Understanding the Puzzle of Growth in Indian States: Convergence or Divergence?

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Nesiya Josephine[1] and **P. K. Santhosh Kumar** [2]

Abstract

The convergence dynamics among Indian states have been a subject of profound debate among researchers for several decades. This study presents a comprehensive analysis of the convergence phenomenon among 15 states in India. The states are classified into four distinct groups based on their average growth rates over the period spanning from 2005 to 2019. Employing advanced panel cointegration methods, including the Pedroni residual cointegration test, Johansen trace test, FMOLS, and Panel VECM, this research investigates the patterns of convergence among fiscal, social, and infrastructure-related variables. The data analysis reveals compelling evidence of convergence and divergence trends across the identified groups. The study identifies clusters of states experiencing similar growth patterns through rigorous statistical techniques, shedding light on the underlying mechanisms driving their economic trajectories. Moreover, it discerns distinct patterns of divergence in certain vital variables, signaling variations in economic performance and policy outcomes among the states. The findings of this research contribute to a nuanced understanding of the complex dynamics of economic growth and development across the diverse landscape of Indian states. The insights from this study may assist policymakers in formulating region-specific strategies to promote inclusive growth and equitable development across the country. Furthermore, adopting sophisticated panel cointegration methods paves the way for a more robust and accurate convergence analysis among subnational entities, thus enhancing the scope and quality of future research in this domain.

Keywords

Convergence, Panel cointegration, Panel unit root, Pedroni residual cointegration, Panel VECM

1. Introduction

India is a country of immense diversity, with 28 states and eight union territories. Each state has its distinct culture, language, and history, making India a fascinating mosaic of different customs and traditions. However, despite this diversity, specific trends of convergence and divergence are evident among Indian states.

Classical convergence theory, also known as neoclassical convergence theory, is an economic theory that suggests that, over time, poorer economies will catch up to and converge with the more prosperous economies in terms of per capita income (Solow 1999, 2001; Barro, 1991). This theory suggests that countries with lower levels of per capita income will experience higher rates of growth than

[1] Centre for Budget Studies, Cochin University of Science and Technology, Kochi-22

[2] Director & Associate Professor, Centre for Budget Studies, School of Social Science, Cochin University of Science and Technology, Kochi-22. Email: s.kumar@cusat.ac.in

Corresponding author:
P. K. Santhosh Kumar, Director & Associate Professor, Centre for Budget Studies, School of Social Science, Cochin University of Science and Technology, Kochi-22. Email: s.kumar@cusat.ac.in

countries with higher levels of per capita income, leading to a narrowing of the income gap between them. The theory is based on the idea that capital and labor will move from richer to poorer countries in search of higher returns and that technological progress will be shared across borders. This will result in poorer countries adopting more efficient production methods, leading to higher productivity and economic growth. According to classical convergence theory, convergence occurs due to capital accumulation, technological progress, human capital formation, and openness to trade.

However, critics of classical convergence theory argue that this theory has several limitations. For instance, the theory argues that countries have access to the same technologies and that there are no barriers to the movement of capital, labor, and goods. But in reality, there are several barriers to technology transfer, including intellectual property rights, trade barriers, and political instability. Additionally, some countries may be better suited to specific industries, such as resource-rich countries, leading to a divergence rather than convergence.

Numerous studies have been done in the Indian context, and there are advocates for both convergence and divergence. Economic development is considered one of the critical factors driving convergence among Indian states. This growth has been driven by various factors, including foreign investment, increased urbanization, and improved connectivity. Despite the trend towards convergence, there are still significant differences among Indian states. These differences are primarily driven by geography, language, culture, and political instability. Some of the states emphasize development rather than economic growth. Since the states exhibit many distinct features, numerous analyses can be done to draw contrasting insights and conclusions. The convergence studies in the context of Indian states are discussed in the succeeding session.

