Electricity consumption and economic growth nexus: Evidence from the Northeastern states of India using panel data

Sorokhaibam Aguraj Singh
Research Scholar, Department of Economics
Manipur University
aguraj@manipuruniv.ac.in

Abstract

Electricity is considered a significant source of economic growth and access to it helps in the production process and overall increases the standard of living. This paper used real per capita net state domestic product (NSDP) and per capita electricity consumption to empirically examined the electricity and economic growth nexus by adopting panel cointegration test for the fiscal period of 2002-03 to 2021-22 in Northeastern states of India. The findings revealed the existence of a long run equilibrium relationship of the two variables.

Keywords: Northeast India, Electricity consumption, Panel data, cointegration

1. Background

The Indian government recognized the significance of the electricity sector from the early phase of planning and gradually expanded it over time. The installed capacity was 1713 MW in 1950 and increased to 370106 MW in 2020, reflecting the government's commitment to deliver electricity to its citizens and industries. However, to meet the needs of domestic consumption and sectoral demands, there is an urgent need to increase capacity. Within India, regional

disparities in electrification and demand differ among the states. Policymakers of both central and state governments aim to reduce such inequalities and divergence through various schemes and projects such as Power for all, SAUBHAGYA- Pradhan Mantri Sahaj Bijli Har Ghar Yojana and Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), etc.

The provision of electricity to the Northeastern states of India has always been challenging due to its hilly terrain geographical structure, lack of infrastructure,sparsely populated areas, etc. With respect to the total geographical area, Northeastern states have the highest percentage of forest for instance, Mizoram (84.53 percent) followed by Arunachal Pradesh (79.33 percent), Meghalaya (76.00 percent), Manipur (74.34 percent) and Nagaland (73.90 percent) (India state of Forest Report, 2021). The collective efforts of the central and state government help in improving the provision of electricity and is growing steadily overtime.

