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Analyzing the Relationship Between Performance of Infrastructure Sector Outputs and Economic Growth in India- a Brief Study:

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Abstract:
Infrastructure is often considered as one of most the essential elements in the process of economic growth in an economy. Without provisioning of adequate infrastructure be it physical or social infrastructure it will not be feasible to utilize all the resources available in an economy up to their actual potential. This paper tries to analysis relationship between outputs of different heads of infrastructure with growth rate of GDP over the past decades. Furthermore this study will look into the performance of the states across decades to get a comparative picture of overall infrastructure facilities and whether there remains any sort of discrepancy in distribution of infrastructural resources . At the end it can be said that some kind of variation in pattern of infrastructure provisioning due to multiple complex factors exist because of uneven resource distribution.
Keywords: Economic growth, GDP , infrastructure provisioning

Introduction:
It has been discovered that infrastructure development in India has a significant positive contribution to economic growth however the relationship is quite complex as it brings forward multiple factors affecting causal relationship. (Aschauer, 1989) Where physical infrastructure is the driving force of the economy and on the other side social infrastructure creates opportunities for newer options for skill development greater human capital formation. Due to fiscal constraints is often seems difficult for government to provide adequate infrastructure financing. Moreover unequal resource allocation and due to other market imperfections this problem leads to roadblocks to not only that specific region or geographical territory but also other surrounding areas too. It is impossible to achieve sustainable growth and reduce poverty without addressing the issue of inadequate infrastructure. (Dash & Sahoo, 2010) There remains need for substantial investment in infrastructure not only from the public sector but also private sector players.

Research objective:

To see trend of magnitude of performance of infrastructure outputs of both physical and social infrastructure across selected states over the period of study.

To analyze the relationship between GDP growth rate and different types of infrastructure sector variables

Literature review:
Studies so far conducted over the point that there perhaps remains direct linkage between infrastructure and economic growth in India are mostly empirical study in nature. There prevails disparity in relative position across states in rural India and even in North Eastern Region of India.(Chakraborty & Guha, 2009).
Instead of using a top-down approach, infrastructure requires careful planning and coordination, decentralization, private engagement, and the commercialization of service providers. Cost recovery and efforts to enhance legislative and institutional frameworks are vital for building a virtuous loop of investment and growth in developing nations, notably in India. This is because private engagement in infrastructure is restricted in developing countries. (Sahoo & Dash, 2009).At the most fundamental level, it is reasonable to anticipate that an increase in public investment would result in a roughly one-to-one reduction in private investment. This is due to the fact that the private sector will most likely use the public capital for its own objectives rather than expanding private capacity. (Aschauer, 1989)
Different sectors such as Telecommunication, roads, railways, energy ,water and side by side social sector such as education, health-care services are essential towards the well being of citizens of India. (Srinivasu & Rao, 2013) . The

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expenditure of the government on social services has been on an upward trend since the fiscal year 2016 (FY16), with an emphasis on many different facets of the social well-being of the residents of the country. Since the fiscal year 2018 through the fiscal year 2020, the proportion of the government's overall expenditures that are allocated to social services has been about 25 percent. (Ministry of Finance, 2023)

Data and Methodology:

We have here used secondary and annual data of RBI's Handbook of Statistics on Indian Economy and RBI's Handbook of Statistics on Indian States for the period of 2006 to 2019.Infrastructure sector output variables for the study have considered both physical and social infrastructure and have been taken as the percentage changes Rail lines (total route-km), Telephones per 100 Population, Total length of roads, Total installed capacity of power, Social sector expenditure, GDP growth (annual).

This study has used unit root tests such as ADF (Augmented Dickey-Fuller) to check the stationarity of variables. Considering the nature of variables and methodological arguments, study has used the unrestricted vector auto-regression (VAR) model to assess the relationship between economic growth and outputs of infrastructure sectors(both physical and social) in India.

Annual data for 15 states have been considered here which are : Andhra Pradesh ,Assam , Bihar , Gujarat, Haryana, Madhya Pradesh, Maharashtra , Rajasthan, Tamil Nadu, Uttar Pradesh, Odisha, Himachal Pradesh, Karnataka, Kerala, Punjab.

