Relationship between agricultural growth and energy consumption in Indian agriculture: A panel co-integration analysis

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Abstract:

Abstract This paper empirically examined the long-run co-movement and the causal relationship between electricity consumption and real Gross State Domestic Product (GSDP) from agriculture and allied sector for 17 major states of India during the period 1993-2013. Since the time series analysis may yield unreliable and inconsistent results with the short time spans of datasets, we employed new heterogeneous panel co-integration and panel-based error correction models techniques to investigate the relationship between two variables. The empirical results fully supported a positive long-run co-integrated relationship between GSDP and electricity consumption when the heterogeneous states effect is taken into account. It is found that although agricultural growth and electricity consumption lack short-run causality, there is a long-run unidirectional causality running from electricity consumption to agricultural growth. This implies that reducing electricity consumption does not adversely affect agricultural growth in the short-run but would affect in the long-run. Keywords: Agricultural growth, Electricity consumption, Panel co-integration

Acknowledgement: I wish to thank ICAR- Indian Agricultural Statistics Research Institute to provide facilities for the work.

JEL Codes: Q47, Q43

#1263

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Abstract

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Keywords: Agricultural growth**,** Electricity consumption**,** Panel co-integration

JEL Classification: Q41, Q47

1. Introduction

Energy consumption is a vital component in agricultural growth either directly or as a complement to other factors of production. The economics of energy-use in agriculture has received less attention in most developing countries in comparison to the developed countries, particularly USA, Canada and Europe (Pachauri, 1998). According to Goelen et al. 2009, in India the total demand of electricity in 2006-07 was 526 TWH and in agriculture 99 TWH, but the projected demand in 2050 is 3229 TWH and 174 TWH respectively. In India, research work relating to energy-use for agricultural activities is largely confined to study on input-output relationship in the production. The structure of energy consumption in the Indian agriculture has changed with a marked shift from animal and human power to tractors, electricity and diesel. The consumption pattern of both direct and indirect energy inputs has revealed that the energy consumption per hectare of net as well as gross cropped area, has increased over time and therefore, the output per unit of energy use has declined (Jha *et al.*, 2012). This shows that the Indian agriculture has become more energy-intensive and implies that energy demand in agriculture will increase sharply in the years to come in order to achieve targeted growth of 4 per cent. But, this aspect has been less studied by the economists. Recently, Jha (2013) examined the relationship between energy-use and agricultural production for major states in India. The study has indicated that high-productivity states like Punjab and Haryana use energy more than seven-times as compared to the low-productivity states like Odisha (4GJ/ha). The paper has also demonstrated that the use of energy-intensive inputs is higher on marginal farms than on large farms.

Following the work of Jha (2012, 2013) who argues that energy is an essential factor for agricultural growth, the purpose of this paper is to extend the empirical literature by examining long-run co-movement and the causal relationship between electricity consumption (EC henceforth) for agricultural purposes and real Gross State Domestic Product from agriculture and allied sectors (GSDP henceforth) for major states of India from 1993-2013. This study used recently developed panel co-integration and error correction model to infer the causal relationship given the relatively short span of the time series data. The current growth in Indian agriculture has been more than three percent, but this growth has not picked up in some of the least-developed states of the country, with the result the gap in performance between the rich and poor states widened dramatically during the previous decade. Knowledge of this long-run relationship between energy and agricultural growth will provide insight to the policy makers for investment pattern for accelerated growth in disadvantaged states for inclusive agricultural growth.

The relationship between energy consumption and economic growth has received increasing attention in the recent energy economics literature, especially in the contest of developed countries. Several researchers have investigated the causal link between the energy consumption and the output growth using different econometric approaches, countries and sample periods with varying results. The interest of energy economists on this issue gained a new momentum with increasing concerns about global warming, especially after adoption of the Kyoto Protocol in 1997 that entered into force in 2005. Industrialized member countries committed themselves to a reduction of greenhouse gas emission, mainly by restricting fossil fuel consumption. However, to our knowledge, none of the study attempted to discover the causal linkage between energy consumption and agricultural growth, more so for developing countries like India.