2. Review of Literature

The debate over convergence or divergence across the Indian states started in the late 90s. Numerous studies were conducted to analyze income convergence. The researchers have used different approaches to convergence. The study of Cashin & Sahay (1996) was prominent among the early studies, which argued for absolute convergence across 20 states during 1961-91. The Central Government grants significantly contributed to convergence. Nagaraj et al. (2000) used Principal Component Analysis as well as panel data estimation techniques and found evidence of conditional convergence, along with persistent income inequalities. Evidence of club convergence was put forward by Bandyopadhyay (2012), who used distribution dynamics and found the presence of two convergence clubs between 1965-97. It was also found that neighboring states do not belong to the same income cluster. Ghosh et al. (2013) acknowledged the presence of club convergence using Philips & Sul approach. Marjit & Mitra (1996) primarily expressed income divergence across states, that the states have been diverging rather than converging. Ghosh et al. (1998) found divergence across 26 states using correlation & regression. Rao et al. (1999) accepted the interstate disparities during 1960-95. On the other hand, Dasgupta et al. (2000) found divergence in per capita income and convergence in shares of different sectors in the State's Domestic Product. Bhattacharya & Sakthivel (2004) discovered that the uneven development process contributed to the divergence. Baddeley et al. (2006) used the Generalized Least Square method and confirmed divergence. Chikte (2011) found a strong divergence in per capita income and its increased standard deviation by studying 15 states. Chakraborty L & Chakraborty P (2018) studied fiscal asymmetries and convergence using panel estimation and GMM and found no evidence of no strong convergence. Sanga & Shaban (2017) used maximum likelihood estimation and spatial autocorrelation models among 15 states during 1970-2014 and found divergence in absolute economy. At the sectoral level, the secondary and tertiary sectors showed absolute divergence. Suthar (2017) stated that richer states have grown faster, and poor states have lagged. Bakshi et al. (2015) found similar results using Principal Component Analysis. Gunji & Nikaido (2010) stated that almost all income sequences in the Indian states have unit roots and the Per Capita Income diverges across states. According to Kar S & Sakthivel (2006), the industrial and services sector mainly contributes to the regional divergence in India. By including other variables like education, Karnik & Lalvani (2012) showed its importance in the growth performance of states. The rate of convergence varied from very low to high. Chikte (2011) included literacy as a factor of growth. Infrastructure was given importance in the study of Dasgupta et al. (2000), and Night-light data was used by Chanda & Kabiraj (2020), along with State Domestic Product, and found the presence of weak convergence. Most researchers have used correlation and OLS methods to test for convergence. These have many limitations, and recently, more effective econometric tools have been introduced in this area of study. Moreover, categorized analyses are fewer in number compared to individual analyses of states in case of convergence. This study aims to analyze the growth of GSDP among 15 Indian states, categorize them into high-income, average-income, and low-income states based on their average growth rate, and check for convergence across them from the period of 2005 to 2019 (15 years). The data is collected from EPWRF and RBI and analyzed using panel cointegration methods.

3. Data and Methodology

The study encompasses seven variables, with the dependent variable being the Growth of Gross State Domestic Product (GSDP). The other variables include Per Capita GSDP, Grants from the central government, Per Capita Capital Expenditure, Per Capita Availability of Power, Per Capita Social Sector Expenditure, and Tele Density. All these variables have been transformed into log values. The research period spans from 2005 to 2019, totaling 15 years, and data has been gathered from reputable sources such as EPWRF (Economic and Political Weekly Research Foundation) and the Reserve Bank of India (RBI) Handbook of Statistics on Indian states. The Growth of GSDP is calculated by obtaining the first difference of GSDP for each state. GSDP represents the total volume of finished goods and services produced within a state's geographical boundaries during a specific timeframe. Per Capita GSDP is obtained by dividing the GSDP by the state's population, while Per Capita Capital Expenditure is derived from the government's spending on assets like schools, hospitals, and infrastructure, divided by the population. Grants-in-aid provided by the Central government refer to financial support extended to state governments. The term "Power availability per capita" refers to the production of power plants and combined heat and power plants, subtracting transmission, distribution, and transformation losses, and the consumption by heat and power plants, divided by the midyear population (as defined by the World Bank). Per Capita Social Sector Expenditure reflects the expenditure by the government, NGOs, or private sector in areas like health, education, urban and rural development, sanitation, nutrition, water availability, and other protective and promotional measures, divided by population. Finally, Tele Density denotes the number of fixed (landline) telephone connections per 100 individuals in a given geographical area, and the percentage values are converted into actual values for expression in lakhs.

