. In contrast, Chhattisgarh, Bihar, and Jharkhand occupied the bottom three positions. The relative positions of the states remained more or less the same in 2010 and 2019, with minor changes in the top positions.[10] However, in the year 2019, Andhra Pradesh dropped significantly in the rankings to occupy one of the bottom positions along with Bihar and Jharkhand. This is due mainly to the division of states in 2014-15. The division of the state was followed by a dismal performance in the road network and power sector. It also suffered from the deteriorating performance of the banking sector. On the other hand, Chhattisgarh has seen a significant improvement in its relative position mainly due to improved electricity capacity. Chhattisgarh has increased access to electricity to almost 100 percent of households by 2019.[11]

Table 2: Relative Performances of States for Physical Infrastructure Index

	2005		2010			2019		
States	***Score***	***Rank***	***State***	***Score***	***Rank***	***State***	***Score***	***Rank***
Punjab	0.532	1	Kerala	0.941	1	HP	1.791	1
Kerala	0.513	2	Punjab	0.896	2	Punjab	1.729	2

[10] However, in the year 2019, Andhra Pradesh dropped significantly in the rankings, possibly due to division of the state, to occupy one of the bottom positions along with Bihar and Jharkhand.

[11] The state has augmented coal-fired power generation along with smart city infrastructure, https://csis-website-prod.s3.amazonaws.com/s3fs-public/publication/190920_U.S.IndiaState_Chhattisgarh_FINAL_update_v2.pdf.

HP	0.414	3	HP	0.808	3	Tamil Nadu	1.649	3
Tamil Nadu	0.393	4	Tamil Nadu	0.746	4	Kerala	1.535	4
Karnataka	0.381	5	Gujarat	0.692	5	Gujarat	1.506	5
Haryana	0.351	6	Haryana	0.659	6	Karnataka	1.457	6
Gujrat	0.348	7	Karnataka	0.636	7	Haryana	1.294	7
Maharashtra	0.302	8	Maharashtra	0.605	8	Maharashtra	1.284	8
Andhra	0.270	9	WB	0.552	9	Chhattisgarh	1.132	9
Assam	0.255	10	Andhra	0.542	10	Rajasthan	1.062	10
Odisha	0.210	11	Chhattisgarh	0.479	11	WB	0.973	11
Rajasthan	0.208	12	Rajasthan	0.451	12	Assam	0.952	12
WB	0.202	13	Assam	0.416	13	Odisha	0.934	13
UP	0.172	14	MP	0.394	14	MP	0.920	14
MP	0.160	15	Odisha	0.381	15	UP	0.837	15
Chhattisgarh	0.125	16	UP	0.367	16	Bihar	0.696	16
Bihar	0.109	17	Bihar	0.301	17	Jharkhand	0.612	17
Jharkhand	0.097	18	Jharkhand	0.253	18	Andhra	0.462	18
CV	47.3			39.5			34.3	

Source: Author's calculations. C.V- Coefficient of Variations

Social Infrastructure: Table 3 reports the score for the social infrastructure index and the relative ranking of the states. Like physical infrastructure, there is wide variation in social infrastructure across states, although the disparities have declined from 2010 to 2019. States such as Himachal Pradesh, Karnataka, and Assam are in the top ranks, whereas Uttar Pradesh, Jharkhand, and Bihar feature in the bottom positions. The relative positions of states have remained more or less constant, barring a few exceptions. For example, the relative position of Maharashtra has worsened (Rank 3 in 2005 to 11 in 2019), whereas Chhattisgarh and Assam have improved their respective ranks during the same period.

Table 3: Relative Performances of States for Social Infrastructure Index

	2005		**2010**			**2019**		
States	***Score***	***Rank***	***State***	***Score***	***Rank***	***State***	***Score***	***Rank***
HP	1.652	1	HP	1.669	1	HP	1.868	1
Karnataka	1.071	2	Karnataka	1.313	2	Karnataka	1.400	2
Maharashtra	1.061	3	Kerala	0.984	3	Assam	1.379	3
Kerala	0.958	4	Chhattisgarh	0.908	4	Kerala	1.344	4
Tamil Nadu	0.899	5	Maharashtra	0.883	5	Tamil Nadu	1.281	5
MP	0.895	6	Rajasthan	0.876	6	Chhattisgarh	1.212	6
Rajasthan	0.888	7	Odisha	0.870	7	Rajasthan	1.158	7
Gujarat	0.808	8	MP	0.787	8	Punjab	1.154	8
Odisha	0.800	9	Assam	0.775	9	WB	0.977	9
Assam	0.788	10	Andhra	0.752	10	MP	0.963	10
Punjab	0.692	11	Punjab	0.727	11	Maharashtra	0.939	11
Chhattisgarh	0.679	12	Tamil Nadu	0.703	12	Odisha	0.903	12
WB	0.655	13	Gujarat	0.689	13	Gujarat	0.864	13
Andhra	0.612	14	WB	0.630	14	Haryana	0.806	14
Haryana	0.448	15	Jharkhand	0.460	15	Andhra	0.780	15
UP	0.354	16	UP	0.410	16	UP	0.752	16
Jharkhand	0.168	17	Haryana	0.396	17	Jharkhand	0.665	17

Bihar	0.121	18	Bihar	0.304	18	Bihar	0.395	18
C.V.	47.1			41.8			32.7	

Source: Author's Calculations. C.V- Coefficient of Variations

Financial Infrastructure: Table 4 compares the performances of different states in terms of the financial infrastructure index, where we find large inequality among the states. Though the variations across states in financial infrastructure over time have narrowed down, the CV is still high. The CV is higher for financial infrastructure than physical and social infrastructure for all three-time points. Additionally, the relative positions of states have not changed much from 2005 to 2019. Exceptions include Haryana and Chhattisgarh experienced significant improvement in their relative positions, whereas Andhra Pradesh witnessed deterioration in its position and is among one of the worst-performing states along with Uttar Pradesh and Bihar.

Table 4: Relative Performances of States for Financial Infrastructure Index

	2005		**2010**			**2019**		
States	***Score***	***Rank***	***State***	***States***	***Score***	***Rank***	***State***	***States***
HP	1.505	1	HP	1.624	1	HP	2.277	1
Punjab	0.780	2	Kerala	0.950	2	Punjab	1.789	2
Kerala	0.777	3	Punjab	0.945	3	Kerala	1.733	3
Karnataka	0.677	4	Karnataka	0.841	4	Karnataka	1.500	4
Tamil Nadu	0.625	5	Tamil Nadu	0.788	5	Haryana	1.458	5
Andhra	0.609	6	Andhra	0.680	6	Tamil Nadu	1.372	6
Gujrat	0.538	7	Maharashtra	0.671	7	Maharashtra	1.290	7
Odisha	0.519	8	Gujrat	0.626	8	Odisha	1.128	8
Maharashtra	0.471	9	Haryana	0.617	9	Gujrat	0.932	9
Haryana	0.443	10	Odisha	0.601	10	Rajasthan	0.847	10
Rajasthan	0.438	11	Rajasthan	0.472	11	WB	0.809	11
MP	0.305	12	WB	0.367	12	Chhattisgarh	0.754	12
WB	0.291	13	MP	0.349	13	MP	0.722	13
Assam	0.282	14	Jharkhand	0.335	14	Jharkhand	0.718	14
Jharkhand	0.281	15	Chhattisgarh	0.326	15	Assam	0.672	15
Chhattisgarh	0.278	16	Assam	0.324	16	UP	0.671	16
UP	0.249	17	UP	0.311	17	Andhra	0.640	17
Bihar	0.143	18	Bihar	0.143	18	Bihar	0.440	18
C.V.	61			56.8			46	

Source: Author's Calculations. C.V- Coefficient of Variations

Overall, we find inter-state variation in all three infrastructure indices, but there has been a gradual reduction in interstate disparities measured by the coefficient of variation from 2005 to 2019 (Figure 1). While some states like Kerela, Himachal Pradesh, Tamil Nadu, and Karnataka have performed well across all three indices, States like Bihar, Uttar Pradesh, and Jharkhand have underperformed and lagged behind the remaining states. Figure 2 reports inter-state variation (Coefficient of variation) in per capita income growth, investment rate, and

social and capital expenditure from 2005 to 2019. While there has been a decrease in interstate disparity for per capita income growth, we observed an increase in inter-state disparity for investment rate over 2005-19. In contrast, there has been no such clear trend observed for capital and social expenditures. However, an increase in inequality in investment rates (Figure 2) along with other factors may have contributed to the continued and significant differences in infrastructure levels among the Indian states as investment is one of the crucial determinants of infrastructure development (Cerra *et al*. 2017; Vinogradova et al., 2015).

