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Determinants of Teledensity and Digital Divide in India: Panel Fixed Effects Arellano-Bond GMM Estimation

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Abstract: The growth of telecommunications infrastructure and telecom performance is at the heart of the digital economy that is so essential for information dissemination and citizen-centric services. Though India has made rapid strides in the provision of telecommunications networks, the teledensity is uneven across the states of India. This paper analyses the determinants of teledensity and its distribution dynamics across 18 Indian states over the years 2000 to 2023 using kernel density plots and the dynamic panel fixed effects Arellano-Bond GMM estimation technique. The AB-GMM estimates show that network externality, NSDP per capita, service sector share in NSDP and literacy rate are the important determinants of relative teledensity across the states of India. The kernel density plots indicate a gradual reduction of disparity and convergence of teledensity across states over the years. The half-life estimate suggests that the speed of convergence is 1.13 years, i.e. it takes 1.13 years to converge in teledensity across the states of India.

Keywords: Telecommunications, teledensity, convergence, kernel plots, panel Arellano-Bond GMM estimation

INTRODUCTION

Among the myriad of essential infrastructures in any economy, telecommunications is the lifeline of an economy and, in fact, a base of the modern quality of human life. Within the service sector, telecommunications is the most important and fast-growing segment. The significance of information

and communications technology (ICT) for economic growth, particularly telecommunications, is well recognised in the literature and research studies. Telecommunications infrastructure investment and the derived services provide significant benefits, and their presence enhances the productivity of productive units (Roller and Waverman, 2001). The telecommunications infrastructure is not the same as other types of infrastructure, such as economic and social overheads. The major difference between telecommunications technology with other infrastructure lies in its network structure and the externality arising out of the networks. Telecommunications networks provide not only more value to the users, but also the values increase with more and more uses and users. The ability to communicate at will increases the ability of firms to engage in new productive activities as the information intensity of the production process increases. However, Sridhar and Sridhar (2007) point out that the impact of telecommunications infrastructure on economic growth in developing countries is less significant than in developed economies.

The size, growth, utilisation and performance of telecommunications infrastructure are generally assessed in terms of teledensity, the number of subscribers per 100 people. In India, the teledensity has increased from less than 1% in 1990 to 85% by 2023. In urban India, teledensity is 131% and 58% in rural India. The Indian telecommunications sector is the second largest in the world in terms of the number of subscribers and one of the fastest-growing infrastructure sectors (TRAI, 2008; Yadav *et al.*, 2015). There are 7.3 crore internet and 7.7 crore broadband subscriptions in India, and the telecom sector grow by 1.3% by 2023. The telecommunications sector has been contributing to GDP and job opportunities at large in the Indian economy. The telecommunications sector reforms and developments in India have been an unambiguous success from a macro and temporal perspective. The Indian telecommunications sector has emerged as an emerging sector and witnessed exponential growth since the 1990s.

Telecommunications in India was once considered a natural monopoly, and the post-1990 structural reforms and liberalisation policies introduced privatisation and encouraged competition in the provision of telecommunications services. The National Telecom Policy (NTP) of 1994 set the stage for private sector entry, and in 1997, the Telecom Regulatory Authority of India (TRAI), an independent regulatory body, was established in India. The accompanied

technical developments in the telecommunications infrastructure in India have made it possible to provide telecommunications services at affordable prices even to the end users. Such dramatic progress in telecommunications services has made it possible to provide knowledge-based services more easily. This great competitive advantage of India has been recognised globally, as most multinational telecommunications firms have a presence or service utilisation originating in India. Since the telecommunications services for business are of recent origin, the industry is largely dominated by private firms in India. The private sector telecommunications services play a major role and have witnessed impressive growth in the Indian telecommunications sector in recent years. Subsequent National Telecom Policies place the telecommunications sector at the heart of the digital India programme, enabling data and citizen-centric services.

Despite having a pan-India telecommunications policy and impressive effects of the telecommunications sector on economic growth, not only at the national level but also in the states, the expansion and utilisation of telecommunications services have not been the same in the states, and there exists a wide gap in teledensity across states of India. Compared with other developed economies, the growth of the teledensity of India varies widely, and there exists a wide disparity in teledensity between the states in India (Barman *et al.*, 2018). The disparity in teledensity among the Indian states is sometimes attributed to the frequent failure of telephone services and its effect on economic performance (Ghosh and Prasad, 2012).