Table 1. *Variables, details, and source.*

Variables	Details	Period	Source
lgrw	Log of growth of GSDP (in lakhs)	2005-19	EPWRF
lpcgsdp	Log of per capita GSDP (in lakhs)	2005-19	EPWRF
lcapex	Log of per capita capital expenditure (in lakhs)	2005-19	RBI
lgrt	Log of grants from the central government (in lakhs)	2005-19	RBI
lpow	Log of per capita power availability (KW/H)	2005-19	RBI
lsoc	Log of per capita social sector expenditure (in lakhs)	2005-19	RBI
ltele	Log of teledensity (in lakh)	2005-19	RBI

This study considers 15 states in India that contribute a significant portion to the national GDP. The states are divided based on their average growth rate of Gross States Domestic Product from 1990 to 2020 (30 years). They are classified into four groups: High growth states, Medium growth states, Low growth states, and All states. High-growth states are Gujarat, Haryana, Karnataka, Maharashtra, and Tamil Nadu. Medium-growth states are Andhra Pradesh, Kerala, Madhya Pradesh, Orissa, Rajasthan, and West Bengal. Low-growth states are Assam, Bihar, Punjab, and Uttar Pradesh.

Table 2. *Classification of states.*

States	Average growth rate	Category
Gujarat	8.61	High growth
Haryana	7.50	
Karnataka	7.46	
Maharashtra	7.14	
Tamil Nadu	7.11	
Andhra Pradesh	6.61	
Kerala	6.46	Medium growth
Madhya Pradesh	6.39	
Orissa	6.32	
Rajasthan	6.07	
West Bengal	6.07	
Assam	5.68	Low growth
Bihar	5.46	
Punjab	5.18	
Uttar Pradesh	4.79	

Source: author's calculation based on data from EPWRF

Descriptive statistics and panel correlation analysis provide a comprehensive summary of the characteristics of variables in each state. They facilitate data distribution understanding and enable comparison between states, offering insights into potential convergence patterns. Panel cointegration is a suitable approach to analyze long-run equilibrium relationships between variables in a panel dataset, which is crucial for studying convergence among multiple states over time. It helps identify whether the variables tend to move together in the long run, indicating economic convergence or divergence. The Panel Vector Error Correction Model (VECM) is appropriate for studying the dynamic relationships between variables and detecting short-run and long-run causality. It allows researchers to assess the speed of adjustment towards equilibrium in the states, considering the impact of short-run shocks on long-run relationships. Stationarity testing is critical to ensure that variables are stationary at first difference (I(1)) for panel cointegration analysis. Non-stationary variables could lead to spurious regression results, affecting the accuracy of cointegration analysis. The Johansen Trace Statistics test is valuable for identifying cointegrating relationships and determining the number of cointegrating vectors in the panel dataset. This knowledge is essential for understanding convergence patterns. Pedroni Residual Cointegration Test and Fully Modified OLS provide additional validity checks for cointegration analysis, especially in the presence of cross-sectional dependence and heterogeneity. They enhance the credibility and reliability of the research findings. Panel VECM allows for the study of long-run causality and speed of adjustment in the panel dataset, complementing panel cointegration analysis. It provides valuable insights into convergence dynamics and the response of states to short-run shocks while maintaining long-term equilibrium relationships. By combining panel cointegration, Panel VECM, and supplementary tests ensures a rigorous examination of convergence among states, enhancing the robustness and significance of research findings. These methods contribute valuable insights into long-run relationships and dynamics between variables.

4. Analysis and Interpretation

The analysis commences by presenting the descriptive statistics for each group, followed by the panel correlation, panel unit root test, and subsequently, the cointegration test, FMOLS, and Panel VECM. Each of these procedures is comprehensively discussed in the subsequent sections.

4.1 *Descriptive Statistics*

This is to gain a broad view of the variables. Mean, median, maximum and minimum values and standard deviation are calculated. Skewness, kurtosis, and normality are also tested to understand the features of the distribution of values. The log values are taken for analysis.

4.1.1 *High-growth states*

The variables growth, per capita GSDP, grants, social expenditure, and teledensity are negatively skewed, which means they have a long tail on the left side, and the values are concentrated mainly on the right side of the mean value, or they are more significant than the mean when we plot them. Capital expenditure and power availability exhibit the opposite. All the variables except growth and teledensity follow normality.