Fig 1: Variations in Infrastructure Development

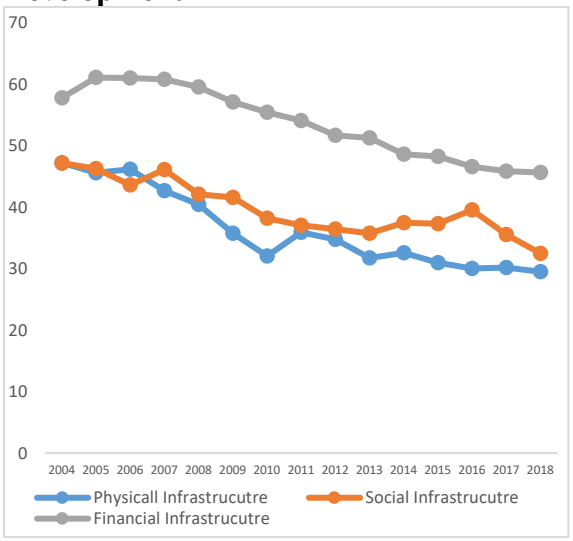
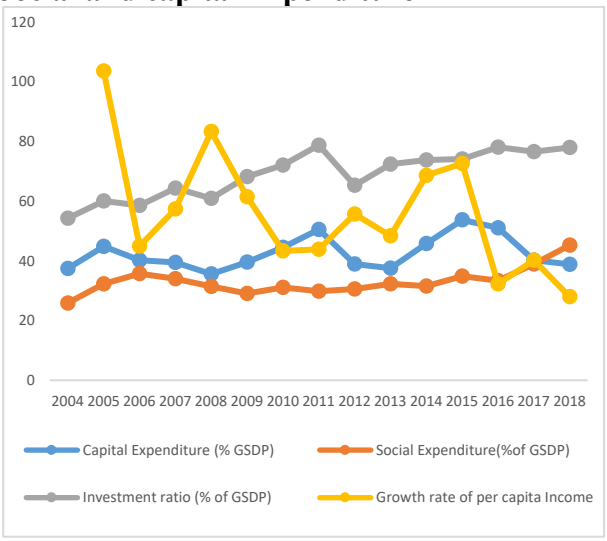


Fig 2: Variations in Per Capita investment, Social and capital Expenditure



Source: Author's calculations

We also plot the two-way relationship between infrastructure indices and some of its major determinants (see Appendix C). The graphs indicate that the infrastructure indices are positively associated with economic development, investment rate, capital and social government expenditure, urbanization rate, and financial development level. In contrast, fiscal deficit and debt negatively affect infrastructure development. More importantly, a positive relationship exists between physical-, social-, and financial- infrastructure indices. A few states, Himachal Pradesh, Kerela, and Tamil Nadu, perform well in all infrastructure indices. On the other hand, Bihar, Uttar Pradesh, and Jharkhand are falling behind the remaining states in all three indices.

5. Empirical Analysis: Determinants of Infrastructure Development

The statistical results of the eight different specifications (Equations 1, 2, and 3) are presented in Tables 5, 6, and 7. These results pass through necessary diagnostic tests, including

the Arellano-Bond test of first and second-order serial correlation, the Sargan test of over-identification, and the Hansen test of exogeneity of GMM instruments.

We first check cross-section dependency and stationary properties of all variables by using the Pesaran CD test (2004) and the second generation panel unit root model developed by Pesaran (2007). The CD test suggests the presence of cross-section dependence among variables and therefore, a panel unit that accounts for cross-section dependency is appropriate. The unit root test results using the CIPS test suggest that most of the variables (except FINFRA, and CRE) are non-stationary in their levels or I (1) process (Table-B1, Appendix –B). We then examine the existence of cointegration to establish the long-run relationship by using Westerlund's (2007) panel error correction model (see Appendix-B for details). The cointegration results reveal that the null of no cointegration is rejected by group tests (G_t and G_a) as well panel tests (P_t and P_a) level in favor of the existence of cointegration in the panel (Table-B2, Appendix –B).

5.1. Determinants of Physical Infrastructure

The estimations of the relationship of the physical infrastructure index with its potential drivers are reported in Table 5. The estimations under the baseline model are presented in column 2 with the heading "Model 1". The results under successive models (Model 2 to 8) with additional and alternative determinants[12] of the physical infrastructure index are presented in the rest of the columns. The results reveal that all the potential determinants with the exception of population density, have expected signs and significant effects on physical infrastructure. Infrastructure is highly path-dependent as its past values are significant in all specifications. This indicates that infrastructure development has an inertia effect and is procyclical.

The coefficient of the size of the economy or economic performance (GSDP) is positive and significant across models indicating that the size of the economy is one of the most important determinants of physical infrastructure. The bigger economy size, primarily due to better economic performance/economic growth, increases the demand for infrastructure facilities such as roads, power, and telecom and thereby increases supply (Sharma, 2012;

[12] We use additional and alternatives variables in these 8 specifications to support the robustness of our results. Some of the variables are also corelated, like GSDP, per capita GSDP and population density which we use alternatively. Similarly, investment and capital expenditures are used alternatively. We have also included the lag of the dependent variable to capture the dynamic aspects.

Jadhav and Choudhury, 2019). Higher economic growth also usually translates into higher tax and non-tax revenues for the government and improves the performance of the private sector due to higher demand and capacity utilization. A rise in public revenue and corporate performance can lead to higher infrastructure expenditure resulting in greater physical infrastructure development (Randolph et al.,1999; Arimah, 2005). Higher economic growth leads to improved living standards for the general population and, correspondingly, increases the demand for infrastructure facilities such as transport, telecom, and power (Vinogradova et al. 2015), thereby leading to an increase in the supply of infrastructure services. Similar results are found when GSDP is replaced with per capita GSDP. Therefore, States with higher GSDP (or per capita GSDP) tend to have higher levels of physical infrastructure development. This finding is also supported by literature that suggests that income disparities are one of the major factors for interstate differences in infrastructure levels in India (Nayyar, 2008; Majumder, 2012; Bandyopadhyay, 2012; Ghosh, 2017). Further, the coefficient of share of the manufacturing sector (SMNF) in GSDP has a positive impact on physical infrastructure. It indicates that states with higher SMNF and industrialization have a better physical infrastructure. Moreover, higher manufacturing GDP leads to higher infrastructure development, which facilitates higher manufacturing GDP through backward linkage[13] (Luger et al. 2013). States such as Punjab, Maharashtra, Gujrat, Karnataka, and Tamilnadu have higher manufacturing GDP, and these states have also performed better in physical infrastructure development.

Table 5: Determinants of Physical Infrastructure

Variables	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*	*Model 7*	*Model 8*
Constant	-2.16** (-3.85)	-2.54** (-5.91)	-1.35** (-4.45)	-3.61** (-3.61)	-1.05** (-3.23)	-3.54** (-5.99)	-3.22** (-4.45)	-3.87** (-5.35)
PINFRA$_{t-1}$	0.72** (25.34)	0.65** (19.34)	0.77** (21.54)	0.65** (19.34)	0.77** (21.54)	0.65** (19.34)	0.77** (21.54)	0.65** (19.34)
GSDP	0.24** (3.94)	-	0.11* (2.64)	-	0.20* (2.51)	0.17** (6.22)	0.12** (2.77)	-
PGSDP	-	0.55** (5.10)	-	0.48** (3.66)	-	-		0.31** (7.61)
INV	0.004** (4.93)	0.002** (4.43)	-	-	0.002** (4.62)	0.005** (4.32)	0.006** (5.21)	0.007** (3.12)
CEXP	-	-	0.006* (2.54)	0.007* (2.06)	-	-	-	-
SMNF	0.008** (3.04)	0.012* (2.10)	0.014* (2.45)	0.002** (3.82)	0.012* (2.10)	0.014* (2.45)	0.002* (2.88)	0.002 (0.89)
Debt	-0.004** (-3.64)	-0.006* (2.86)	-0.002** (-3.03)	-0.005** (-3.20)	-0.014* (-2.68)	-0.008 (-1.92)	-0.005* (-2.05)	-0.005* (-2.71)

[13] Infrastructure development boosts industrial development by encouraging the demand for input and helping the ancillary industry to develop through its multiplies effect.