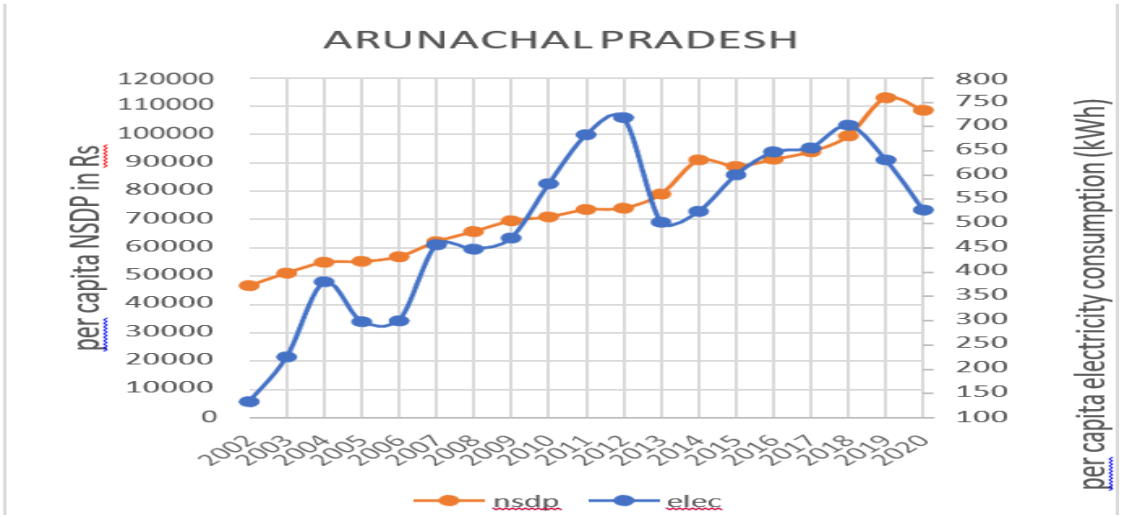


Fig.1

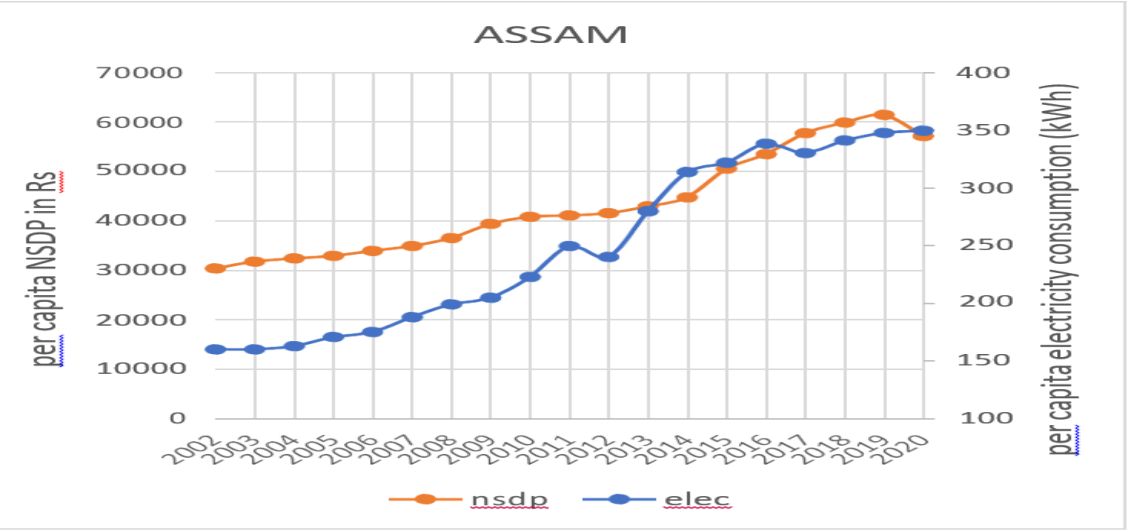
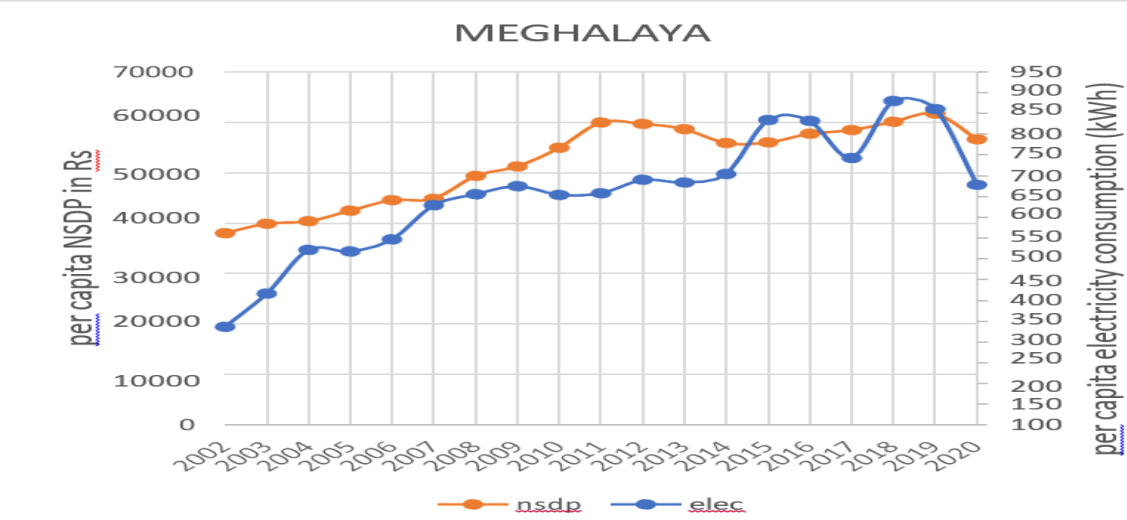

ASSAM
per capita NSDP in Rs
per capita electricity consumption (kWh)
70000
60000
50000
40000
30000
20000
10000
0
400
350
300
250
200
150
100
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
nsdp
elec

Fig.2


MEGHALAYA
per capita NSDP in Rs
per capita electricity consumption (kWh)
70000
60000
50000
40000
30000
20000
10000
0
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
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150
100
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
nsdp
elec