Table 3. *Descriptive statistics of high growth states.*

	lgrw	lpcgsdp	lcapex	lgrt	lpow	lsoc	ltele
Mean	15.423	11.647	8.122	13.584	7.109	8.743	5.769
Median	15.484	11.637	8.108	13.529	7.090	8.771	6.139
Maximum	16.541	12.195	9.215	15.29	7.672	9.796	6.982
Minimum	13.428	11.107	6.942	11.621	6.476	7.682	3.131
Std. Dev.	0.595	0.286	0.533	0.820	0.269	0.551	0.952
Skewness	-0.679	-0.005	0.093	-0.195	0.125	-0.273	-0.698
Kurtosis	3.324	1.964	2.355	2.605	2.507	2.123	2.607
Jarque-Bera	6.102*	3.352	1.406	0.962	0.952	3.333	6.577*
Observations	75	75	75	75	75	75	75

Asterisk (*) shows the rejection of the null hypothesis at a 5% significant level

The data analysis reveals intriguing patterns and disparities among the high income states. The GSDP growth rates exhibit a balanced distribution with slightly skewed positive skewness, indicating the presence of outliers. Per Capita GSDP and Per Capita Capital Expenditure also display balanced distributions, with the latter showing variations among states due to outliers. Grants from the Central Government are well-distributed, but with some outliers. Per Capita Power Availability and Per Capita Social Sector Expenditure exhibit slightly skewed distributions with positive kurtosis, suggesting the presence of outliers. Tele density, however, shows substantial variations with skewed distribution and prominent outliers.

4.1.2 *Medium growth states*

Variables except per capita GSDP and power availability are negatively skewed. All the variables except growth and teledensity follow normality.

Table 4. *Descriptive statistics of medium growth states.*

	lgrw	lpcgsdp	lcapex	lgrt	lpow	lsoc	ltele
Mean	14.632	11.113	7.803	13.72	6.504	8.530	5.513
Median	14.678	11.076	7.823	13.668	6.455	8.529	5.791
Maximum	15.511	11.999	9.134	14.977	7.186	9.584	6.715
Minimum	11.717	10.290	6.366	12.236	5.722	7.263	2.681
Std. Dev.	0.586	0.380	0.598	0.763	0.328	0.626	0.961
Skewness	-1.672	0.272	-0.069	-0.130	0.039	-0.242	-0.997
Kurtosis	8.607	2.688	2.226	2.031	2.467	2.00	3.10
Jarque-Bera	159.84*	1.480	2.318	3.775	1.088	4.629	14.95*
Observations	90	90	90	90	90	90	90

Asterisk (*) shows the rejection of the null hypothesis at a 5% significant level

The data analysis of various economic indicators for middle-income states in India offers valuable insights into their distributional characteristics. The log of GSDP growth appears to have a relatively symmetric distribution, but the significant positive Jarque-Bera test statistic indicates possible deviations from normality. The log of per capita GSDP data exhibits a near-normal distribution. The log of per capita capital expenditure data is moderately positively skewed, and its normality is not confirmed entirely. The log of grants from the central government shows moderate positive skewness but may be considered approximately normally distributed. The log of per capita power availability data has a reasonably symmetric distribution. The log of per capita social sector expenditure data exhibits some deviation from normality. The log of tele density data indicates an asymmetric and light-tailed distribution, significantly departing from normality.

4.1.3 *Low-growth states*

The variables growth, grants, and teledensity are negatively skewed. All the other variables are positively skewed, which means the values are more concentrated on the left side, which is less than the mean. All variables except capital expenditure follow normality.

Table 5. *Descriptive statistics of low growth states.*

	lgrw	lpcgsdp	lcapex	lgrt	lpow	lsoc	ltele
Mean	14.387	10.713	7.584	13.74	5.955	8.235	5.418
Median	14.386	10.665	7.447	13.767	5.69	8.219	5.625
Maximum	16.15	11.799	9.794	15.298	7.624	9.764	7.299
Minimum	12.731	9.588	6.362	12.04	4.465	6.950	2.001
Std. Dev.	0.726	0.563	0.658	0.852	0.976	0.611	1.200
Skewness	-0.065	0.204	0.769	-0.123	0.470	0.032	-0.542
Kurtosis	2.654	2.244	4.144	2.191	1.971	2.437	3.062
Jarque-Bera	0.335	1.844	9.197*	1.789	4.859	0.800	2.95
Observations	60	60	60	60	60	60	60

Asterisk (*) shows the rejection of the null hypothesis at a 5% significant level