Unit root test has been performed to check stationarity of both dependent and independent variables using Augmented Dickey-Fuller test technique over the period of study. Furthermore, Johansen's Cointegration Test has been performed to ascertain whether there prevails any co-integration between output variables of infrastructure sector and GDP Growth Rate in this study. The optimum lag order for infrastructure variables has been selected using VAR Lag Order Selection Criteria. Finally VAR (vector auto-regression) model has been used to analyze the causal relationship between GDP growth and different kinds of infrastructure output.

State wise performance of infrastructure sector output variables :

Figure 1

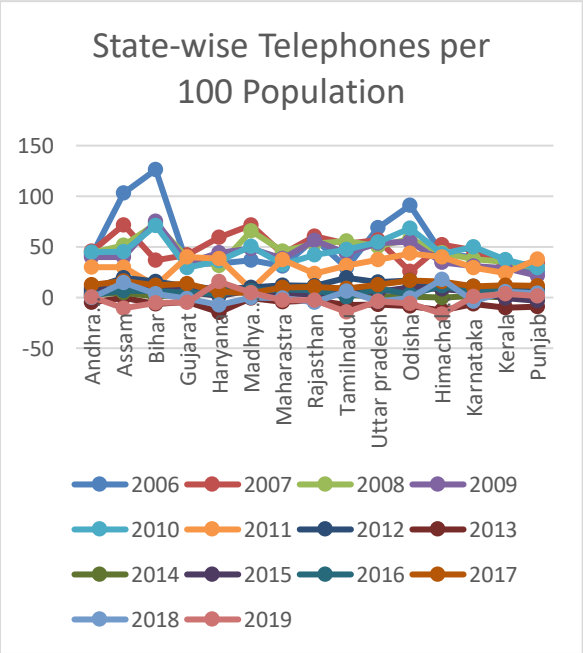
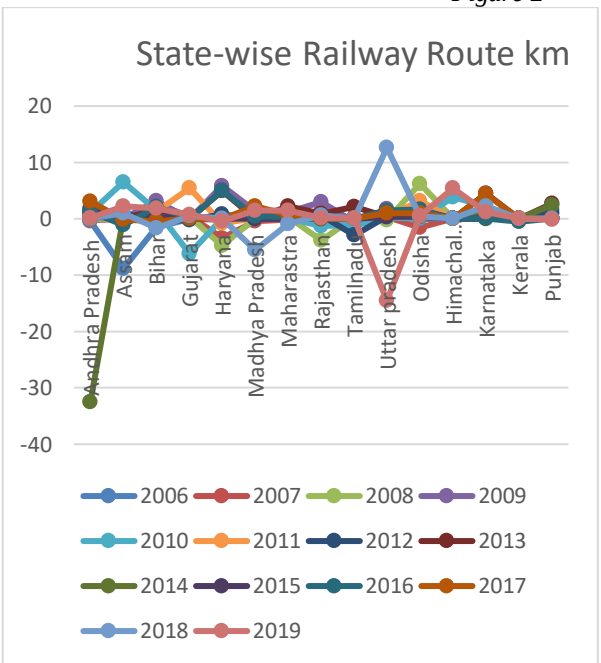


Figure 2



European Economic Letters
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Figure 3