It has been pointed out that developing countries have a less significant effect of telecommunications on economic activity because the critical mass or the threshold level has not been achieved (Sridhar and Sridhar, 2007). A state-level study by Barman *et al.* (2018) analysing the telecommunications divide among 16 major states has not taken into account two important states, viz. Tamil Nadu and West Bengal, where telecommunications play an important role due to the existence of metropolitan cities in these states.

Existing studies on the role and contribution of the telecommunications infrastructure to economic development largely focus on the aggregate effects at the national or cross-country levels. Studies that examine the causes and consequences of regional disparities in teledensity are sparse. Therefore, this paper attempts to examine the reason behind the disparity in teledensity that

exists across Indian states. The main objectives of this paper are to understand the dynamics of telecommunications distribution and the determinants of teledensity in 18 Indian states during the period 2000 to 2023. The panel data are sourced from the Government of India Department of Telecommunications (DoT) and the Reserve Bank of India Handbook of Statistics on the Indian Economy. The variables used are teledensity, NSDP per capita, service sector share in NSDP, electricity consumption and literacy rates of states of India. In the econometric estimation, this paper uses the parametric unit root test to test the stationarity property of relative teledensity and nonparametric kernel density distribution dynamics to determine the distribution of relative teledensity. The determinants of teledensity are estimated by a dynamic panel fixed effects Arellano-Bond GMM method.

LITERATURE REVIEW

Datta and Agarwal (2004) analysed the impact of telecommunications investment on economic growth and the convergence hypothesis in 22 OECD countries. The results of the dynamic fixed effects estimation indicate that there exists a strong relationship between macro variables and economic growth, and the countries at an earlier stage of development are likely to gain the most from investing in telecommunications, implying that telecommunications investments are subject to diminishing returns.

Roller and Waverman (2001) examined the impact of telecommunications infrastructure on economic development in 21 OECD countries over a period of 20 years from 1970 to 1990. They found significant two-way causation between economic growth and investments in telecommunications. Further, the existence of network externality was analysed using a nonlinear function, and the results show that an increase in telecommunications infrastructure could create higher growth effects.

Koutroumpis (2009) studied the impact of broadband on economic growth in 22 OECD countries for the period 200-2007. He found an increasing return to broadband telecommunications investments and persistent network effects. He also found that the broadband infrastructure investment critical mass was at 30% implying that about half of the population has broadband access. The returns to broadband connection are higher in the Scandinavian countries due to their higher use.

Sridhar and Sridhar (2007) analysed the impact of landline and cell phone penetration on economic development in an attempt to examine the relationship between telecommunications infrastructure investment and economic growth in developing countries. The 3SLS results showed that the penetration of landline and cell phone connections affects economic growth significantly. However, the low penetration relative to the penetration in OECD countries dissipates the convergence hypothesis. They also found that the demand for landline connections is related to the traditional economic factors, but not the cell phone demands.

Zahra *et al.* (2009) examined the impact of telecommunications infrastructure development and economic growth for 24 low-income, middle-income income and high-income countries over a period of 18 years using a Solow-type equation and convergence hypothesis. The fixed effects and random effects results showed that the macro variables are significantly related to economic growth. There exist increasing returns to scale in telecommunications investment and convergence.

In the Indian context, Ghosh and Prasad (2012) examined the impact of telephone penetration on the economic growth of India over 26 years from 1980-81 to 2006-07 using annual data and employing cointegration and Granger causality tests. The cointegration test shows no long-term relationship between the macro variables used. The failure of the cointegrating relationship is attributed to the fact that India has not reached the critical mass of users to have any impact because of the social disparity across and within states. The Granger causality test indicates unidirectional causation from telephone connectivity to growth in the short run. The impulse response function result shows that the positive response of GDP to innovations in telephone services and the initial level is restored with a four-year gap.