The descriptive statistics provide valuable insights into the economic and developmental conditions of low-income states in India. The study reveals a positive economic trend with a mean log growth of GSDP at 14.387. However, disparities among states are evident, as indicated by a slightly asymmetric distribution (skewness value of 0.726). The analysis of per capita GSDP shows that middle-income states have a lower mean log per capita GSDP (10.713) compared to low-income states, suggesting wealth disparities among the population (skewness of 0.563). Investment in infrastructure and development projects is observed in low-income states, with a moderate mean log of per capita capital expenditure (7.584), although there may be outliers or deviations from a normal distribution (high kurtosis of 4.144 and Jarque-Bera of 9.197). Low-income states receive significant financial assistance, with the log of grants having a mean value of 13.74, but there might be a concentration of grants toward certain states (negative skewness of -0.123). Progress in power availability is evident in low-income states with a log of per capita power availability at 5.955, but disparities in access to electricity remain (skewness of 0.976). Social development is a priority for low-income states, as reflected in their mean log of per capita social sector expenditure (8.235) with a relatively even distribution of spending (near-zero skewness). Tele density also shows progress in communication infrastructure in low-income states (5.418), but variations in urban-rural access might be contributing to the positively skewed distribution (skewness of 1.2).

4.1.4 *All states*

When considering all 15 states, all variables except capital expenditure are negatively skewed, and only capital expenditure and grants follow normality.

Table 6. *Descriptive statistics of all states.*

	lgrw	lpcgsdp	lcapex	lgrt	lpow	lsoc	ltele
Mean	14.883	11.185	7.851	13.680	6.559	8.522	5.573
Median	14.836	11.244	7.854	13.656	6.668	8.596	5.752
Maximum	16.541	12.195	9.794	15.298	7.672	9.796	7.299
Minimum	11.717	9.588	6.362	11.621	4.465	6.950	2.001
Std. Dev.	0.7603	0.548	0.628	0.806	0.719	0.627	1.033
Skewness	-0.460	-0.438	0.089	-0.153	-0.834	-0.219	-0.780
Kurtosis	3.693	2.673	2.679	2.328	3.236	2.193	3.175
Jarque-Bera	12.417*	8.224*	1.262	5.111	26.62*	7.909*	23.10*
Observations	225	225	225	225	225	225	225

Asterisk (*) shows the rejection of the null hypothesis at a 5% significant level

For GSDP growth, the distribution appears relatively balanced, but with potential outliers on the higher side. Per capita GSDP shows a roughly symmetric distribution with less extreme values compared to GSDP growth. Per capita capital expenditure exhibits a balanced distribution with close-to-zero skewness and kurtosis values, indicating normality. Grants from the central government display a right-skewed distribution influenced by a few high-value outliers. Per capita power availability suggests a left-skewed distribution with potential lower outliers. Per capita social sector expenditure shows a relatively balanced distribution similar to GSDP growth. Tele density exhibits a right-tailed distribution with potential outliers on the higher side. Overall, the analysis highlights disparities in economic growth, public spending, and infrastructural development among Indian states. Some indicators display more balanced distributions, while others are influenced by extreme values.

4.2 ***Panel Unit root test***

The Levin, Lin, and Chu t statistics (2003) is used to determine the presence of unit root. It is based on a regression framework that allows for cross-sectional dependence among the units in the panel. The general equation of the LLC test can be expressed as:

$$\Delta y_{it} = \alpha_i + p y_{it-1} + \sum_{j=1}^{p-1} \beta_j \Delta y_{it-j} + u_{it}$$

Where Δy_{it} is the first-differenced value of the variable for unit *i* at time *t*, α_i is a fixed effect for each individual *i*, *p* is the coefficient of lagged value of the variable, $\beta_j \Delta y_{it-j}$ are the coefficients on lagged first-differences of the variable and u_{it} is the error term. The null hypothesis (H0) is the presence of the unit root, and the alternative hypothesis (Ha) is its absence or stationarity. All of the variables under all of the groups are stationary at first difference. They are integrated to order one, or they are I(1) series.