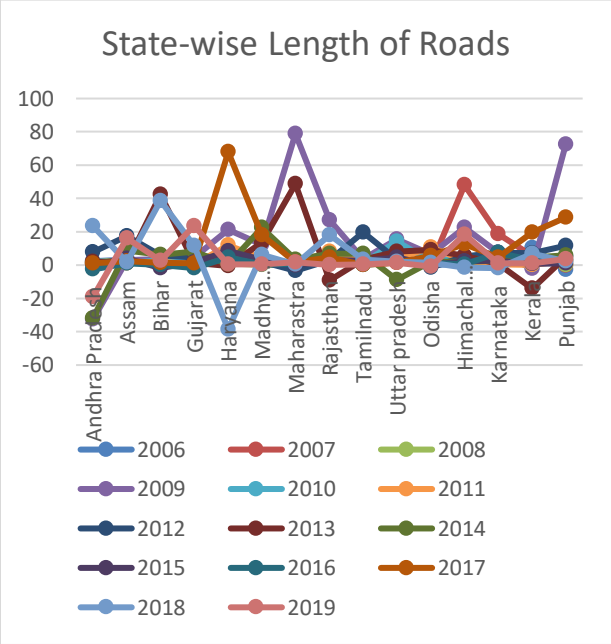


Figure 4

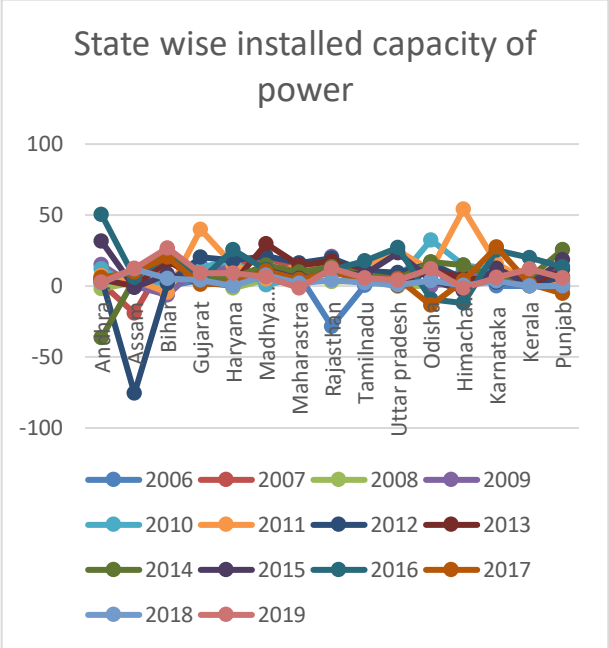
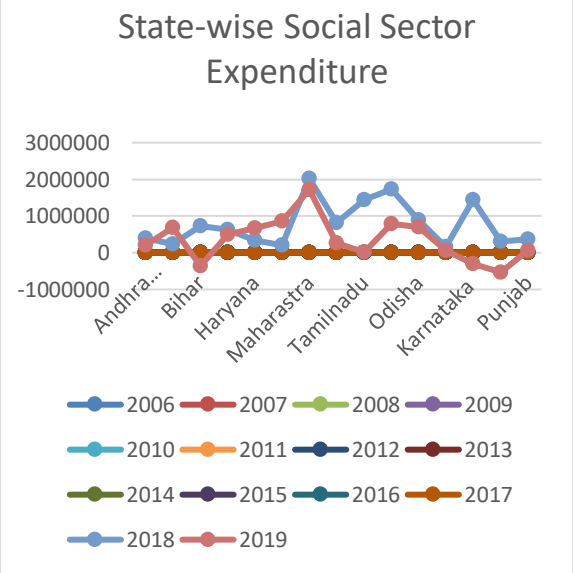


Figure 5



Results of unit root test:

Null Hypothesis: **GDP GROWTH ANNUAL** has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.996289	0.0597
Test critical values:	1% level	-4.004425	
	5% level	-3.098896	

	10% level	-2.690439

Here the p value of the augmented Dickey–Fuller test statistic is 0.0597 which is greater than its critical value 0.05 . therefore, we accept the null hypothesis that GDP GROWTH ANNUAL has a unit root, implying that the series is not stationary.

Null Hypothesis: **SOCIAL SECTOR EXPENDITURE** has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.687191	0.4142
Test critical values:	1% level	-4.057910	
	5% level	-3.119910	
	10% level	-2.701103	

Here the p value of the augmented Dickey–Fuller test statistic is 0.4142 which is greater than its critical value 0.05 .therefore, we accept the null hypothesis that SOCIAL SECTOR EXPENDITURE has a unit root, implying that the series is not stationary.