Barman *et al.* (2018) analysed the telecommunications divide among 16 major Indian states and the impact of telecommunications on the service sector by analysing the pattern, distribution dynamics and drivers of teledensity for a period of 15 years. The kernel density distribution dynamics indicate a convergence of teledensity across Indian states. However, the Markov transition probability matrix of the evolution of the distribution dynamics of teledensity over time shows a slow speed of convergence. The Arellano and Bond panel GMM estimates show that NSDP and the lagged teledensity have a significant

impact on teledensity across Indian states. The study finds convergence in teledensity in rural areas but not in urban areas. Further sensitivity diagnostics show the robustness of the baseline model, wherein the effect of NSDP and lagged teledensity on teledensity remains positive and statistically significant.

DATA AND METHODOLOGY

This paper uses the annual data on teledensity, NSDP per capita, literacy rate, service sector share in NSDP and electricity consumption for 18 Indian states for the years 2000 to 2023. The data were obtained from the Government of India Department of Telecommunications (DoT) and the Reserve Bank of India Handbook of Statistics on the Indian Economy. The per capita NSDP is for the 2011-12 base year. As the service sector is important not only for economic growth but also for telecommunications services growth, the service sector share in NSDP has been included. Teledensity is defined as the total number of mobile and landline subscribers per 100 inhabitants. Teledensity is considered an indicator of telecommunications penetration in the country. Following Barman *et al.* (2018), the relative teledensity is defined as:

$$Relative\,teledensity_{it} = Teledensity_{it} - \overline{Teledensity_t} \qquad (1)$$

where the relative teledensity in the *i*-th state at time *t* is the difference between the state teledensity and the average national teledensity.

Parametric Panel Unit Root Test: Since the data are time series, parametric panel unit root tests were used to test the stationarity of the series. The usual panel unit root tests are the Levin, Lin, Chin (2002), Im, Pesaran and Shin (2003) and Pesaran (2007) unit root tests that test the stationarity of relative teledensity.

Levin, Lin and Chu (LLC) Test: If the deviations from equilibrium are persistent, the panel unit root test is more powerful than the individual cross-section unit root tests. The LLC unit root test can be specified as:

$$\Delta y_{it} = \rho y_{it-1} + \Sigma_{j=1}^{p_i} \delta_{ij} y_{it-j} + \alpha_i x_{it} + \varepsilon_{it} \qquad (2)$$

where y_{it} is the relative teledensity in state *i* at time *t*, x_{it} is a vector of deterministic variables, and α_i is the corresponding vector of coefficients. To overcome the problem of unknown lag order p_i, the LLC test is implemented with three steps. The first step is the Augmented Dickey-Fuller (ADF) test for individual cross-sections with varying lag orders across individual states:

$$\Delta y_{it} = \rho y_{it-1} + \Sigma_{j=1}^{P_i} \delta_{ij} y_{it-j} + \alpha_i x_{it} + \varepsilon_{it} \tag{3}$$

Given T, the maximum autoregression order (lag) order p^{max} is chosen. However, since p_i is not known, two auxiliary ADF regressions are run to get orthogonalised residuals:

$$\Delta y_{it} \text{ on } \Delta y_{it-j} \ (j = 1, 2, 3 \ ..., p_i) \text{ and } x_{it} \text{ obtain residuals } \hat{e}_{it} \tag{4}$$

$$\Delta y_{i, \ t-1} \text{ on } \Delta y_{it-j} (j = 1, 2, 3 \ ..., p_i) \text{ and } x_{it} \text{ and obtain residuals } \hat{v}_{it-1} \tag{5}$$

These residuals are then standardised to control for individual state heterogeneity. Normalising $\hat{e}_{it}$ and $\hat{v}_{it-1}$ by the regression standard error:

$$\tilde{e}_{it} = \frac{\hat{e}_{it}}{\hat{\sigma}_{\varepsilon i}} \text{ and } \tilde{v}_{it-1} = \frac{\hat{v}_{it-1}}{\hat{e}_{\varepsilon i}} \tag{6}$$

$$\text{Or } \hat{\sigma}_{\varepsilon i}^2 = \frac{1}{T - p_i - 1} \Sigma_{t=p_i-2}^{T} (\hat{e}_{it} - \hat{\rho}_{i\hat{v}_{it-1}})^2 \tag{7}$$

where $\hat{\sigma}_{\varepsilon i}$ is the standard error from each ADF cross-section regression.