The literature has emphasized four possible relationships between energy consumption and economic growth: growth, conservation, neutrality and feedback hypotheses. The growth hypothesis suggests that energy consumption plays an important role in economic growth both directly and indirectly in the production process as a complement to labour and capital. The growth hypothesis is confirmed if an increase in energy consumption causes an increase in real GDP whereby the economy is considered energy dependent. In such a scenario, it is argued that reducing energy consumption may hamper economic growth and hence increase unemployment. The conservation hypothesis asserts that the positive relationship between energy consumption and output level stems from positive effects of output growth rate on energy consumption, and hence policies aimed at conserving energy consumption will have only a limited, if any, adverse effect on economic growth. Similarly, supporters of the neutrality hypothesis argue that energy consumption and output level are not correlated, and therefore neither energy conservation nor energy promoting policies will affect economic growth of countries (see, for example, Lee and Chang, 2005; Apergis and Payne, 2009). Finally, the feedback hypothesis suggests that energy consumption and economic growth are interrelated and may very well serve as complements to each other. The feedback hypothesis suggests there is a bidirectional causal relationship between energy consumption and economic growth. If this is the case an energy policy oriented towards improvements in energy consumption efficiency would not adversely affect economic growth. Taking account of these alternative views regarding the relationship between energy consumption and output level, it is evident that discovering the causal linkages between energy consumption and economic growth is vital in designing energy policies for each nation.

To test these hypotheses in case of Indian agriculture, we utilized recently developed techniques in panel unit root testing, co-integration and causality. Adoption of such new methods is preferred to get rid of the problems associated with low power of traditional unit root and co-integration tests based on time series data. Many studies suggested that panel-based tests have higher power than tests based on individual series. For instance, Perron (1991) indicated that the power of a co-integration test is considerably affected by the span of the data. The methodology used in this analysis, namely panel co-integration, allows for heterogeneity among the members of the panel. Pedroni (1999, 2004) showed the adverse effects of falsely imposing homogeneity across panel members. Panel data can provide much more information than either cross-sectional data or time series, and in light of the lack of power of individual unit root tests and traditional co-integration tests, we need to combine information from time series and cross-sectional data. Thus, we used the panel unit root tests and heterogeneous panel cointegration tests which, when compared to the cross-section approach, is more powerful and allows us to increase the degrees of freedom. We then used the fully modified ordinary least squares (FMOLS) technique to estimate the co-integration vector for heterogeneous co-integrated panels. This enables us to correct the standard ordinary least squares (OLS) for bias induced by endogeneity and serial correlation of the regressors. Furthermore, we specified and estimated a dynamic vector error correction model (VECM) that is appropriate for heterogeneous panels and that distinguishes between short-run and long-run causality.

The remainder of this paper is organized as follows. In Section 2, we provide a brief discussion of the estimation methodology. Section 3 presents the data, implementation and empirical results. Finally, Section 4 concludes with summary of the findings.

2. Methodology

The test for causality between electricity consumption (EC) and agricultural growth (GSDP) in the 17 major states of India was performed in three steps. Firstly, test for the order of integration in the GSDP and electricity consumption time series was done. Secondly, having established the order of integration in the series, panel co-integration was used to test for the long run relationships between the two variables. Finally, dynamic panel causality was used to assess the short run co-integration and the direction of causality between the two variables.

In order to ensure robustness, we used four panel unit root tests suggested by Im et al. (IPS) (2003), Levin et al. (LLC) (2002), Fisher-ADF and Fisher-PP statistics. Panel unit root tests are classified on the basis of whether there are restrictions on the autoregressive process across cross-section or series. We adopted two different tests, namely those of Im, Pesaran and Shin (2003) and Levin, Lin & Chu (2002). The Im et al. (2003) test allow for heterogeneity for cross-sectional unit in contrast to Levin et al., which assumes that all cross-sections have the same first order autoregressive parameters. Let us consider the following autoregressive specification:

$$y_{it} = \rho_i y_{it-1} + \delta_i X_{it} + e_{it} \tag{1}$$

where i = 1,…,N for each state in the panel; t = l, ..., T refers to the time period; X_{it} represents the exogenous variables in the model including fixed effects or individual time trend; ρ_i are the autoregressive coefficients; and e_{it} are the stationary error terms. If $\rho_i < 1, y_{it}$ is considered weakly trend stationary whereas if $\rho_i = 1$, then y_{it} contains a unit root.