UR	0.008** (8.10)	0.002** (5.42)	0.003** (7.83)	0.005** (5.14)	0.007* (1.99)	0.008** (4.58)	0.002** (5.45)	0.009* (4.14)
CRE	0.003* (2.45)	0.007** (3.04)	0.008** (3.49)	0.008** (3.14)	0.008** (2.14)	0.002* (2.21)	0.006** (3.35)	0.003* (2.79)
SINFRA						0.20** (3.13)	-	-
PDEN	-0.0003* (-2.11)		-0.0003 (-1.71)		-0.0003 (-0.70)	-	-	-
DUM						0.08* (2.04)	0.09* (2.26)	0.11* (2.19)
AR (1) (p-value)	(0.01)	(0.03)	(0.04)	(0.05)	(0.00)	(0.00)	(0.00)	(0.00)
AR (2) (P-value)	(0.12)	(0.18)	(0.46)	(0.11)	(0.09)	(0.20)	(0.12)	(0.11)
Sargan test (P-value)	(0.23)	(0.26)	(0.42)	(0.09)	(0.33)	(0.52)	(0.09)	(0.22)
No. Instruments	26	27	34	37	33	29	41	32
Hansen test of Exogeniety	0.26	0.19	0.12	0.45	0.22	0.08	0.13	0.23

*Notes: ** and * denote significance at 1 and 5 % levels. Figures in the brackets are t-statistics.*

The results also confirm that investment, represented by gross-fixed capital formation, has a positive impact – positive and significant coefficients - on infrastructure levels (see Table 5). All else equal, a 1% increase in investment rate (as a ratio of GDP) causes an increase in the physical infrastructure index score by 0.002 to 0.007%. Higher investment rates increase the supply of infrastructure facilities, directly and indirectly. The latter occurs through its multiplier effect on the economy, which leads to increased demand for infrastructure. The results align with previous studies such as Cerra et al. 2017. Existing studies, such as Nayyar (2008) and Mallick (2013), also suggest that the differences in investment levels[14] across states are responsible for divergence in their income per capita.

We also investigate the role of fiscal variables (capital expenditure and internal debt) in building the stock of physical infrastructure. The coefficient of capital expenditure[15] is positive and significant, indicating that an increase in capital expenditure by State governments leads to physical infrastructure development. The role of public capital expenditure in providing infrastructure, especially in developing countries, has also been highlighted in previous studies such as Castells and Solé-Ollé (2005), Zheng et al. (2013), and Cerra et al. (2017). As expected, internal debt significantly negatively impacts physical infrastructure development. A rise in internal debt increases the debt, leaving fewer resources for infrastructure development. Further, higher debt by states pushes the cost of borrowing by

[14] Factors such as human capital, fiscal and economic factors, state-specific incentives and strategies and labor productivity are found to be the major determinants of investment across states (Mallick, 2013b).
[15] We consider capital expenditure alternatively to investment as the former is part of investment.

raising interest rates and results in lower investment by crowding out private investment and hence lowering infrastructure development (Aschauer, 2000; Aizenman et al., 2007; Winter, 2017).

Among other variables affecting physical infrastructure, urbanization seems to have a positive and significant effect on infrastructure growth. This implies that rising urbanization increases infrastructure facilities, possibly due to increased demand for the latter (Démurger, 2001 and Li, 2017; Maparu et al. 2021). As per the 2011 census, around 31% of the population lives in urban areas, and is expected to rise to more than 50% by 2050 (UN, 2014). The demographic shift will require huge infrastructure expenditures to increase and upgrade the existing stock of infrastructure facilities such as transport, telecom, water, and energy. On the other hand. Population density has a negative impact indicating the dominance of scale impact over the demand impact (Randolph et al.,1999). Financial development proxies - measured as bank credit to GSDP (CRE) are found to impact infrastructure development positively. The development of the financial sector facilitates long-term project financing with a reasonable cost which is vital for infrastructure development (Agrawal, 2000). Similarly, the social infrastructure index (SINFRA) also positively affects physical infrastructure development supporting the complementarity hypothesis among different types of infrastructure facilities (Cerra et al., 2017).

We also find the coefficient of the dummy variable positive and statistically significant. This indicates that if the center and state governments belong to the same political party or in a coalition government, it would have a positive impact on the state's infrastructure development. State governments with the same political party or coalition in the central government tend to get higher support in terms of financial resources and relevant policies (e.g., the central government's support on national highways that pass through the state, building electric power plants and transmission lines, central government's incentives to promote renewable energy) from the central government for infrastructure projects. We also considered the proportion of the SC/ST population, which is found to be statistically insignificant and hence, dropped from our final estimation.

5.2. Determinants of Social Infrastructure

The results of estimating the relationship between the social infrastructure index and the factors affecting it are presented in Table 6. Like in the case of physical infrastructure, GSDP is found to have a positive and statistically significant impact on social infrastructure,

implying that richer states tend to have higher levels of social infrastructure. Higher GSDP raises the money available for social infrastructure spending, leading to greater infrastructure development in these states (Randolph et al.,1999; Arimah, 2005; Vinogradova et al., 2015). However, the GSDP coefficients under the social infrastructure case are smaller than those in the physical infrastructure case thereby implying that economic development has more pronounced impacts on physical infrastructure development than social infrastructure. This may be due to the weak demand factor and priorities of the state government on providing basic physical infrastructure facilities. When GSDP was replaced by per capita GSDP in our model we obtain similar results. Thus, states with higher GSDP or per capita GSDP will have higher social infrastructure development.

In the same vein, investment is found to have a positive and significant effect on social infrastructure development. Greater investment in social infrastructure, such as education, health, housing, and sanitation, leads to a higher supply of such infrastructure services. Additionally, investment in physical and social infrastructure provisions could promote demand for these provisions through the multiplier effect (Vinogradova et al., 2015). The results are in line with the findings in previous studies such as Dao (2008), Cerra et al. (2017), and Vinogradova et al. (2015). More importantly, the services sector GSDP (SSER) also positively affects social infrastructure. An increase in the services sector GDP increases demand for them and induces the supply of social infrastructure. States such as Kerala, Maharashtra, Himachal Pradesh, and Karnataka have higher services GDP. These states have also performed better in social infrastructure development, indicating the positive relationship between the two.

Table 6: Determinants of Social Infrastructure

Variables	***Model 1***	***Model 2***	***Model 3***	***Model 4***	***Model 5***	***Model 6***	***Model 7***	***Model 8***
Constant	-2.65* (-2.53)	-2.57* (-2.70)	-0.54 (-0.57)	-0.01 (-0.05)	-2.53* (-2.32)	-1.11 (-0.42)	-1.77* (-2.47)	-0.24 (-1.08)
$SINFRA_{t-1}$	0.57** (6.87)	0.43** (3.74)	0.36** (5.97)	0.56** (5.88)	0.38** (7.53)	0.26** (4.88)	0.28** (4.88)	0.34** (5.08)
GSDP	0.45* (2.88)		0.40** (2.97)			0.11** (2.07)	-	0.06* (2.02)
PGSD	-	0.72** (3.06)		0.44* (2.44)	0.62** (4.88)	-	0.41* (2.34)	-
INV	0.005** (4.54)	0.004** (3.52)	0.002* (2.12)	0.002* (2.16)	-	-	0.003* (2.66)	0.004** (4.84)
CEXP	-	-		-	0.002* (2.53)	0.003** (2.18)		
SSER	0.005* (2.36)	0.007* (2.57)	0.006** (3.61)	0.01* (2.91)	0.004* (2.53)	0.005 (1.10)	0.012** (5.23)	0.01** (4.28)

UR	0.005 (0.46)	-0.005* (-2.05)	-0.005 (-1.28)	0.001* (1.99)	0.001** (2.34)	0.001** (3.32)	-	0.002* (2.22)
Debt	0.005 (1.66)	0.002 (0.57)	-0.014** (-3.27)	-0.005* (-2.01)	0.003 (1.51)	-0.009** (-3.18)	-0.009* (-2.61)	-0.01** (-3.22)
SCST			-0.02** (-3.57)	-0.008** (-3.01)	-0.001* (-2.78)	-0.002** (-3.47)	-0.002** (-3.11)	-0.01* (-2.75)
CRE	-0.002* (-2.75)	-0.004 (-1.9)	-	-	-	-	-	-
PDEN	0.0003** (3.82)	0.0004* (2.55)	0.001 (1.69)	-	0.0002* (2.38)	-	-	-
FINFRA							0.05* (2.11)	
PINFRA						0.33* (2.49)		
DUM							0.17** (3.12)	0.19** (3.24)
AR (1) (p-value) AR (2)(P-value) Sargan test (P-value) No. Instruments Hansen test of Exogeniety	(0.02) (0.49) (0.17) 23 0.17	(0.02) (0.29) (0.14) 26 0.15	(0.03) (0.425) (0.46) 26 0.45	(0.06) (0.15) (0.17) 24 0.57	(0.00) (0.12) (0.45) 32 0.31	(0.00) (0.33) (0.19) 23 0.60	(0.00) (0.18) (0.41) 27 0.45	(0.02) (0.36) (0.72) 20 0.30

Notes: ** and * denote significance at 1 and 5 % levels. The figures in the brackets are t-statistics.

The study also analyzes the role of capital expenditure on social infrastructure. The coefficient of capital expenditure is found to be positive and significant, indicating that an increase in capital expenditure by the state government leads to higher availability of social infrastructure. Like physical infrastructure, the internal debt ratio is found to have a significant negative impact on social infrastructure, indicating that a high level of internal debt is detrimental to social infrastructure development (Aizenman et al. 2007; Winter, 2017).