Null Hypothesis: **TELEPHONES_PER_100_POPULATION** has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.803989	0.7838
Test critical values:	1% level	-4.057910	
	5% level	-3.119910	
	10% level	-2.701103	

Here the p value of the augmented Dickey–Fuller test statistic is 0.7838 greater than its critical value 0.05 . Therefore we accept the null hypothesis that TELEPHONES PER 100 POPULATION has a unit root, implying that the series is not stationary.

Null Hypothesis: **TOTAL INSTALLED CAPACITY OF POWER** has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.251083	0.0401
Test critical values:	1% level	-4.057910	
	5% level	-3.119910	
	10% level	-2.701103	

Here the p value of the augmented Dickey–Fuller test statistic is 0.0401 which is less than its critical value 0.05. Therefore, we reject the null hypothesis that TOTAL INSTALLED CAPACITY OF POWER has a unit root, implying that the series is stationary.

Null Hypothesis: **TOTAL LENGTH OF ROADS** has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.048065	0.0007
Test critical values:	1% level	-4.200056	
	5% level	-3.175352	
	10% level	-2.728985	

Here the p value of the augmented Dickey–Fuller test statistic is 0.0007 which is less than its critical value 0.05 . Therefore we reject the null hypothesis that TOTAL LENGTH OF ROADS has a unit root, implying that the series is stationary.

Null Hypothesis: **RAIL LINES TOTAL ROUTE KM** has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.790719	0.0159
Test critical values:	1% level	-4.057910	
	5% level	-3.119910	
	10% level	-2.701103	

Here the p value of the augmented Dickey–Fuller test statistic is 0.0159 which is less than its critical value 0.05 . Therefore we reject the null hypothesis that RAIL LINES TOTAL ROUTE KM has a unit root, implying that the series is stationary.

Results of co-integration test :

Series: RAIL_LINES__TOTAL_ROUTE_KM_ GDP_GROWTH__ANNUAL___
Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	1.000000	451.8128	15.49471	0.0001
At most 1 *	0.599190	10.97122	3.841466	0.0009

The maximum eigen statistic for both *r*=0 and r=1 exceeds its critical value of at 5% level and we can reject the null hypothesis of no cointegration equations.

Series: GDP_GROWTH TELEPHONES

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.702008	15.66635	15.49471	0.0471
At most 1	0.090481	1.138076	3.841466	0.2861

The value of trace statistic show that at *r*=0 it exceeds its critical value at 5% level, and we can reject the null hypothesis of no cointegration equations. But at *r*=1, the value of trace statistic is less than its critical value at 5% level, which means we accept the null hypothesis that there is only one cointegration equations exist.

Series: TOTAL_LENGTH_OF_ROADS GDP_GROWTH__ANNUAL___

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	1.000000	434.6179	15.49471	0.0001
At most 1 *	0.580062	10.41178	3.841466	0.0013

The value of trace statistic show that at *r*=0 and r=1 they exceed its critical value at 5% level, and we can reject the null hypothesis of no cointegration equations.

Series: TOTAL_INSTALLED_CAPACITY_OF_POWER GDP_GROWTH__ANNUAL___
Exogenous series: TOTAL_INSTALLED_CAPACITY_OF_POWER

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	1.000000	431.4762	15.49471	0.0001
At most 1 *	0.727193	15.58790	3.841466	0.0001

The value of trace statistic show that at *r*=0 and r=1 they exceed its critical value at 5% level, and we can reject the null hypothesis of no cointegration equations.

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Series: GDP_GROWTH SOCIAL_SECTOR

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.666363	13.85564	15.49471	0.0870
At most 1	0.055344	0.683211	3.841466	0.4085

The value of trace statistic show that at *r*=0 and r=1 they are is less than its critical value at 5% level, and we can accept the null hypothesis of no cointegration equations.

Lag length criterion:

As we have run EViews Software for optimum lag length different criterion such as FPE(Final prediction error), AIC(Akaike information criterion) , SC(Schwarz information criterion), HQ(Hannan-Quinn information criterion) have been provided. Here for the purpose of the study we have chosen Akaike information criterion for VAR Lag Order Selection Criteria.