Fig.3

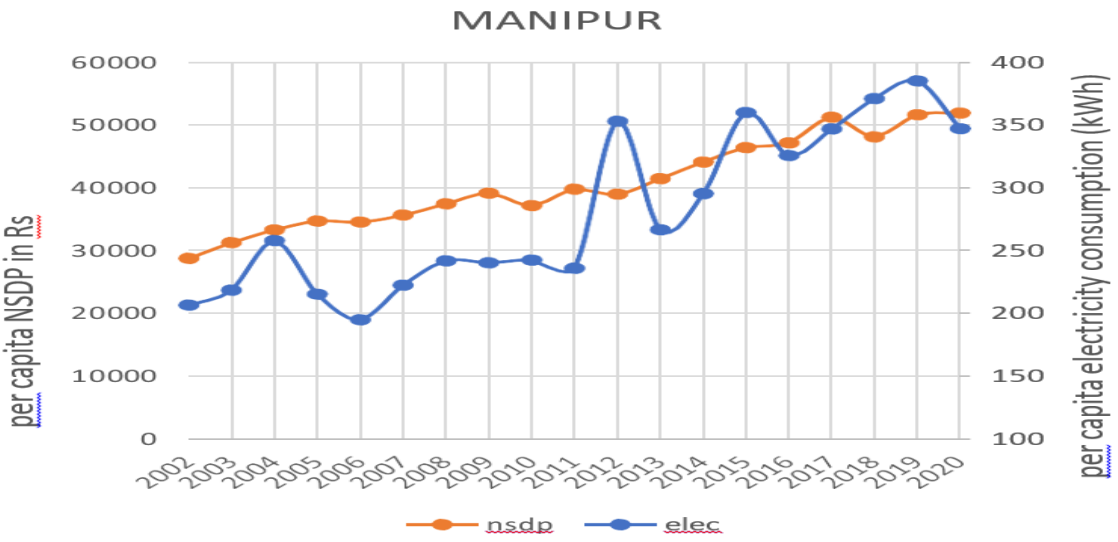

MANIPUR
per capita NSDP in Rs
per capita electricity consumption (kWh)
60000
50000
40000
30000
20000
10000
0
400
350
300
250
200
150
100
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
nsdp
elec

Fig.4

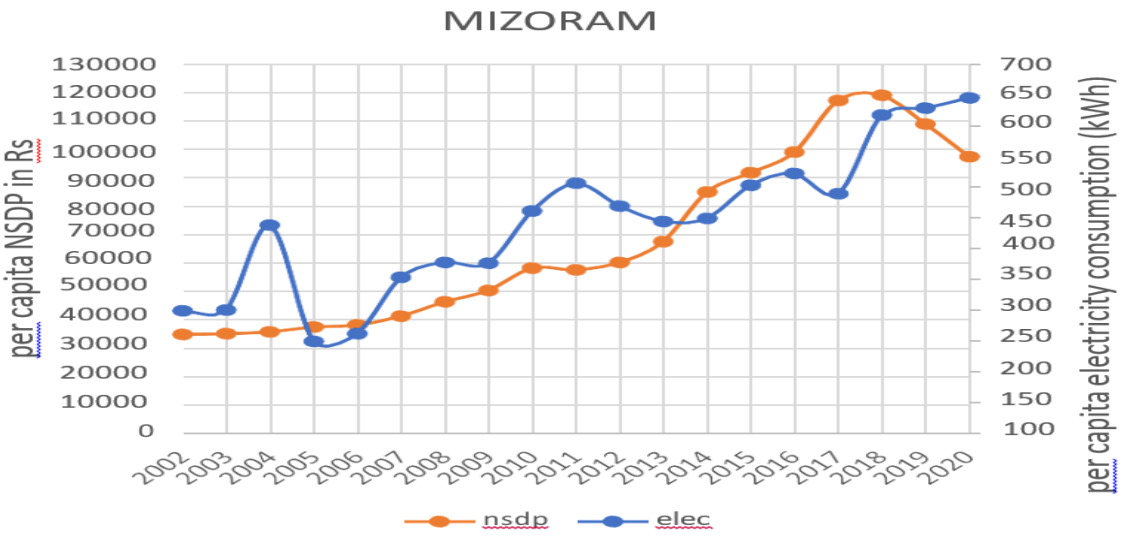

MIZORAM
per capita NSDP in Rs
per capita electricity consumption (kWh)
130000
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
700
650
600
550
500
450
400
350
300
250
200
150
100
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
nsdp
elec