The impact of urbanization on social infrastructure is also found to be positive and statistically significant. The result is in keeping with existing literature which suggests that infrastructure facilities like education, health, and housing are important for the urban population, and thus, the supply of such facilities rises with urbanization (Biehl, 1989). It is not surprising to observe that more urbanized states, such as Kerala, Karnataka, Tamil Nadu, and Maharashtra, perform well in terms of their social infrastructure indices. The impact of population density is found to be positive and significant, implying that higher population density increases demand for social infrastructure leading to higher development. These findings are in line with previous findings on infrastructure (Glover, 1976, Frederiksen, 1981; Randolph et al.,1999).

The proportion of SC/STs population in the state also affects the level of social infrastructure development as people belonging to marginalized communities suffer from a higher degree of economic deprivation, social exclusion, and poverty, which limits their access to social and financial services (Thorat, 2007). Thus, states such as Jharkhand, Odisha, and Madhya Pradesh which have a higher share of the SC/ST population, are poor performers in terms of social infrastructure provisions. It has been pointed out that SC/STs have been facing discrimination in accessing education, health, labor market, financial services, and product market, resulting in a higher incidence of poverty and lagging behind social development and having an implication on infrastructure development (Mamgain, 2013).

The current empirical estimation also examines the role played by the physical and financial infrastructure index in promoting social infrastructure. Results from Table 6 suggest that physical and financial infrastructure development positively influences social infrastructure development, implying the presence of complementarity among different types of infrastructure facilities (Cerra et al., 2017). However, financial sector development – as measured by per capita credit – is found to have no significant impact on the availability of social infrastructure, indicating that credit availability is not a significant factor in developing social infrastructure.

Finally, the coefficient of the dummy variable is positive and statistically significant, as given in Table 6. This indicates that when both the central and state governments are from the same party or coalition, it helps increase the provision of social infrastructure facilities in that state as there tends to be greater support from the central government for such activities.

5.3. Determinants of Financial Infrastructure

The factors influencing the financial infrastructure development are reported in Table 7. Like physical and social infrastructure, financial infrastructure is also time persistent and has a significant inertia effect. Further, GSDP or per capita GSDP positively affects financial infrastructure levels. Higher economic status or per capita income stimulates financial development by increasing the demand for financial services (Huang, 2005). All else equal, a 1% increase in GSDP or per capita GSDP is expected to result in an increase in the financial index by around 0.1% percent. The results seem to corroborate the findings in previous studies such as Levine (2005) and Huang (2005). The effect of investment on financial infrastructure provisions is positive and significant. An increase in investment rate is expected to foster financial development as higher investment leads to higher demand for financial products

(Voghouei et al. 2011). Social infrastructure, the services sector GSDP (SSER) also positively affects financial infrastructure as an increase in the services sector GSDP induces higher demand for financial products and simultaneously increases the supply of financial infrastructure.

The impact of debt on financial development is positive and significant, indicating that public debt plays a critical role in promoting financial sector development by providing safe and benchmarking assets (Hauner, 2009). The development of the debt market will broaden the financial sector in India, and that will help finance infrastructure at a reasonable cost. However, the capital expenditure is found to be statistically insignificant and hence, dropped from our final estimation.

Table 7: Determinants of Financial Infrastructure

Variables	***Model 1***	***Model 2***	***Model 3***	***Model 4***	***Model 5***	***Model 6***	***Model 7***	***Model 8***
Constant	-1.32** (-3.21)	-1.24** (-3.39)	-1.78** (-3.44)	-1.33** (-3.27)	-0.58* (-1.97)	-0.37** (-4.27)	-0.94** (-3.57)	-0.68** (-4.48)
$FINFRA_{t-1}$	0.94** (74.34)	0.84** (29.87)	0.92** (67.22)	0.82** (22.25)	0.86** (30.25)	0.83** (30.25)	0.91** (51.65)	0.80** (33.18)
GSDP	0.14** (3.06)		0.10* (2.33)		0.08* (2.33)	0.07** (4.21)	0.11* (2.55)	
PGSDP	-	0.20** (2.55)	-	0.28** (4.14)	-	-	-	0.49* (2.89)
INV	0.002** (4.96)	0.004** (5.98)	0.002* (2.29)	0.003* (2.38)	0.008** (4.47)	0.002** (3.87)	0.001** (3.43)	0.006* (5.48)
SSER	0.003** (3.23)	0.003** (4.21)	0.003* (2.78)	0.003** (4.21)	0.003** (2.95)	0.003** (5.55)	0.004** (4.80)	0.002** (5.55)
UR	-0.0002 (-1.62)	-0.0001 (-0.15)	0.0003 (0.37)	0.002* (-2.15)	-	-	-	-
Debt	0.001* (2.26)	0.001* (2.11)	0.001** (2.24)	0.0001 (0.39)	0.0001 (0.62)	0.0001 (0.75)	0.01 (0.83)	0.0001* (2.18)
PDEN	0.0001** (4.14)	0.0005** (3.95)	0.0001** (3.81)	0.0002** (3.65)	0.0001** (5.53)	0.0003** (3.44)	-	-
SCST	-	-	-0.004* (-2.29)	-0.008** (-3.98)	-0.003* (-2.77)	-0.009** (-4.08)	-0.001* (-2.61)	-0.006 (-1.30)
SINFRA					0.10** (3.07)			
PINFRA						0.08** (2.16)		
DUM							0.06* (3.43)	0.07** (4.02)
AR (1) (p-value)	(0.00)	(0.00)	(0.05)	(0.05)	(0.00)	(0.05)	(0.04)	(0.00)
AR (2)(P-value)	(0.87)	(0.14)	(0.32)	(0.26)	(0.32)	(0.31)	(0.51)	(0.34)
Sargan test (P-value)	(0.11)	(0.07)	(0.07)	(0.09)	(0.08)	(0.15)	(0.08)	(0.13)
No. Instruments	22	22	17	21	22	16	17	16
Hansen test of Exogeniety	0.12	0.06	0.09	0.12	0.06	0.09	0.33	0.21

Notes: ** and * denote significance at 1 and 5 % levels. The figures in the brackets are t-statistics.

The results further indicate that the urbanization rate has no significant impact on financial development. However, we observe a strong positive impact of population density on financial development. A rise in population density increases the demand for financial services resulting in higher financial development. At the same time, it is easy for the financial institution to cover a larger population at a lower cost. In India, there is a significant concentration of financial institutions in major cities where population density is very high, suggesting population density has a strong influence on financial development. This is consistent with findings from existing studies (Allen et al. 2014).

Further, the results reveal that the proportion of the SC/ST population in a state has important implications for its financial infrastructure level. People belonging to SC/ST communities tend to have a lower demand for financial services owing to their poor economic conditions. Moreover, being socially and economically disadvantaged, such communities face all kinds of credit constraints and financial exclusion (UNDP, 2010; Cnaan et al., 2012). Thus, states with a higher proportion of SC/ST population will have poorer outcomes in terms of financial infrastructure development due to lack of demand.

The study also examines the role of social infrastructure (SINFRA) and physical infrastructure (PINFRA) in promoting financial infrastructure. The values of their coefficients suggest that the development of social and physical infrastructure has a significant and positive influence on financial infrastructure development, indicating the presence of complementarity between social, physical, and financial infrastructure. Similar findings are reported in existing studies (Okeahalam 2005; Cerra et al. 2017; Nguena, 2019). Finally, the coefficient of the dummy variable is found to be positive and statistically significant, indicating better coordination between the center and states and resource allocation when both belong to the same government and political party.

5.4. Ranking of Factors

Overall, the results indicate differential determinants of physical, social, and financial infrastructure development at the state level (See Table 8). While economic factors are relatively more important for physical infrastructure, fiscal and demographic factors are crucial for improving social and financial infrastructure levels. Investment is a critical factor for developing all three types of infrastructure, i.e., physical, social, and financial infrastructure.

Lastly, there seems to be complementarity among the different kinds of infrastructure facilities, indicating that the development of one may foster the development of the other.

Based on the above results, we rank the determinants of infrastructure in terms of their significance using three criteria: magnitude of the coefficients, significance level, and the consistency of the coefficients. The ranking of determinants is reported in Table 8. First, there are differences in determinants for different categories of infrastructure. For instance, the size of the state, complementary infrastructure, and political factors played a vital role in driving the performance of three types of infrastructure. However, variables like investment rate, financial development, and manufacturing GDP played a bigger role in driving physical infrastructure, while Services GDP and SCST population have a higher impact on social and financial infrastructure. While debt has a significant negative impact on physical and social infrastructure development, it has a weak positive impact on financial infrastructure. Further, urbanization positively impacts both physical and social infrastructure but no significant impact on financial infrastructure.