Table 7. *Levin, Lin, and Chu t stat values of unit root test.*

	High growth	Medium growth	Low growth	All states
Lgrw	-9.59*	-8.79*	-6.71*	-14.5*
Lpcgsdp	-1.95*	-2.4*	-2.07*	-3.68*
Lcapex	-4.01*	-5.13*	-3.77*	-7.49*
Lgrt	-3.59*	-5.37*	-3.22*	-7.17*
Low	-4.29*	-3.71*	-3.60*	-6.64*
Lsoc	-2.58*	-3.103*	-2.85*	-4.85*
Ltele	-3.73*	-4.81*	-3.06*	-6.76*

Asterisk (*) shows the rejection of the null hypothesis at a 5% significant level

4.3 *Johansen trace statistics*

It is used to determine the number of cointegrating equations in a panel data set and to analyze the long-run relationship between multiple variables (Johansen, S.,1991). The rank of the estimated coefficient matrix of the cointegrating relationships is denoted as 'r.' The general form of Johansen trace test for panel data can be expressed as:

$$\Lambda_{trace} = -T \sum_{i=r+1}^{p} \ln(1-\lambda_i)$$

Where T is the number of observations, p is the number of lags, and λ_i is *the* i^{th} largest eigenvalue of the trace matrix. The null hypothesis for the trace test is that the number of cointegration vectors is r=r*< k, and the alternative hypothesis is r=k, while the value of k changes from 1 to n. Below are the values of Johansen trace statistics. The hypothesis of no cointegration is rejected across all groups, and the hypothesis of at least one cointegrating vector has been accepted. For low-growth states, there are at least three cointegrating equations.

Table 8. *Johansen trace statistics values.*

	r=0	r≤1	r≤2	r≤3	r≤4	r≤5
High growth	144.73*	77.27	32.07	15.69	7.497	2.593
Medium growth	143.22*	75.48	41.39	22.88	6.876	1.615
Low growth	178.77*	122.31*	70.35*	36.92	12.39	3.929
All states	198.31*	89.17	55.04	28.69	10.07	0.736

Asterisk (*) shows the rejection of the null hypothesis at a 5% significant level

The normalized cointegration coefficients (when r=0) according to trace statistics are as follows. The reverse sign of coefficients is considered as it is for estimating long-run cointegration.

Table 9. *Normalised cointegration coefficients according to trace values when (r=0)*

	High growth	Medium growth	Low growth	All states
Lgrw	1	1	1	1
Lpcgsdp	0.670	-1.504	0.027	-0.595
	(1.686)	(1.013)	(0.159)	(0.485)
Lcapex	-1.075	-0.110	0.369	-0.334
	(0.482)	(0.842)	(0.109)	(0.478)
Lgrt	-0.136	-1.213	0.730	-0.615
	(0.357)	(0.513)	(0.048)	(0.263)
Low	0.248	-1.622	0.501	0.012
	(0.521)	(0.829)	(0.086)	(0.300)
Lsoc	2.017	4.367	-0.901	3.265
	(0.964)	(1.304)	(0.115)	(0.621)
ltele	1.386	2.804	0.183	1.643
	(0.294)	(0.443)	(0.047)	(0.201)

Standard error in parenthesis, values are significant at 5% level

In the case of high-growth states, per capita GSDP, power availability, social expenditure, and teledensity have a positive impact on growth, while Capital expenditure and grants have a negative impact on growth. Among the medium growth states, social expenditure and teledensity impact growth positively, and the rest of them impacts negatively. For low-growth states, only social expenditure has a negative impact on growth. While considering all the states, power availability, social expenditure, and teledensity have positive impacts on growth, and others have a negative impact on growth.

4.4 *Panel cointegration test*

The basic panel cointegration test equation can be expressed as:

$$y_{it} = \alpha_i + \beta_i * X_{it} + u_{it}$$

Where Y_{it} is the dependent variable for entity I at time t, α_i is the individual specific fixed effect, β_i is the individual specific coefficient, X_{it} is the independent variable for entity I at time t, and u_{it} is the error term.

Since the variables are stationary at the first difference, the Pedroni residual cointegration test (Pedroni 1999, 2004) is used for testing convergence. The Pedroni test statistic can be defined as:

$$t = \left[\frac{(\sum_{i=1}^{N}\sum_{t=1}^{T}\delta_{it})^\wedge 2}{\sum_{i=1}^{N}\sum_{t=1}^{T}\delta_{it}^2}\right] * \left[NT^{\left(-\frac{1}{2}\right)}\right] * \left[\left(\sum_{i=1}^{N}\sum_{t=1}^{T}U_{it}^2\right)^\wedge \frac{-1}{2}\right]$$

Where δ_{it} is the first difference of y_{it} and X_{it}, *N* is the number of cross-sectional units, *T* is the number of periods, and U_{it} is the residual from the panel regression of y_{it} on X_{it}. It derives seven-panel cointegration statistics. The first category of four statistics is defined as within-dimension-based (panel) statistics which is based on pooling, and the second category of three statistics is defined as between-dimension-based (group) statistics which is based on a group mean approach. These seven statistics focus on the null hypothesis of no cointegration. The calculated test statistics should be smaller than the critical value, or their probability should be less than 5% to reject the null hypothesis of no cointegration.