Fig.5

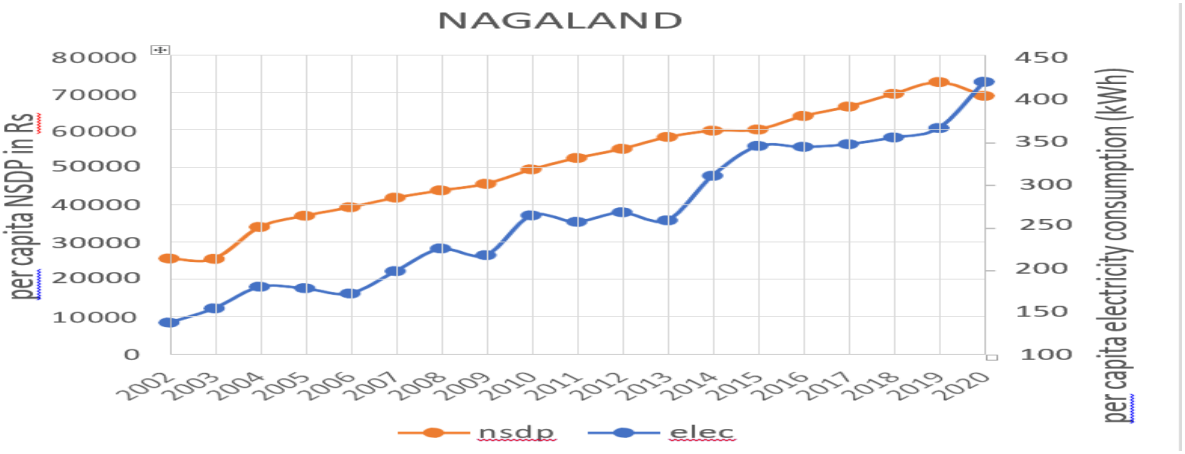
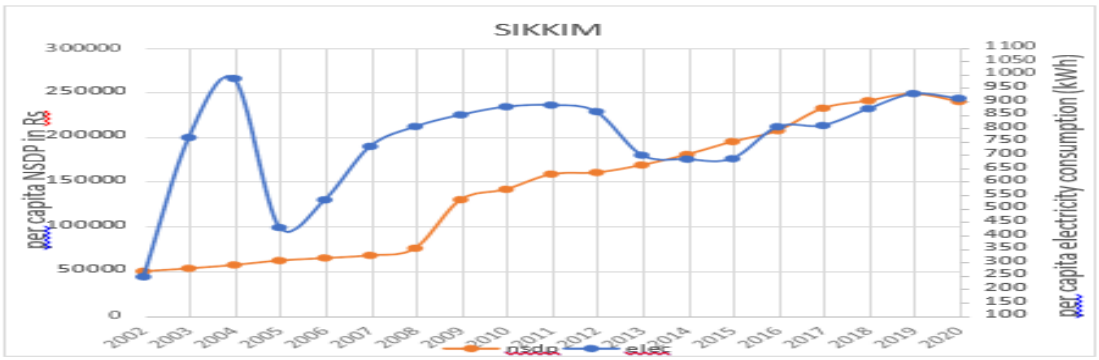