Endogenous variables: D(ROADS) D(GDP_GROWTH)

Lag	LR	FPE	AIC	SC	HQ
0	NA	54.74930	9.677177	9.737694	9.610790
1	2.418135	89.48345	10.13173	10.31328	9.932568
2	4.909635	87.46798	9.949802	10.25239	9.617867
3	11.14777*	7.593763*	7.033879*	7.457498*	6.569170*

Akaike information criterion here suggests that optimum lag is 3 , value of which is 7.033879.

Endogenous variables: D(GDP_GROWTH) D(RAIL)

Lag	LR	FPE	AIC	SC	HQ
0	NA*	7.664494*	7.711011	7.771528*	7.644624
1	4.610662	9.158382	7.852345	8.033896	7.653184
2	4.095122	10.53593	7.833321	8.135906	7.501386
3	3.246854	12.73666	7.551036*	7.974655	7.086327*

Akaike information criterion here suggests that optimum lag is 3, value of which is 7.551036.

Endogenous variables: D(GDP_GROWTH) D(POWER)

Lag	LR	FPE	AIC	SC	HQ
0	NA*	143.3356*	10.63994	10.71228*	10.59433

1	5.387715	155.4483	10.69374	10.91078	10.55694
2	5.507771	144.1390	10.50306*	10.86478	10.27504*

Akaike information criterion here suggests that optimum lag is 3 , value of which is 10.50306.

Endogenous variables: D(GDP_GROWTH) D(SOCIAL_SECTOR)

Lag	LR	FPE	AIC	SC	HQ
0	NA	195.3158	10.94903	11.00955	10.88264
1	4.647607	232.1564	11.08509	11.26664	10.88593
2	10.39626	75.73992	9.805835	10.10842	9.473900
3	13.88613*	2.639452*	5.977123*	6.400742*	5.512414*

Akaike information criterion here suggests that optimum lag is 3 , value of which is 5.977123.

Endogenous variables: D(GDP_GROWTH) D(TELEPHONES)

Lag	LR	FPE	AIC	SC	HQ
0	NA*	348.0762*	11.52683	11.58735*	11.46045
1	3.090641	516.7908	11.88531	12.06686	11.68615
2	6.645400	356.9888	11.35623*	11.65882	11.02430*
3	0.724284	1000.499	11.91481	12.33843	11.45010

Akaike information criterion here suggests that optimum lag is 2 , value of which is 11.35623.

Results of VAR model:

For the sake of brevity and visual symmetry multiple variable names have been abbreviated, such GDP_GROWTH__ANNUAL___,RAIL_LINES__TOTAL_ROUTE_KM,TOTAL_LENGTH_ OF_ROADS, TOTAL_INSTALLED_CAPACITY_OF_POWER, TELEPHONES_ PER_100 POPULATION_, SOCIAL_SECTOR_EXPENDITURE have represented as GDP_GROWTH , RAIL,ROADS,POWER,TELEPHONES,SOCIAL_SECTOR.

In the upper panel of the results we have individual variable's coefficients , standard errors and the value of t- statistic .

In the lower panel we have different statistical values of OLS (Ordinary Least Squares) estimates .

	D(TELEPHONES)	D(GDP GROWTH)
D(TELEPHONES(-1))	0.438451	0.058682
	(0.36874)	(0.08791)
	[1.18904]	[0.66751]
D(TELEPHONES(-2))	-0.183740	-0.008890

	(0.36685)	(0.08746)
	[-0.50086]	[-0.10165]
D(GDP_GROWTH(-1))	-1.509912	-0.597445
	(1.57494)	(0.37548)
	[-0.95871]	[-1.59115]
D(GDP_GROWTH(-2))	-2.223029	-0.593676
	(1.55750)	(0.37132)
	[-1.42731]	[-1.59882]
C	-3.222619	0.042411
	(3.38157)	(0.80620)
	[-0.95299]	[0.05261]
R-squared	0.400570	0.414788
Adj. R-squared	0.000950	0.024647
Sum sq. resids	609.7437	34.65705
S.E. equation	10.08087	2.403367
F-statistic	1.002378	1.063176
Log likelihood	-37.69161	-21.92016
Akaike AIC	7.762111	4.894574
Schwarz SC	7.942973	5.075435
Mean dependent	-4.303417	-0.109724
S.D. dependent	10.08566	2.433545
Determinant resid covariance (dof adj.)		562.0180
Determinant resid covariance		167.2120
Log likelihood		-59.37259
Akaike information criterion		12.61320
Schwarz criterion		12.97492
Number of coefficients		10