Under the null hypothesis of a unit root, the long-run variance is estimated by:

$$\hat{\sigma}_{yi}^2 = \frac{1}{T-1} \Sigma_{t=2}^{T} \Delta y_{it}^2 + 2 \Sigma_{j=1}^{k} \omega_{kj} \left[\frac{1}{T-1} \Sigma_{t=2+j}^{T} \Delta y_{it} \Delta y_{it-j} \right] \tag{8}$$

where k is a data-dependent truncation lag that ensures the consistency of $\hat{\sigma}_{yi}^2$ and $\omega_{kj} \left(= 1 - \dfrac{j}{k+1} \right)$ is a Bartlett kernel. For each cross-section i, an estimate of the ratio of the long-run to short-run innovation standard deviation is obtained as:

$$\hat{S}_i = \frac{\hat{\sigma}_{yi}}{\hat{\sigma}_{\varepsilon i}} \tag{9}$$

An estimate of the average standard deviation is given by:

$$\hat{S}_n = \frac{1}{n} \Sigma_{i=1}^{n} \hat{S}_i \tag{10}$$

Finally, pooling all the cross-section and time series observations, the panel standard error is obtained as:

$$\tilde{e}_{it} = \rho \hat{v}_{it-1} + \tilde{\varepsilon}_{it} \tag{11}$$

Then, the LLC test is to test H_0: $\rho = 0$ with the t-test.

Im, Pesaran and Shin (IPS) Test: The LLC test is restrictive as it requires ρ to be homogeneous across cross-sections. Allowing heterogeneous coefficients of y_{it-j}, Im *et al.* (2003) propose averaging of the individual ADF unit root test statistics when ε_{it} is serially correlated across cross-sectional units. The null hypothesis is that each series in the panel contains a unit root, and while some but not all individual series contain unit roots is the alternative hypothesis:

$$H_0: \rho_i = 0,\ H_1: \rho_i < 0 \text{ for } i = 1, 2,..., n_1 \text{ and } H_1: \rho_i = 0 \text{ for } i = n_1+1,..., N$$

(12)

The IPS t-bar statistic is defined as the average of the individual ADF statistics:

$$\bar{t} = \frac{1}{N}\Sigma_{i=1}^{N} t_{pi}$$

(13)

where t_{p_i} is the t-statistic for H_0: $\rho_i = 0$ for all i.

Pesaran (CIPS) Test: While the LLC and IPS tests are based on the assumption of cross-sectional dependence, Pesaran (2003) suggests augmenting the ADF regressions with the lagged cross-sectional mean and its first difference to capture the cross-sectional dependence. The cross-sectionally augmented Dickey-Fuller (CADF) regression can be specified as:

$$\Delta y_{it} = \alpha_i + \rho_i^* y_{it-1} + \beta_i \bar{y}_{t-1} + \gamma_i \Delta \bar{y}_t + \varepsilon_{it}$$

(14)

where $\bar{y}_t$ is the average of all cross-sections. The cross-sectional dependence is accounted for by a factor structure in the lagged cross-sectional average and its first difference. If the error term or the factor is serially correlated, the first difference lags of y_{it} and $\bar{y}_t$ are included in the regression:

$$\Delta y_{it} = \alpha_i + \rho_i^* y_{it-1} + \gamma_0 \bar{y}_{t-1} + \Sigma_{j=1}^{p} \gamma_{j+1} \Delta \bar{y}_{t-j} + \Sigma_{q=1}^{p} \tau_q \Delta y_{it-q} + \varepsilon_{it}$$

(15)

where a sequential test or an information criterion gives the degree of augmentation. The Pesaran (CIPS) panel unit root t-statistics are obtained as averaged lagged values from the CADF regression for each cross-sectional unit (CADF_i):

$$CIPS = \frac{1}{n}\Sigma_{i=1}^{n}CADF_i \tag{16}$$

Nonparametric Kernel Density Distribution Dynamics

The parametric methods assume a specific distribution function for the relative teledensity and do not explain the distribution dynamics across states over time. Nonparametric methods that allow the distribution of relative teledensity to be empirically determined are well-suited to analyse the distribution dynamics of teledensity over space and time. The probability densities of relative teledensity across states are estimated by the kernel density estimator:

$$\hat{f}(y) = \frac{1}{nh}\Sigma_{i=1}^{n}K\left[\frac{y_{it} - \bar{y}_t}{h}\right] \tag{17}$$

where h is the bandwidth and K is the kernel function. The kernel density estimator weighs each cross-section observation y in the range [0,1]. The weight is determined by the distance between observation y_i and the average *y*. This density estimate provides a visual of the shape of the relative teledensity distribution and an understanding of its dynamic evolution through time.