Fig.6



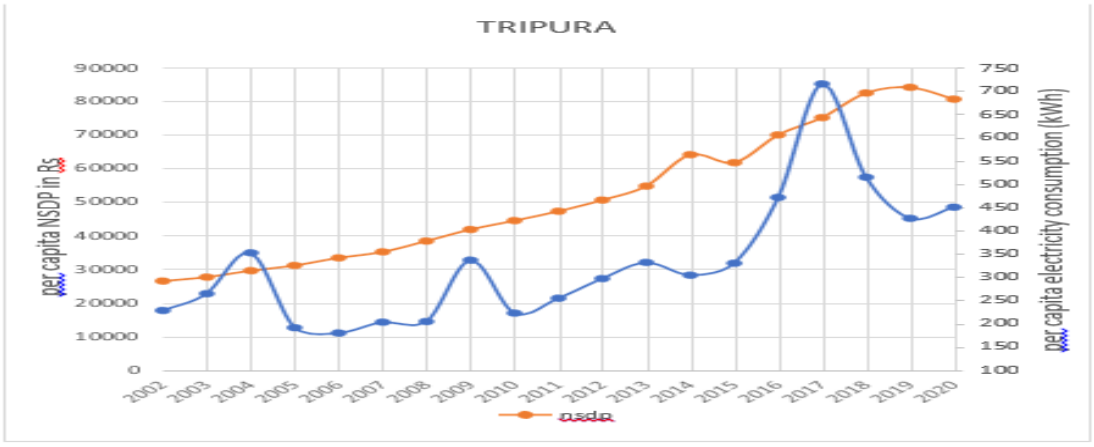


Fig.7 and Fig.8

Fig 1 to 8 shows the trends of per capita NSDP and per capita electricity consumption (kWh) f

the Northeastern states. It is evident that Sikkim per capita NSDP increases gradually but electricity

consumption per capita reached its highest point in the year 2004 and a sudden dip in the next year and it increases gradually after that similar pattern can be seen also from Arunachal Pradesh data in the year 2012. For other states such as Assam, Meghalaya, Manipur and Tripura the per capita NSDP in the most of year is higher than the per capita electric consumption except for some years. Interestingly for the state of Nagaland per capita NSDP is consistently higher than the per capita consumption of electricity but the pattern changes in the year 2020.

In the light of these this paper assesses the interconnection between electricity consumption and economic growth nexus for Northeastern states of India, Arunachal Pradesh (AR), Assam (AS), Meghalaya (ML), Mizoram (MZ), Nagaland (NL), Sikkim (SK) and Tripura (TR) using panel cointegration methods.

The paper is structure as follows Section 2 review the related literature, Section 3 model and sources of data, Section 4 methods and findings and Section 5 conclusion.

2. Literature Review

The economic growth and electricity consumption nexus is examined empirically by a plethora of studies. Rufael (2005) studied the per capita energy use and real GDP per capita relationship from 1971-2001 for 19 African countries. The research revealed that 8 countries are long-run cointegrated, and in 12 countries, there is evidence of causality. Al-Iriani (2006) examined the consumption of energy and GDP causality relationship of Gulf Cooperation Council (GCC) six countries, i.e., Kuwait, Saudi Arabia, Qatar, United Arab Emirates (UAE), Oman, and Bahrain from 1971-2002 and found causality which is unidirectional from GDP to energy consumption.

Chen et al. (2007) studied for the 10 developing Asian countries' GDP and electricity relationship and panel causality tests. They found causality is unidirectional in the short run and bidirectional in the long run. Further, the single-country causality test shows that long-run causality doesn't exist in India.

Chontanawat et al. (2008) also causality tested the same variable relationship for 30 countries from OECD and 78 non-OECD countries. The finding is that energy consumption to GDP causality is higher in OCED compared to non-OECD countries. Apergis and Pane (2009) also tested the economic growth and energy consumption relationship from 1980-2004 in the six countries of Central America. The Granger causality finding showed the causality existence in short and long run, which is from consumption of energy to economic growth. Acaravci and Ozturk (2010) investigate the nexus of the similar variables for the selected 15 transition economies in Europe and the former Soviet Union from 1990-2006. Pedroni panel cointegration test suggests among the variables there is no long-run relationship. Narayan and Popp (2012) investigated the consumption energy and real GDP nexus for 93 countries from 1980 to 2006. Abbas & Choudhury (2013) analyzed the same relationship of India and Pakistan's from 1972-2008 and found that in India, there are short and long-run relationships among the variables, and in Pakistan, there is a bidirectional relationship. Karanfil & Li (2015) used the panel data of 160 countries to investigate the same relationship in the short and long- run with annual data from 1980-2010. They found that in most countries, there is a long-run. Interestingly, for countries with high-income, there is a short-run relationship. With panel data, Raza et al. (2016) estimates the economic growth and consumption of electricity nexus for four South Asian countries i.e., Sri Lanka, Bangladesh, Pakistan, and India with panel data period from 1980-2010. Pedroni panel cointegration results revealed a long run relationship and from Granger causality a unidirectional relationship from consumption of electricity to economic growth. Hasanov et al. (2017) studied the energy-growth relationship for the developing oil- exporting ten Eurasian