Here for lag 1 and lag 2 for both the set of variables TELEPHONES and GDP GROWTH we have value of t-statistics which are all less than 1.96 , hence we can simply summarize that they are not statistically significant .

	GDP_GROWTH	RAIL
GDP_GROWTH(-1)	-0.231133	0.145043
	(0.44078)	(0.25502)
	[-0.52437]	[0.56875]
GDP_GROWTH(-2)	-0.514989	0.022284
	(0.38005)	(0.21988)
	[-1.35506]	[0.10135]

GDP_GROWTH(-3)	-0.215463	0.048519
	(0.46894)	(0.27131)
	[-0.45946]	[0.17883]
RAIL(-1)	1.026766	-0.705660
	(1.48278)	(0.85788)
	[0.69246]	[-0.82256]
RAIL(-2)	0.940236	-0.265489
	(1.23829)	(0.71643)
	[0.75930]	[-0.37057]
RAIL(-3)	0.102820	-0.301969
	(1.68086)	(0.97248)
	[0.06117]	[-0.31051]
C	11.97467	-0.103658
	(5.50627)	(3.18571)
	[2.17473]	[-0.03254]
R-squared	0.522170	0.423617
Adj. R-squared	-0.194575	-0.440957
Sum sq. resids	12.46206	4.171468
S.E. equation	1.765082	1.021209
F-statistic	0.728529	0.489972
Log likelihood	-16.29469	-10.27537
Akaike AIC	4.235398	3.140977
Schwarz SC	4.488604	3.394183
Mean dependent	6.676546	0.581402
S.D. dependent	1.614947	0.850725
Determinant resid covariance (dof adj.)		2.916336
Determinant resid covariance		0.385631
Log likelihood		-25.97584
Akaike information criterion		7.268335
Schwarz criterion		7.774747
Number of coefficients		14

Here for lag 1,lag 2 and lag 3 for the all sets of variables GDP GROWTH, RAIL we have value of t-statistics which are all less than 1.96 , hence we can simply summarize that they are not statistically significant .

	D(GDP_GROWTH)	D(SOCIAL_SECTOR)
D(GDP_GROWTH(-1))	-0.564610	0.177281
	(0.14361)	(0.75449)
	[-3.93161]	[0.23497]

D(GDP_GROWTH(-2))	-0.528261	-1.772534
	(0.14597)	(0.76687)
	[-3.61907]	[-2.31137]
D(GDP_GROWTH(-3))	-0.271763	-0.484242
	(0.14756)	(0.77522)
	[-1.84177]	[-0.62465]
D(SOCIAL_SECTOR(-1))	0.045958	-0.509027
	(0.05834)	(0.30650)
	[0.78776]	[-1.66075]
D(SOCIAL_SECTOR(-2))	0.176344	-0.100012
	(0.05996)	(0.31503)
	[2.94088]	[-0.31747]
D(SOCIAL_SECTOR(-3))	0.200621	-1.024495
	(0.06918)	(0.36346)
	[2.89999]	[-2.81876]
C	0.651851	-2.234672
	(0.29901)	(1.57095)
	[2.18001]	[-1.42250]

R-squared	0.946831	0.847847
Adj. R-squared	0.840493	0.543541
Sum sq. resids	1.983075	54.73737
S.E. equation	0.813034	4.271509
F-statistic	8.903961	2.786168
Log likelihood	-6.099704	-22.68919
Akaike AIC	2.619941	5.937839
Schwarz SC	2.831750	6.149648
Mean dependent	0.336715	-1.349576
S.D. dependent	2.035723	6.322380

Determinant resid covariance (dof adj.)	0.913305
Determinant resid covariance	0.082197
Log likelihood	-15.88562
Akaike information criterion	5.977123
Schwarz criterion	6.400742
Number of coefficients	14

Here for lag 1 and lag 2 value of t-statistic for GDP_GROWTH are greater than 1.96 implying that they are statistically significant. Similarly SOCIAL_SECTOR is statistically significant for lag 2 and lag 3.