EMPIRICAL ANALYSIS

Table 1 presents the descriptive statistics of the variables included in the empirical analysis. The descriptive statistics show that Himachal Pradesh has the highest teledensity of 94.30, while Bihar has the lowest teledensity of 39.06 per 100 inhabitants. Kerala has the highest literacy rate, 94.31, while Bihar has the lowest literacy rate, 63.28. Maharashtra has the highest share of the service sector to NSDP, with 5491.37 billion, and Himachal Pradesh has the lowest share of the service sector to NSDP, with 280.59 billion. While Andhra Pradesh consumes 1536.06 kilowatts of electricity, Assam has the lowest electricity consumption of 216.93 kilowatts. The per capita NSDP of Maharashtra is ₹122735.3 crores, and Bihar has the lowest NSDP per capita of ₹24829.13 crores. In West Bengal, the share of the service sector in NSDP is the highest at ₹8150.83 crores and in Assam is the lowest at ₹603.63 crores.

Table 1: Descriptive Statistics of Variables

State	Teledensity (TD)		Service sector share in NSDP (SER)		Literacy rate (LR)		Electricity consumption (EC)	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
AP*	65.85	25.82	3863.67	2352.49	67.68	2.17	1536.06	821.69
Assam	39.50	18.50	603.63	335.11	73.08	2.97	216.93	45.51
Bihar	39.06	17.48	1039.13	475.07	63.28	4.91	157.46	59.08
Gujrat	74.69	29.51	2162.19	906.60	78.92	2.95	1462.82	233.31
Haryana	67.85	24.65	1281.20	664.77	76.31	2.53	1616.07	270.09
HP	94.30	38.06	280.59	137.08	83.43	2.10	1205.06	124.89
J&K	54.96	24.67	374.18	268.22	68.32	3.86	992.65	121.92
Karnataka	77.64	29.87	3803.07	3462.69	76.86	4.94	920.72	121.33
Kerala	84.46	26.79	2059.31	1034.73	94.31	1.04	611.04	90.81
MP	46.51	18.05	1307.25	701.22	69.88	1.85	700.77	144.29
Maharashtra	63.23	25.59	5491.37	2239.83	82.89	1.81	1121.58	116.49
North East**	56.57	24.27	415.81	186.02	65.32	2.11	2157.85	374.44
Odisha	49.74	24.08	608.27	232.77	73.87	3.25	592.23	51.64
Punjab	88.57	28.68	1028.20	586.68	76.46	2.05	1711.45	140.17
Rajasthan	60.62	25.11	1580.86	890.99	66.68	1.89	831.07	137.23
Tamil Nadu	89.10	37.33	3268.28	1733.10	80.75	2.20	1207.53	161.80
UP	47.16	21.26	8150.83	11064.40	68.82	3.78	414.72	86.39
West Bengal	45.64	21.89	2558.70	1062.75	77.02	2.53	457.61	65.17

Note   *Including Telangana. ** Including all states in North-East India.
Source: Computed from the Government of India Department of Telecommunications (DoT) and Reserve Bank of India Handbook of Statistics on the Indian Economy data. Mean and standard deviations are the average and deviations of the variables during the period 2000-2023.

The estimating dynamic panel fixed effects regression equation of the determinants of teledensity is specified as:

$$TD_{it} = \beta_1 TD_{it-1} + \beta_2 NSDP_{it} + \beta_3 SER_{it} ++ \beta_4 LR_{it} + \beta_5 EC_{it} + \lambda_i + \eta_t + \varepsilon_{it} \qquad (18)$$

where λ represents state-fixed effects and η represents time-fixed effects. Applying OLS estimation to the above equation may provide biased and inconsistent estimates, as the lagged teledensity variable may be endogenous, as it may be correlated with the (unobserved) state-specific fixed effects. Therefore, the Arellano-Bond Generalised Method of Moments (GMM) estimation is used in the empirical estimation. The fixed effects are eliminated by differencing.