Table 8: Ranking of Determinants of Different types of Infrastructure

Physical Infrastructure	**Social Infrastructure**	**Financial Infrastructure**
Gross State Domestic Product (GSDP)/ Per capita (GSDP)	Gross State Domestic Product (GSDP)/ Per capita (GSDP)	Gross State Domestic Product (GSDP)/ Per capita (GSDP)
Finanacial Infrastructure (FINFRA)/ Social Infrasrtucture (SINFRA)	Political DUMMY	Social Infrasrtucture (SINFRA)/ Physical Infrasructure (PINFRA)
Political DUMMY	Finanacial Infrastructure (FINFRA)/ / Physical Infrasructure (PINFRA)	Political DUMMY
Share of Manufacturing (SMNF)	Share of Services sector to GSDP (SSER)	Share of Services sector to GSDP (SSER)
Investment (INV)	Schedule Caste and Schedule Tribe Population (SCST)	Schedule Caste and Schedule Tribe Population (SCST)
Urbanisation (UR)	Investment (INV)	Investment (INV)
Credit (CRE)	Internal debt (Debt)	Internal debt (Debt)
Internal debt (Debt)	Urbanisation (UR)	Population Density (PDEN)
Population Density (PDEN)	Population Density (PDEN)	Urbanisation (UR)

Source: Based on the results of the authors' empirical estimation

6. Conclusion and Policy Implications

The literature on economic growth, convergence, and divergence across the Indian states explains that one of the main reasons for the interstate disparity in economic development

is the variation in infrastructure development. However, only a few studies have examined the underlying factors responsible for the differential development of infrastructure across the Indian states. Using the panel data from 18 Indian states between 2004 and 2020, this study empirically analyzes the factors influencing infrastructure development across the states. The results show that although the inter-state difference in infrastructure levels has been narrowing over time, it is still high in all three types of infrastructure considered in the study – physical, social, and financial-. Kerela, Himachal Pradesh, and Karnataka have performed well in all three infrastructure indices, while Bihar, Uttar Pradesh, and Jharkhand have been lagging behind other states.

The determinants for physical, social, and financial infrastructure development are different. While economic factors are relatively more influential for physical and financial infrastructure, fiscal and demographic factors are more relevant for social and financial infrastructure. There is also complementarity between these three types of infrastructures. An increase in physical infrastructural assets is found to promote both social and financial infrastructures. Financial development also positively impacts both physical and social infrastructure development, as the availability of credit and financial instruments at a reasonable cost is important for public and private infrastructure investment.

The level of economic development is the primary driver for the endowment of all three types of infrastructures as it contributes to infrastructure development through both demand and supply pulls. Similarly, an increase in investment leads to infrastructure development both directly and indirectly. The latter occurs through its multiplier effect on the economy. Fiscal factors such as government expenditure (capital and social expenditure) and debt have differential effects on the different types of infrastructures. Contrary to expectations, an increase in debt seemed to promote infrastructure growth for all three kinds of infrastructure.

The study also confirms that demographic factors such as urbanization, population density, and proportion of SC/ST population have affected infrastructure development. Intuitively, a rise in urbanization increases the demand for physical and social, leading to an increase in the supply of such provisions. As expected, the higher share of the SC/ST population in a state negatively affects social and financial infrastructure because people belonging to SC/ST communities are more likely to experience economic deprivation and social exclusion. Political factors such as having both state and central government from the

same party (or coalition) positively influence infrastructure development through the higher allocation of resources from center to state and better coordination.

Given that infrastructure development is crucial for regional development in India, the results of the study have some important policy implications. Central and state governments should implement policies for increasing infrastructure investment, increasing capital expenditure and improving access to financial services. Since the internal debt negatively affects infrastructures, it should be maintained below the threshold level to avoid the adverse effects of high debt. There also need to be efforts made to create a favorable business climate in the poorer and infrastructural deficient states to attract private investment in the infrastructure sector. Further, the promotion of the welfare of SC/ST communities could also have a beneficial effect on infrastructure development in the Indian states. Lastly, there needs to be better coordination between center and state governments to ensure better outcomes for infrastructure growth, especially in the low-performing states. As such, the central government should augment the financing capacity of the laggard states through grants or special provisions.

Appendix- A: Component-Level Scores

Table A1: Physical Infrastructure: Component-Level Scores, 2019

States	Road	States	Rail	States	Tel	States	Power
Kerala	0.45	WB	0.08	HP	1.04	HP	0.68
Assam	0.31	Punjab	0.08	Tamil Nadu	0.99	Chhattisgarh	0.60
WB	0.25	UP	0.07	Punjab	0.89	Gujarat	0.59
Punjab	0.21	Bihar	0.07	Kerala	0.88	Punjab	0.55
Bihar	0.15	Haryana	0.07	Andhra	0.85	Karnataka	0.52
Maharashtra	0.14	Jharkhand	0.05	Gujarat	0.81	Haryana	0.49
Tamil Nadu	0.14	Assam	0.05	Karnataka	0.79	Tamil Nadu	0.48
Haryana	0.13	Tamil Nadu	0.05	Maharashtra	0.69	Maharashtra	0.43
Odisha	0.13	Gujarat	0.04	Rajasthan	0.63	Rajasthan	0.36
Karnataka	0.13	Kerala	0.04	Haryana	0.61	MP	0.35
UP	0.12	Andhra	0.04	Odisha	0.58	Andhra	0.32
MP	0.07	Maharashtra	0.03	Assam	0.55	Odisha	0.20
Andhra	0.07	Karnataka	0.03	WB	0.53	Kerala	0.17
HP	0.07	Rajasthan	0.02	UP	0.51	UP	0.13
Jharkhand	0.07	Odisha	0.02	Chhattisgarh	0.48	WB	0.11
Gujarat	0.06	MP	0.02	MP	0.48	Assam	0.04
Rajasthan	0.05	Chhattisgarh	0.01	Bihar	0.45	Jharkhand	0.04
Chhattisgarh	0.04	HP	0.00	Jharkhand	0.45	Bihar	0.03

Source: Author's Calculations

Table A2: Social Infrastructure: Component-Level Scores, 2019

States	SCH	States	TCH	States	BED	States	DOC
HP	0.38	HP	0.77	HP	0.63	Karnataka	0.35
Chhattisgarh	0.29	Assam	0.70	Kerala	0.63	Kerala	0.34
Assam	0.29	Chhattisgarh	0.60	Karnataka	0.57	Tamil Nadu	0.33
MP	0.28	Rajasthan	0.52	Tamil Nadu	0.56	Punjab	0.31
Odisha	0.22	Punjab	0.47	WB	0.44	Maharashtra	0.28
Rajasthan	0.19	Haryana	0.43	Andhra	0.36	Andhra	0.21
UP	0.17	Odisha	0.37	Rajasthan	0.34	Gujarat	0.20
Jharkhand	0.17	Kerala	0.36	Gujarat	0.32	WB	0.14
Karnataka	0.15	MP	0.34	Maharashtra	0.29	Assam	0.14
WB	0.11	Tamil Nadu	0.33	Punjab	0.27	Rajasthan	0.11
Punjab	0.11	Karnataka	0.29	Assam	0.26	Odisha	0.10
Maharashtra	0.09	UP	0.29	Chhattisgarh	0.26	MP	0.09
Gujarat	0.08	WB	0.28	Haryana	0.25	HP	0.08
Haryana	0.08	Maharashtra	0.28	MP	0.25	UP	0.07
Bihar	0.07	Gujarat	0.27	UP	0.22	Bihar	0.07
Tamil Nadu	0.07	Jharkhand	0.27	Odisha	0.21	Chhattisgarh	0.06
Andhra	0.06	Bihar	0.22	Jharkhand	0.20	Haryana	0.04
Kerala	0.02	Andhra	0.15	Bihar	0.04	Jharkhand	0.03

SCH stands for School per 1000 people, TCH stands for School teachers per 1000 people, BED stands for Hospital Beds per 1000 people and DOC stands for per 1000 people.

Source: Author's Calculations

Table A3: Financial Infrastructure: Component-Level Scores, 2019

States	AC	States	BB	States	PO
Kerala	0.64	Punjab	0.69	HP	0.31
Punjab	0.63	HP	0.65	Odisha	0.13
Karnataka	0.55	Kerala	0.57	Kerala	0.09
HP	0.54	Haryana	0.52	Tamil Nadu	0.09
Haryana	0.54	Karnataka	0.43	Karnataka	0.09
Tamil Nadu	0.53	Tamil Nadu	0.38	Rajasthan	0.08
Maharashtra	0.47	Gujarat	0.31	Punjab	0.07
WB	0.44	Odisha	0.28	Assam	0.06
Gujarat	0.42	Maharashtra	0.24	Andhra	0.06
Odisha	0.40	Rajasthan	0.22	Chhattisgarh	0.06
UP	0.36	Chhattisgarh	0.19	MP	0.05
Jharkhand	0.36	Jharkhand	0.17	Maharashtra	0.05
MP	0.36	UP	0.17	Jharkhand	0.04
Assam	0.36	MP	0.17	Haryana	0.04
Chhattisgarh	0.34	WB	0.17	WB	0.04
Rajasthan	0.34	Andhra	0.15	UP	0.03
Bihar	0.28	Assam	0.12	Bihar	0.03
Andhra	0.27	Bihar	0.07	Gujerat	0.00

AC stands for Bank Accounts per 1000 people, BB stands for Bank Branches per million people and PO stands for Post office per million people.