Table 10. *Results of Pedroni residual cointegration test statistics.*

	High growth		Medium growth		Low growth		All states	
	Panel	Group	Panel	Group	Panel	Group	Panel	Group
Variance ratio	-1.462		-0.742		-0.757		-1.430	
Rho statistic	1.984	2.794	1.897	3.350	1.922	2.952	3.187	5.257
PP statistic	-3.34*	-9.05*	-15.6*	-13.9*	-1.83*	-6.3*	-14.2*	-17.3*
ADF statistic	-1.132	-1.595	-1.92*	-0.547	0.721	-1.60	-1.94*	-2.1*

Asterisk (*) shows the rejection of the null hypothesis of no cointegration at a 5% significant level

The results show that under the PP statistic, the null hypothesis of no cointegration is rejected across all categories of states, and the values are negative, which means the presence of convergence.

4.6 *FMOLS method*

Pedroni (2000) suggested the Fully Modified Ordinary Least Squares or FMOLS method to estimate the long-run relationship between the variables. It corrects for both endogeneity and heteroskedasticity of the error terms in panel data models. The FMOLS estimator for panel data is defined as:

$$\beta_{fmols} = \frac{\left(\sum_{i=1}^{N}\sum_{t=1}^{T}\sum_{j=1}^{k}\rho_{it}\,\Delta y_{i,t-j}\,\Delta X_{i,t-j}\right)}{\sum_{i=1}^{N}\sum_{t=1}^{T}\Delta X_{i,t}^2}$$

Where *N* is the number of cross-sectional units, *T* is the number of periods, *K* is the number of lags to be included, ρ_{it} is the residual autocorrelation function, $\Delta y_{i,t-j}$, and $\Delta X_{i,t-j}$ are the first differences of the dependent and independent variables for cross-sectional units and time periods and $X_{i,t}$ is the first difference of the independent variable for cross-sectional unit *I* at time *t*.

Table 11. *Cointegration coefficients under FMOLS method.*

	High growth	Medium growth	Low growth	All states
Lpcgsdp	2.114*	2.399*	1.240	1.826*
Lcapex	-0.261	-0.052	0.211	-0.054
Lgrt	-0.920*	0.404	-0.309	-0.243
Low	1.494	-0.953	0.255	0.166
Lsoc	0.558	-0.567	-0.067	0.004
ltele	-0.360*	-0.143	-0.062	-0.167*

Asterisk (*) shows the rejection of the null hypothesis of no cointegration at a 5% significant level

The coefficient substituted models can be expressed as:

High growth states

$$LGRW = 2.114 * LPCGSDP - 0.261 * LCAPEX - 0.920 * LGRT + 1.494 * LPOW + 0.558 * LSOC - 0.360 * LTELE + [CX = DETERM]$$

Medium growth states

$$LGRW = 2.399 * LPCGSDP - 0.052 * LCAPEX + 0.404 * LGRT - 0.953 * LPOW - 0.567 * LSOC - 0.143 * LTELE + [CX = DETERM]$$

Low growth states

$$LGRW = 1.240 * LPCGSDP + 0.211 * LCAPEX - 0.309 * LGRT + 0.255 * LPOW - 0.067 * LSOC - 0.062 * LTELE + [CX = DETERM]$$

All states2

$$LGRW = 1.826 * LPCGSDP - 0.054 * LCAPEX - 0.243 * LGRT + 0.166 * LPOW + 0.004 * LSOC - 0.167 * LTELE + [CX = DETERM]$$

The significant variables, which are, Per capita GSDP (in high growth, medium growth, and all states), Grant (in high growth states), and teledensity (in high growth and all states), show that they are cointegrated into the growth variable and their negative sign indicates that they are converging. The insignificant variables show the absence of cointegration.