It is common in telecommunications literature to estimate a value known as the half-life. The half-life is the required time to dissipate by one-half for any

deviations from the steady state (Barman *et al.*, 2018). The half-life is estimated from the autoregressive coefficient in the panel unit root test equation as:

$$h(\rho) = \frac{\ln(0.5)}{\ln(\rho)}$$

(19)

where ρ is the AR(1) coefficient and $h(\rho)$ is the half-life.

Table 2 presents the results of the panel unit root test, along with the half-life. The LLC test rejects the null hypothesis of the unit root test at a 5% level of significance and stationarity at levels by assuming there is a homogeneity of the coefficient of the AR(1) across the cross-section. The IPS test also rejects the null hypothesis at 5% at the first difference by assuming heterogeneity of the coefficient of the AR(1) across the cross-section. The Pesaran CIPS test rejects the null hypothesis and stationarity at the first difference by assuming cross-sectional dependence. The rejection of the null hypothesis by all the panel unit root tests implies that relative teledensity across states converges to a steady state. The estimate of half-life estimate from the coefficient of AR(1) of the LLC test shows that about 1.13 years is required to dissipate by half the deviations of state teledensity from the national average.

Table 2: Panel Unit Root Tests and Half-Life

Stationarity	Test	Statistic	Average	Half-life
At levels	Levin, Lin and Chu t*	-2.7985**	-0.45793	1.13
At first difference	Im, Pesaran and Shin W-stat	-4.7296**	-	-
	Pesaran CIPS	-1.202**	-	-

Note: ** Significance at 5% level.

Towards an understanding of the relative teledensity distribution dynamics in states of India, nonparametric kernel density plots for some of the years are presented in Figure 1. In 2004, a majority of the states lie on the negative side, implying that state teledensity is lower than the national average. The comparatively smaller peak on the positive side shows few states have teledensity higher than the national average. In 2008, the distribution was on the negative side and so wide, implying a significant disparity between the states. The 2012 plot also shows a similar distribution, but there is no distinct peak, implying that a number of states have teledensity higher than the national average. The kernel density distribution for 2018 indicates that

the states are moving from the negative side to the positive side, implying a considerable improvement in teledensity in the states of India.
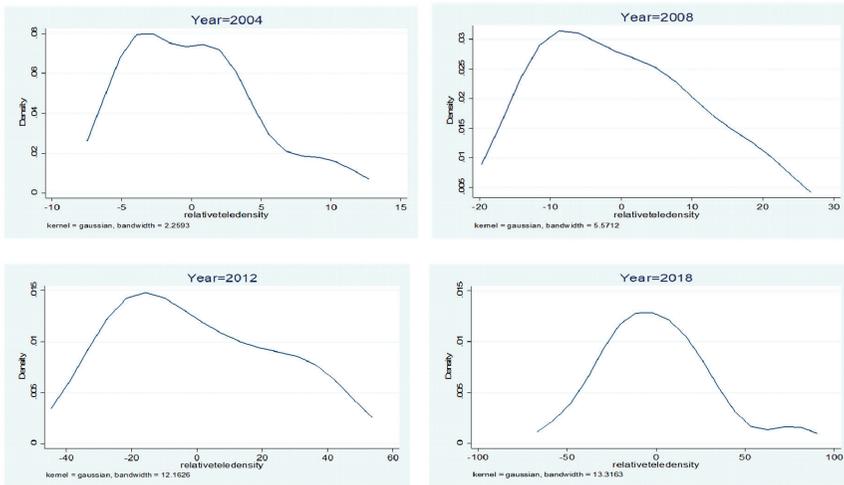

Figure 1: Kernel Density Plots of Relative Teledensity

Table 3 presents the panel dynamic fixed effects Arellano-Bond GMM estimates of teledensity in states of India, along with the results of autocorrelation and Sargan tests. The estimated coefficient of NSDP per capita is positive and statistically significant. On average, an increase in NSDP per capita by one percentage has the effect of increasing teledensity in states by 23 percentage points. This shows that more demand for telecom services is required as the economy grows. The coefficient of the lagged teledensity is also positive and statistically significant at the 5% level.