countries, namely Kazakhstan, UAE, Azerbaijan, Qatar, Bahrain, Russia, Oman, Saudi Arabia, Kuwait and Iran with panel data from 1997-2017. "They revealed in the short run and long run between primary energy consumption and GDP there exist a relationship whereas absence of such relationship between residential consumption of electricity and economic growth. Khobai (2018) also studied using panel data from 1990-2014 the for Brazil, Russia, India, China, and South Africa (BRICS) countries. The results directed a unidirectional causality existence from economic growth to consumption of electricity. Topolewski (2021) also empirically analyzed for 34 European countries the energy and economic growth relationship from 2008-2019 and concluded that unidirectional relationship from economic growth to energy exists in the short and long-run. Zhang et al. (2021) analyzed empirically the 45 Belt and Road Initiative (BRI) countries, including China from 1990-2015. These countries are divided as all countries, high income, low and medium income and OPEC (Organization of the Petroleum Exporting Countries). The findings revealed unidirectional

causality from economic growth to electricity consumption in the short-run and long-run". For OPEC, only short-run causality exists. Majewski et al. (2022) also investigate the similar variable nexus of Bangladesh, Pakistan, Sri Lanka and India and for the period 1990-2018 and found a long-term relationship as indicated by the Pedroni panel cointegration.

Another strand of literature examined the relationship at the country level. For instance, Yang (2000) explores the energy consumption and GDP relationship using Granger causality from 1954-1997 Taiwan and found that "there are bidirectional causality linkages. Akinlo (2009) investigates the relationship between consumption of electricity and economic growth in Nigeria with time series data from 1980-2006 and the results revealed unidirectional causality. Mozumder and Marathe (2007) examine the relationship between the consumption of electricity and GDP applying cointegration and vector error correction model. They found that from GDP to electricity consumption a unidirectional causality exists. Hwang and Yoo (2016) in Nicaragua

with data from 1971-2010 found a bi-directional relationship. They concluded that policymakers should emphasize on increasing strategies and infrastructure to provide electricity. Xia et al., (2020) investigated for China with quarterly data from 2011-2018 between the variables and revealed a long-run relationship exists. However, for Cameroon, Tamba et al. (2017) found the absence of causal association between consumption of electricity and economic growth. They gave some reasons such as inefficient in providing electricity, old electrical infrastructure, lag in implementation of huge scale projects, etc. Girish et al. (2022) examines the causal connection among consumption of electricity, economic growth, and FDI from 1986-2021 and found a unidirectional relationship between consumption of electricity and economic growth and a bi-directional relationship between consumption" of electricity and FDI.

Form the above literature it is found that most of the studies used panel data to study cross country or used time series data for a country. In the case of India most of it confined to the bigger states of study India without segregating states this study tries to fill the literature gap by studying the state level of India.

3. Model and sources of data

3.1 Model to be estimated

The model to estimate the association between economic growth, which is proxy by per capita NSDP and per capita electricity consumption (kWh), is as follows:

NSDP =f (per capita electricity consumption) which can be rewritten as

$$Yiit = \alpha ii + \beta ii \text{ PCEC } iit + \varepsilon\varepsilon iit$$

Where $Yiit$ is the log of per capita real NSDP

PCEC i15T s the per capita ectricity consumption

t denotes the time from 2002-03 to 2021-22 and ii is the states

α and βii are the coefficients and $\varepsilon\varepsilon iit$ 15Tis the error term.