	D(GDP_GROWTH)	D(ROADS)
D(GDP_GROWTH(-1))	-0.990432	0.844495
	(0.51671)	(0.38922)
	[-1.91681]	[2.16969]
D(GDP_GROWTH(-2))	-1.227312	0.890435
	(0.57609)	(0.43395)
	[-2.13043]	[2.05192]
D(GDP_GROWTH(-3))	-0.678182	0.501431
	(0.57718)	(0.43478)
	[-1.17499]	[1.15331]
D(ROADS(-1))	-0.183928	-0.412141
	(0.23659)	(0.17821)
	[-0.77742]	[-2.31261]
D(ROADS(-2))	-0.298381	-0.434279
	(0.28393)	(0.21388)
	[-1.05088]	[-2.03048]
D(ROADS(-3))	-0.188865	-0.499493
	(0.25491)	(0.19202)
	[-0.74090]	[-2.60125]
C	0.468012	-0.614381
	(0.55875)	(0.42089)
	[0.83761]	[-1.45971]
R-squared	0.770374	0.970818
Adj. R-squared	0.311123	0.912453
Sum sq. resids	8.564470	4.859691
S.E. equation	1.689622	1.272752
F-statistic	1.677457	16.63358
Log likelihood	-13.41457	-10.58133
Akaike AIC	4.082914	3.516267
Schwarz SC	4.294724	3.728076
Mean dependent	0.336715	-1.032055
S.D. dependent	2.035723	4.301521
Determinant resid covariance (dof adj.)		2.627600
Determinant resid covariance		0.236484
Log likelihood		-21.16940
Akaike information criterion		7.033879
Schwarz criterion		7.457498
Number of coefficients		14

	D(GDP_GROWTH)	D(POWER)
D(GDP_GROWTH(-1))	-0.339814	0.150519
	(0.29766)	(0.66452)
	[-1.14162]	[0.22651]
D(GDP_GROWTH(-2))	-0.559036	-0.765035
	(0.28696)	(0.64063)
	[-1.94814]	[-1.19419]
D(POWER(-1))	0.115728	-0.376524
	(0.16402)	(0.36617)
	[0.70558]	[-1.02829]
D(POWER(-2))	-0.153221	0.036678
	(0.16476)	(0.36782)
	[-0.92998]	[0.09972]
C	-0.118744	-0.040041
	(0.58652)	(1.30940)
	[-0.20245]	[-0.03058]
R-squared	0.623223	0.457834
Adj. R-squared	0.372039	0.096391
Sum sq. resids	22.31325	111.2085
S.E. equation	1.928439	4.305200
F-statistic	2.481137	1.266682
Log likelihood	-19.49839	-28.33264
Akaike AIC	4.454254	6.060479
Schwarz SC	4.635115	6.241341
Mean dependent	-0.109724	0.045932
S.D. dependent	2.433545	4.529007
Determinant resid covariance (dof adj.)		68.12820
Determinant resid covariance		20.26955
Log likelihood		-47.76681
Akaike information criterion		10.50306
Schwarz criterion		10.86478
Number of coefficients		10

In this case the value of t-statistics for GDP_GROWTH and POWER are all lags are less than 1.96 implying that they are not statistically significant.

Conclusion:

Like previous studies (Kumari & Sharma, 2017), (Ghosh & De, 2005),(Chotia & Rao, 2018) the study focuses on possible linkages between infrastructure outputs with rate of GDP growth and has got similar findings like earlier ones.

this might be because of presence of some sort of indirect causal relationship between infrastructure development and GDP growth.

At the end it can be concluded that gradually over decades the volume of infrastructure output has shown an upward trend however this trend is not similar all the states implying some kind of variation in pattern of infrastructure provisioning.

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