Table 3: Arellano-Bond GMM Estimates of Teledensity in the States of India

Variable	Estimate	Std. error	P>|z|
Lagged teledensity	0.303**	0.011	0.00
ln(NSDP)	22.81**	1.159	0.00
ln(share of service sector in NSDP)	3.147**	0.533	0.00
Literacy rate	0.181**	0.601	0.003
Electricity consumption	0.001	0.00	0.101
Autocorrelation order 1	-2.324#	-	0.021
Autocorrelation order 2	1.205#	-	0.228
Sargan test	17.199+		0.246@

Note: # z-statistic. + Chi^2 value. @ Prob.> chi^2. ** significant at 5% level.

The coefficient of network externality is also a significant 0.30. These estimates together accord well as the subscriber base of the telecom network increases, so also the network externality arising out of it. The estimated coefficient of the service sector share in NSDP is significantly positive with a point estimate of 3.14. A one percentage point increase in service sector share in NSDP increases teledensity by 3% on average. The estimated coefficient of literacy rate is significantly positive with a point estimate of 0.18. As the literacy rate increases by a percentage, the teledensity rises by 0.18 percentage points. The coefficient of electricity consumption is positive but insignificant, indicating no significant effect of electricity consumption on teledensity.

CONCLUSION

Given the importance of telecommunications for economic development, this paper analyses the determinants of telecommunications performance across 18 Indian states over the years 2000 to 2023. The relative teledensity across states is computed to understand the performance of the telecommunications in the states. The panel unit root test of LLC, IPS and Pesaran CIPS tests are used. The distribution dynamics and the determinants of teledensity are examined using kernel density plots and the dynamic panel fixed effects Arellano-Bond GMM estimation technique. The panel unit root tests show that the null hypothesis was rejected at levels for the LLC test and at the first difference for the IPS test and Pesaran CIPS, implying that relative teledensity across states converges to a steady state. The kernel density plots show a disparity in teledensity across Indian states and gradual improvement over the years, indicating convergence. The half-life estimation indicates that the speed of convergence is 1.13 years, i.e. it takes 1.13 years for the states to converge. The NSDP per capita and network externality are important factors in the teledensity of states. The service sector share in the NSDP and literacy rate are the other significant factors that determine the teledensity in the states of India.

As for the impact of investment in the telecommunication sector, it proves beneficial to the development of the economy, as telecommunication networks and network externality are the requirements of economic growth. As most of the telecom service providers are multinational companies, the FDI flows increase in the telecom sector of the economy, providing more employment and tax revenues. While the contribution of the telecom sector to growth is

not huge, it is significant. Being greenfield projects, telecom infrastructure setup needs huge investment, for which the governments need to subsidise its expansion. Policy and regulatory mechanisms should promote a competitive environment for international and domestic investments to spur the growth of the telecom sector and reduce telecom tariffs.

The results of this study indicate strong evidence that telecommunications networks that are efficient and balanced infrastructure significantly foster economic growth, reduce regional connectivity and shrink the digital divide. Apart from the positive side of the telecom sector growth in India, the telecom sector also faces serious challenges. The first and foremost challenge is the poor teledensity in rural areas, for which steps to overcome this problem are needed. An added problem is the poor standards in service provision, lack of network security, and, importantly, low awareness and patronage. The lack of sufficient service provider companies, low broadband penetration and high-frequency charges pose big challenges for telecom penetration in rural and poor households. Poor quality human resources in the information technology and telecom sector, and the lack of R&D activities in the telecommunications sector for home production of equipment, necessitate big imports of telecom equipment. The government policy should aim to improve telecom infrastructure in rural and inaccessible areas by giving incentives to service providers and encouraging home production of telecom equipment. The policy should also aim to increase provider competition in telecom service provision in neglected areas, which will ultimately reduce the costs and tariffs and reduce the digital divide. Just like the existence of financial literacy programmes, the telecom policy should also prioritise consumer literacy, especially in the wake of increasing cyber frauds and crimes, and close the regional gaps in teledensity and the digital divide.

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