3.2 Sources of data

The consumption of electricity and economic growth nexus is investigated using panel data from the eight northeastern states of India from 2002-03 to 2021-22. Data for the real per capita NSDP at 2011-12 prices expressed in Indian Rupees (INR) was taken from EPW time series data and per capita consumption (kWh) of electricity from the Central Electrical Authority (CEA). The software used for the calculation is EViews 10. All the variables use in the study are converted into their natural logarithm form. All the tests are analyzed using EViews 10 with a five percent significance level.

4. Methods and Findings

4.1 Variables descriptive statistics

The mean electricity consumption for these states is 5.94 with minimum of 5.87 and maximum of 6.89 and the standard deviation of 4.88. The average net state domestic product is 10.95. The maximum is 12.42 and minimum is 10.91 with a standard deviation of 10.16.

Descriptive statistics of the variables

	lnelec	lnnsdp
Mean	5.94	10.95
Min	5.87	10.91
Max	6.89	12.42
Std. Dev.	4.88	10.16
Observations	152	152

4.2 Unit root test

"All the variables are tested for stationary using Levin, Lin & Chu (LLC) test assumes common unit root process whereas individual unit root process is assumed by Im, Pesaran and Shin W-stat test, ADF - Fisher Chi-square test and PP - Fisher Chi-square test to avoid" the spurious regression.

Table 2 report the test results where intercept and intercept with trends value are shown. In the levels, some of the variables are not stationary. To make them stationary, the variables are differentiated, and they are all stationary at first difference. Since all the variables used for the study are of same order integrated, the subsequent step is to check among the variables for the cointegration.

Results of panel unit root tests

Variables	LLC		IPS		ADF - Fisher Chi-square		PP - Fisher Chi-square	
	intercept	intercept and trend	intercept	intercept and trend	intercept	intercept and trend	intercept	intercept and trend
levels								
lnnsdp	-3.05***	0.34	0.39	-0.76	11.55	22.81	34.63***	33.13***
lnelec	-0.73	-3.00***	0.66	-1.53*	14.02	26.98**	59.59***	47.24***
first difference								
lnnsdp	-4.97***	-5.16***	-6.54***	-5.79***	70.52***	63.48***	100.6***	72.71***
lnelec	-12.3***	-11.6***	-10.9***	-9.65***	120.79***	92.60***	350.9***	139.0***

Notes. *** indicates significance at the 1 percent level. The Schwarz criterion determines the number of lags.

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Source: Computed by author using EViews 10

4.3 Cointegration test

To test the cointegration between the variables, methods such Pedroni panel cointegration test as well as Kao Residual cointegration test were used. Pedroni results showed that out of the eleven statistics results, six of them are 1% level significant. Therefore, no cointegration null hypothesis of variables can be rejected and cointegration alternative hypothesis is accepted.

Kao Residual cointegration test also showed that in the long run the variables are cointegrated. Results of panel cointegration tests

Pedroni residual cointegration test		Statistic	Weighted Statistic
Within dimension (panel)	Panel v-Statistic	-1.5518	-1.958
	Panel rho-	-1.8914**	-1.28828*
	StatisticPanel	-6.435***	-4.64251***
	PP-Statistic	-6.234***	-4.56467***
	Panel ADF-Statistic		
Between-dimension (group)			
		Statistic	
	Group rho-Statistic	0.153	
	Group PP-Statistic	-5.624***	
	Group ADF-Statistic	-5.082***	

Notes. *** indicates significance at the 1 percent level. The Schwarz criterion determines the number of lags.Null Hypothesis: No cointegration

Automatic lag length selection based on SIC with a max lag of 3

Kao Residual Cointegration Test

			t-Statistic
ADF			-4.92554***

Notes. *** indicates significance at the 1 percent level. The Schwarz criterion determines the number of lags.Automatic lag length selection based on SIC with a max lag of 4

Null Hypothesis: No cointegration

5. Conclusion

Northeastern states, compared to other states due to geographical and political reasons, are lagging in economic development. The paper studied the consumption of electricity and economic growth relationship. The findings show that consumption of electricity and economic

growth are cointegrated in the long run, highlighting the importance of the electricity sector in bringing transformation in Northeastern India. Of course, it is not only the factor that will bring economic growth; it should be accompanied by other factors such as health and education.

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