4.7 *Panel VECM*

Vector Error Correction Model can also be applied in the context of panel data (Mandal & Madheswaran, 2010). It analyzes the long-run relationship between multiple variables across different cross-sectional units and time periods. The estimation of VECM in panel data can only be done after performing unit root tests, cointegration, estimation of a number of cointegrating vectors using the Johansen trace test, and parameters using FMOLS or DOLS.

The Panel VECM model can be expressed as:

$$\Delta y_{it} = \alpha_i + \sum_{k=1}^{p} \beta_i \Delta y_{it-k} + \sum_{k=0}^{q} \delta_i \Delta X_{it-k} + \theta_i EC_{it-1} + u_{it}$$

Where EC_{it-1} is the error correction term and is the OLS residuals from the following long-run cointegrating regression:

$$y_{it} = \beta_0 + \beta_1 X_{it} + u_{it}$$

…. and is defined as: $EC_{t-1} = y_{t-1} - \beta_0 - \beta_1 X_{t-1}$

The coefficient of EC or θ is the speed of adjustment. It refers to the rate at which y returns to its long-run equilibrium after a change in *X*. It must be negative and significant to be sure that the equilibrium is reattained in the long run.

Table 11 shows the values of error correction terms or speed of adjustment. Low-growth states reattain the equilibrium at a more incredible speed. The adjustment speed of other categories is much low. The all-states category is the slowest. Only the coefficient of error correction term of low growth states is negative and significant. So, it ensures the long-run cointegration and convergence. The variable teledensity is significant across all the categories, but the positive sign indicates no convergence. Social expenditure is also cointegrated per capita with growth in all categories except in low-growth states. Per capita, power availability is cointegrated in all state's categories. Grants are cointegrated in low-growth states. Per capita capital expenditure is cointegrated into all state categories.

Table 11 *Panel VECM results – Error correction terms.*

	High growth	Medium growth	Low growth	All states
Lgrw	-0.038	0.084	-0.964*	-0.019
Lpcgsdp	0.001	0.003	-0.022	4.33
Lcapex	0.007	-0.006	0.469	0.052*
Lgrt	-0.012	0.022	0.501*	0.022
Low	0.011	0.009	-0.096	0.012*
Lsoc	0.039*	0.032*	0.180	0.063*
Ltele	0.031*	0.045*	0.372*	0.044*

Asterisk (*) shows the rejection of the null hypothesis at a 5% significant level. Standard error in parenthesis and t-statistics in square brackets

5. Conclusion

This study analyzed the convergence across states in India by using fiscal, social, and infrastructure factors. All the variables were found to be I(1) across all categories. By employing Johansen trace statistics, it is evident that while high-growth, medium-growth, and all states have at least one cointegrating equation, low-growth states exhibit the presence of at least three cointegrating equations. The normalized cointegrating coefficients of trace statistics also projected that in low-growth states, all variables except per capita social expenditure positively influence the growth of GSDP. Under Pedroni residual cointegration test, all categories exhibited significant negative values under the PP statistic, which meant the presence of cointegration. When the FMOLS method was used, high growth, medium growth, and all states projected the cointegration of per capita GSDP and teledensity with the growth variable. When the coefficient of the error correction term is analyzed through Panel VECM, it is evident that only low-growth states are cointegrated and converging. Moreover, in this category, only teledensity and grants are significant but positive values, which means they are cointegrated but have no convergence. Under high-growth states, social expenditure and teledensity are cointegrated with growth but not converging. This is similar in the case of medium-growth states. All states category has the most significant variables: per capita capital expenditure, per capita power availability, per capita social expenditure, and teledensity, which are not converging simultaneously. India has seen impressive economic growth in recent years. As a result, many states that were once considered economically backward are now catching up with more developed states, which is evident in this paper also. For instance, states like Maharashtra, Karnataka, and Tamil Nadu have traditionally been more industrialized and economically developed, while states like Bihar and Assam have yet to catch up. However, in recent years, these less-developed states have made significant strides in terms of economic growth. This convergence in economic growth is an encouraging sign for India's overall development. There is also evidence for divergence, mainly due to political instability, regional identity, language and culture. Some states have strong regional identities, which leads to tensions between different regions, which can hamper development. In conclusion, India is a diverse country with many unique states; there are certain trends of convergence and divergence that are evident. Policymakers need to understand these trends and work towards creating a more equitable and inclusive society where all states can develop at a similar pace.

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