Source: Author's Calculations

Appendix B: Econometric Methods

Panel Unit Root Test: In the first step, Pesaran's (2007) panel unit test is applied to examine the time-series properties of variables. The unit root test is carried out using the following standard ADF regression augmented by including both lagged levels and first differences:

$$\Delta X_{it} = \alpha_i + b_i X_{i,t-1} + \sum_{-}(j=0)^{p} \Psi"ij" \ \bar{X}\, t-1 + \sum_{-}(j=1)^{p} \lambda"ij" \ "\Delta" \bar{X}\, t + u_{it} \quad .. \text{(A1)}$$

Where Δ is the difference operator, ¯x t is the cross-section average and P is the lag order. The test for unit root is conducted by assuming null H0: bi= 0 against the alternative Ha: bi< 0 for at least some i. The average cross-sectionally augmented IPS (CIPS) test depends on the average t-ratio is given by:

$$CIPS = \sum_{-}(t=1)^{N} (ti(N,T))/N \qquad \ldots\text{(A2)}$$

Panel Cointegration: In the second step, the Westerlund (2007) panel cointegration test is carried out using the following error correction model to establish a long-run relationship between the Infrastructure Index and its determinants:

$$Dy_{it} = \delta_i d_t + \mu_i (y_{i,t-1} - \beta'_i x_{i,t-1}) \sum_{j=1}^{p} \gamma_{ij} Dy_{i,t-j} + \sum_{j=0}^{p} \lambda_{ij} Dx_{i,t-j} + e_{it} \quad \ldots \text{(A3)}$$

where μ_i is the error correction term and D is the difference operator. Four-panel tests (two group statistics and two-panel statistics) were developed by pooling the error term to test panel cointegration. P_T and P_a are panel statistics and written as:

$$P_T = \frac{\hat{\mu}}{SE(\hat{\mu})} \text{ and } \quad P_a = T\hat{\mu} \qquad \ldots\ldots\ldots\text{(A4)}$$

The null and alternative hypothesis is tested as: H_0: $\mu_i = 0$, H_1: $\mu_i < 0$ for at least some i.

G_α and G_T are group statistics and can be written as:

$$G_a = \frac{1}{N} \sum_{i=1}^{N} \frac{T\hat{\mu}_i}{\hat{\mu}_i} \text{ and } G_T = \frac{1}{N} \sum_{i=1}^{N} \frac{\hat{\mu}_i}{SE(\hat{\mu}_i)} \qquad \ldots\ldots\ldots\text{(A5)}$$

Correspondingly, the null and alternative hypothesis is for group statistics tested as H_0: $\mu_i = 0$, H_1: $\mu_i < 0$ for at least some i.

GMM System Model: Since there is the possibility of endogeneity between infrastructure and its determinants, the study uses a panel dynamic model in the form of a GMM-system model given its superiority over the difference GMM estimator to identify long-run determinants of infrastructure development. Studies suggest that the estimation in first differences has a large bias and low precision in finite samples mainly due to the persistency of the series (Blundell and Bond, 1998; Blundell, Bond, and Windmeijer, 2000). In the presence of persistency of series, the lagged instruments are less correlated with current first-differences used in the first-differences estimation and so they turn out to be weak instruments. Alternative to this, Blundell and Bond (1998) propose to estimate a system of equations augmented with additional instruments in the form of level lag. Blundell and Bond (1998) show that the system GMM estimator performs better than the DIF GMM estimator because the instruments in the level model remain good predictors for the endogenous variables even when the series is very persistent.

Panel Unit Root and Cointegration Results: The result analysis starts by examining the stationary properties of the relevant variables by using the CIPS panel unit root test proposed by Pesaran (2007). The tests are conducted using two specifications: 'intercept' and 'intercept with time trend'. The results are presented in Table B1. The results suggest that most of the variables (except FINFRA, and CRE) are non-stationary in their levels or I (1) process.

Table B1: Results of CIPS Panel Unit Root Test

Variables	At Level		First difference	Conclusion	Pesaran CD Test
	Intercept	Intercept with trend	intercept		
PINFRA	-1.66	-2.46	-2.62*	Non-stationary	-47.45**
SINFRA	-1.94	-2.35	-2.61*	Non-stationary	-23.76**
FINFRA	-3.05*		-3.75**	stationary	-45.64**
INV	-1.43	-1.54	-2.75*	Non-stationary	-35.99**
PGSDP	-2.27	-2.67	-4.10**	Non-stationary	-47.22**
GSDP	-2.09	-2.47	-4.2**	Non-stationary	-44.22**
CEXP	-1.64	-1.97	-2.60*	Non-stationary	-27.07**
UR	0.14	-1.99	-1.94*	Non-stationary	-47.66**
Debt	-1.65	-1.87	-3.57**	Non-stationary	-31.08**
PDEN	1.83	1.70	-3.29**	Non-stationary	-47.90**
CRE	-2.45*			stationary	-44.45**

*Notes: "** and *" indicates rejection of null of unit root at 1% and 5 levels respectively.*

The panel cointegration test is conducted using two specifications: 'intercept' and 'intercept with time trend and AIC criteria is used to select the lead and lag orders for the cointegration test. The results of the panel cointegration test are provided in Table B2. The results reveal that

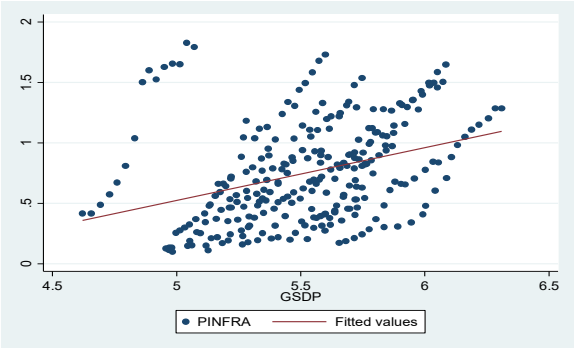
the null of no cointegration is rejected by group tests (G_t and G_a) as well panel tests (P_t and P_a) level in favor of the existence of cointegration in the panel.

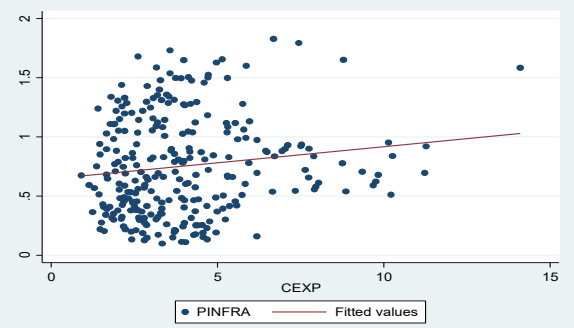
Table B2: Results of Panel Cointegration Tests

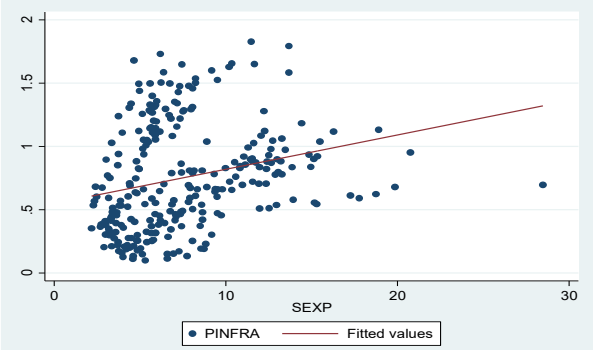
Panel Statistics	Physical Infrastructure	Social Infrastructure	Financial Infrastructure
	Test Values	Test Values	Test Values
G_T	-1.99	-2.13*	-2.35*
G_a	-8.92*	-4.19	-4.64
P_T	-7.30	-10.32*	-10.58*
P_a	-6.40*	-4.56	-5.76

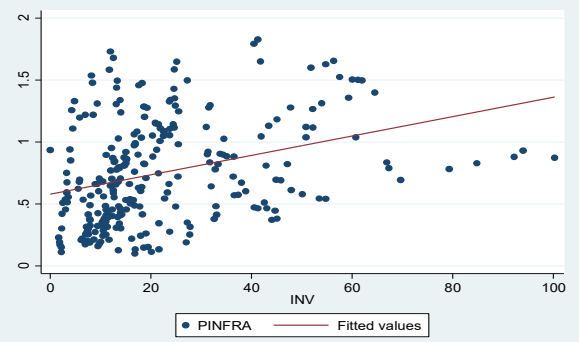
Notes: * Indicates the rejection of null of no cointegration at 5 percent level.

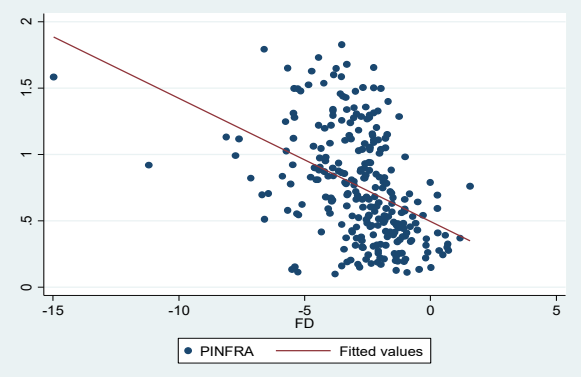
Appendix C: Relationship between PINFRA, SINFRA, PINFRA and its determinants

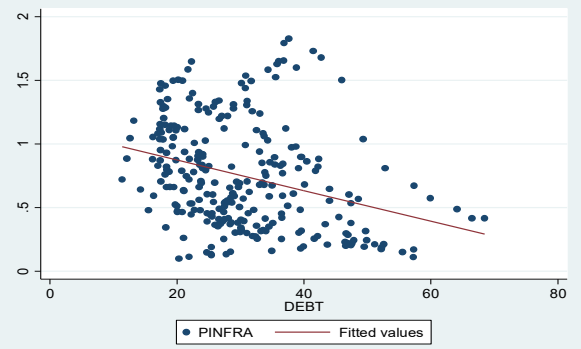


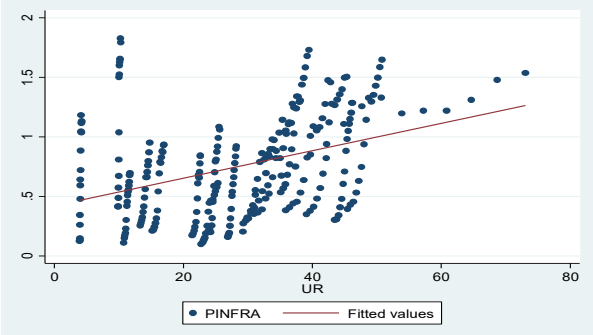


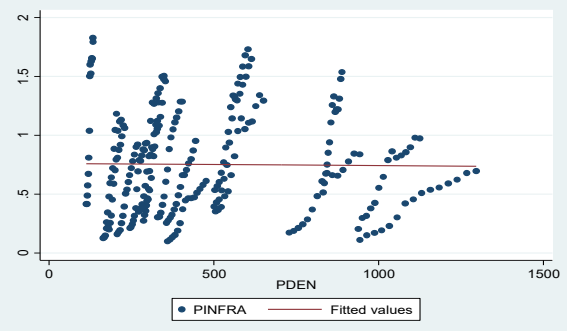


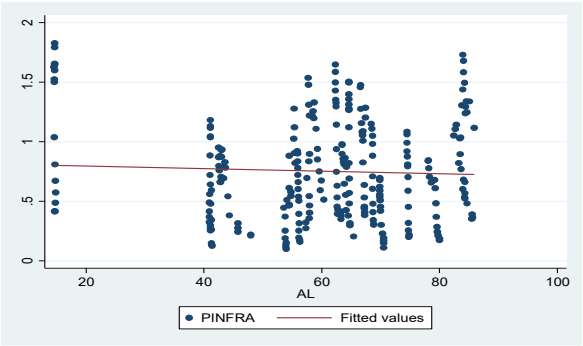


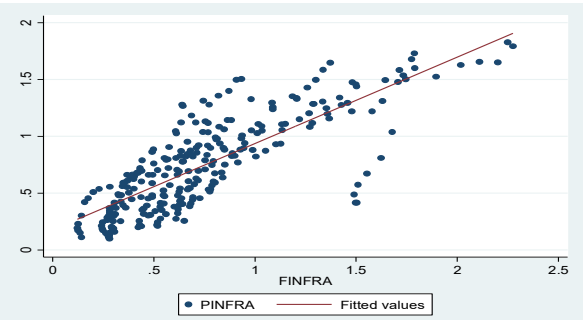




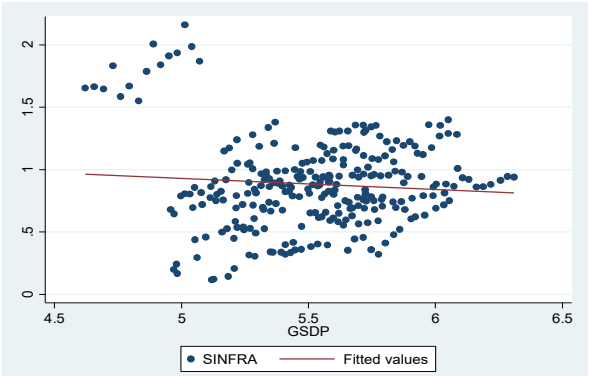


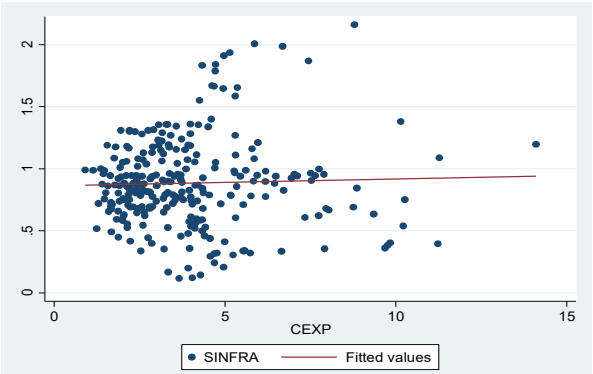


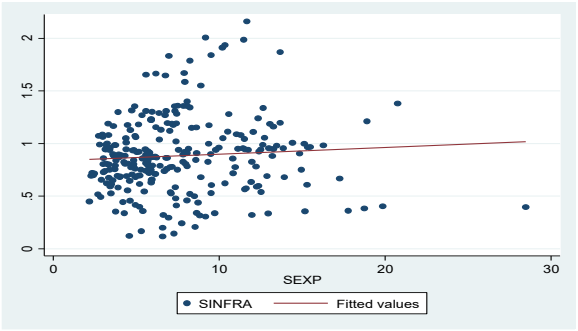


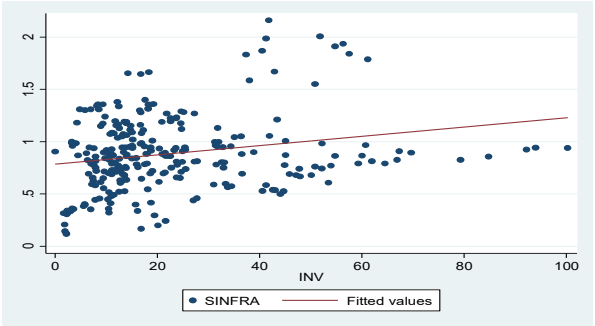


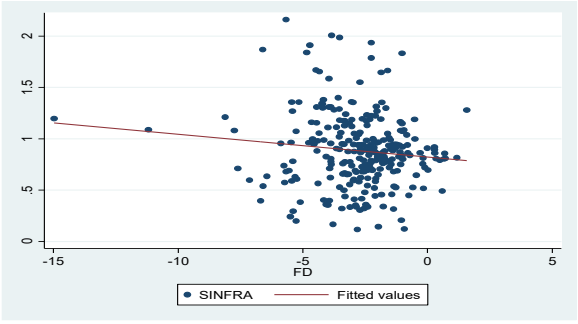
Relationship between SINFRA and its determinants

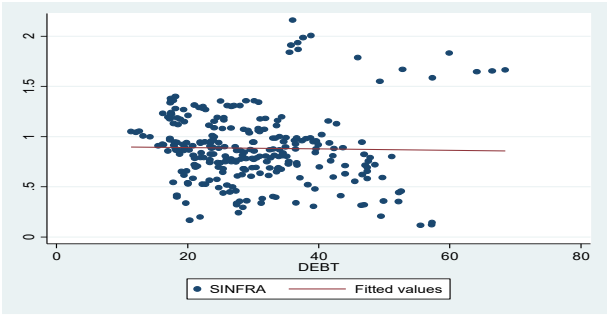


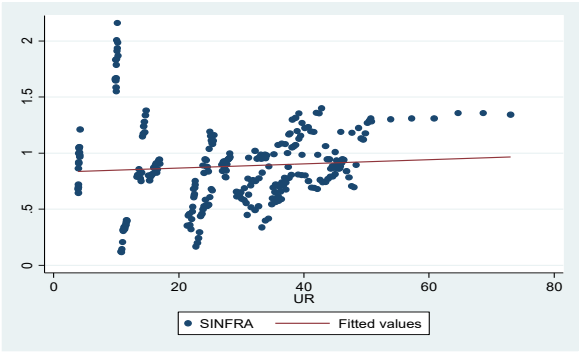


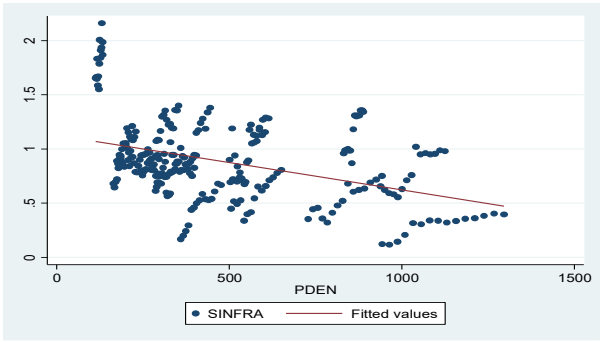


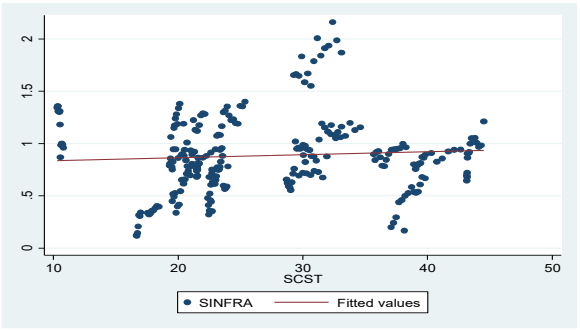


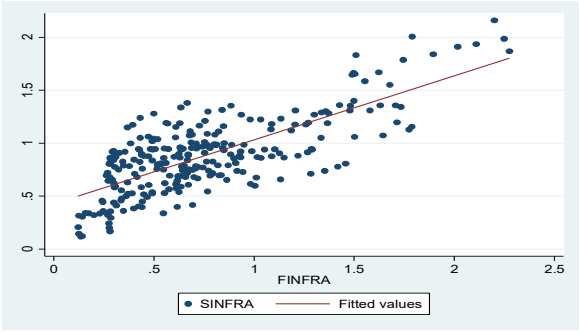




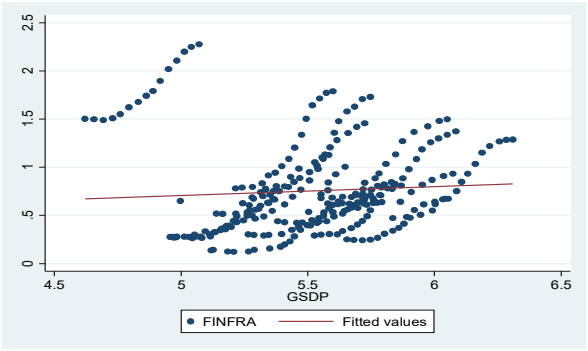


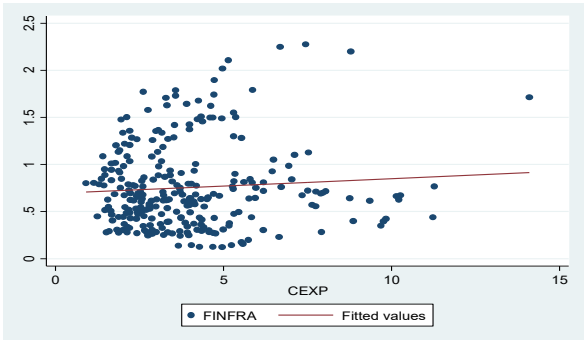


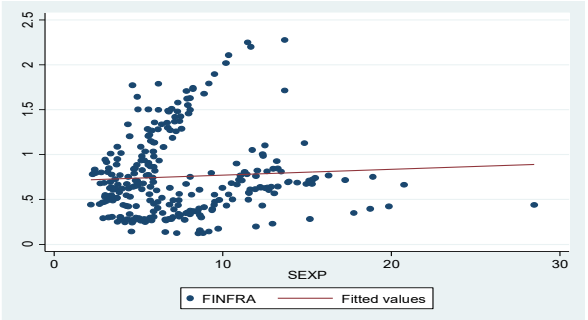


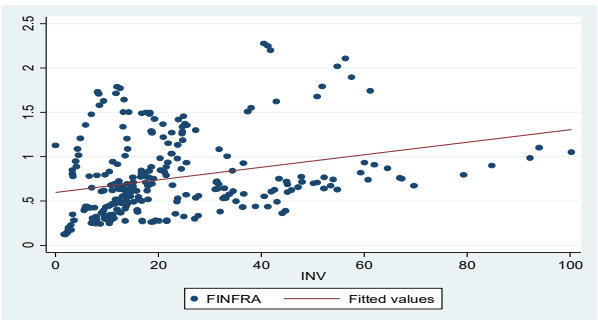


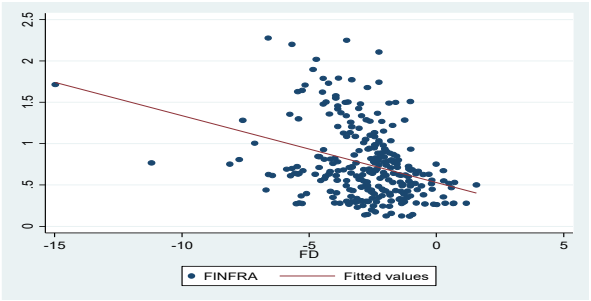
Relationship between FINFRA and its determinants







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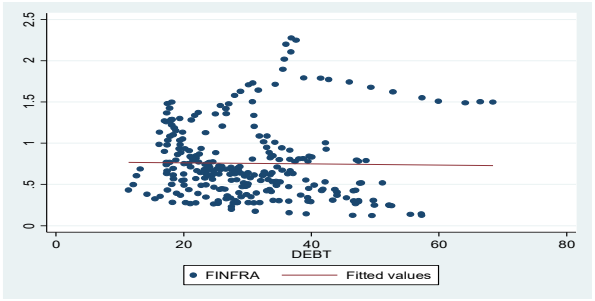
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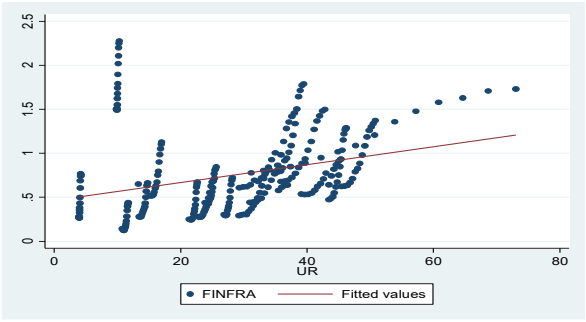
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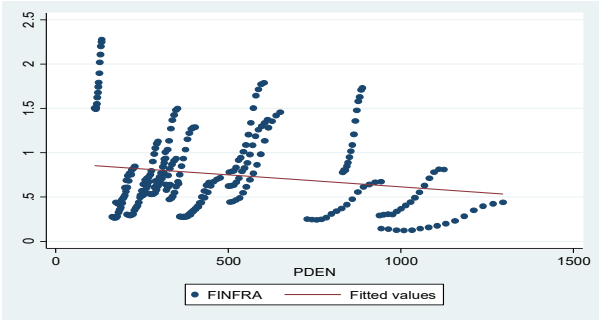
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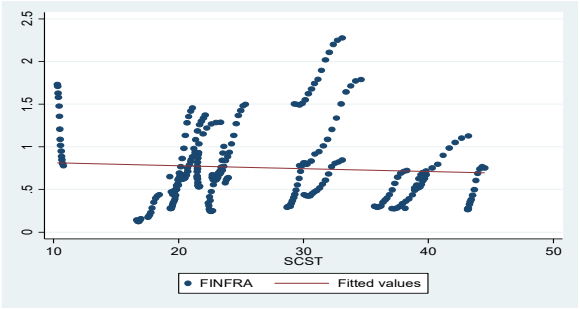
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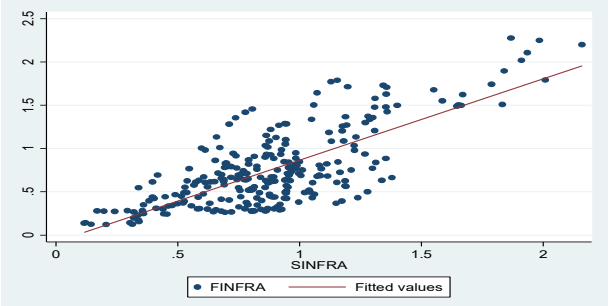
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