In case of dynamic panel data models, the recognition of parameter heterogeneity is important in order to avoid potential biases which could emerge due to an improper specification. For this study, the relationship between electricity consumption and agricultural GSDP for major states is expected to be diverse over time due to the different economic and political conditions as well as stages of agricultural development in each state. Accordingly, in light of parameter heterogeneity, the Im et al. (2003) panel unit root test is preferable as it allows for heterogeneous autoregressive coefficients.

Im, Pesaran, and Shin (2003) suggested averaging the Augmented Dickey-Fuller (ADF) unit root tests while allowing for different orders of serial correlation, $\xi_{it} = \sum_{j=1}^{k_i} \varphi_{ij} \xi_{it-j} + e_{it}$. Substitution of this expression into Eq. (1) yields

$$y_{it} = \rho_i y_{it-1} + \sum_{j=1}^{k_i} e_{ij} \xi_{it-j} + \delta_i X_{it} + e_{it} \tag{2}$$

where k_i represents the number of lags in the ADF regression. The null hypothesis is that each series in the panel contains a unit root $(H_0 : \rho_i = 1 \forall i)$. The alternative hypothesis is that at least one of the individual series in the panel is stationary $(H_0 : \rho_i < 1)$. Im et al. (2003) specified a $\bar{t}$ statistic as the average of the individual ADF statistics as follows:

$$\bar{t} = \frac{1}{N} \sum_{i=1}^{N} t_{\rho_i} \tag{3}$$

where $t_{\rho i}$ is the individual *t*-statistic for testing $H_0 : \rho_i = 1 \forall i$ from Eq.(2). The $\bar{t}$ statistic is normally distributed under the null hypothesis with the critical values for given values of different numbers of cross sections *N* and series lengths *T* provided by Im et al. (2003). This test statistic requires specification of the number of lags and the specification of the deterministic component for each cross-section ADF equation. In addition to IPS and LLC, we followed the procedures of Maddala and Wu (1999), who proposed a more straightforward, nonparametric unit root test and suggest using the Fisher-ADF and Fisher-PP statistics.

2.1 Panel cointegration test

Given the presence of heterogeneity in both dynamics and error variances in the panel, the heterogeneous panel cointegration test advanced by Pedroni (1999, 2004), which allows for cross-section inter-dependence with different individual effects was employed, which is given below:

$$GSDP_{it} = \alpha_{it} + \delta_i t + \gamma_{1i} EC_{it} + e_{it} \tag{4}$$

where $i = 1,...,N$ for each state in the panel and $t = 1,...,T$ refers to the time period. The parameters α_{it} and δ_i allow for the possibility of state-specific fixed effects and deterministic trends, respectively. e_{it} denote the estimated residuals which represent deviations from the long-run relationship. GSDP and EC denote GSDP from agriculture and allied sectors and electricity consumption for agricultural purposes respectively. Since all variables are expressed in natural logarithms, the γs parameters of the model can be interpreted as elasticities.

To test the null hypothesis of no co-integration, $\rho_i = 1$, the following unit root test was conducted on the residuals as follows:

$$e_{it} = \rho_i \varepsilon_{it-1} + u_{it} \tag{5}$$

Pedroni (1999, 2004) proposed two sets of tests for co-integration. The panel tests are based on the within dimension approach (i.e. panel co-integration statistics) which includes four statistics: panel *v*-statistic, panel ρ-statistic, panel *PP*-statistic, and panel ADF-statistic. These statistics essentially pool the autoregressive coefficients across different states for the unit root tests on the estimated residuals. These statistics take into account common time factors and heterogeneity across states. The group tests are based on the between dimension approach (i.e. group mean panel co-integration statistics) which includes three statistics: group ρ-statistic, group PP-statistic, and group ADF-statistic. These statistics are based on averages of the individual autoregressive coefficients associated with the unit root tests of the residuals for each state in the panel. This study has computed all these seven tests which are distributed asymptotically as standard normal.

2.2 Causality from panel vector error correction model

In case of co-integrated variables, a panel vector error correction model was estimated to perform Granger-causality tests using the following dynamic error correction model.

$$\Delta GSDP_{it} = \alpha_{1j} + \sum_{q=1}^{k} \theta_{11iq} \Delta GSDP_{it-q} + \sum_{q=1}^{k} \theta_{12iq} \Delta EC_{it-q} + \lambda_{1i} e_{it-1} + e_{1it} \tag{6a}$$

$$\Delta EC_{it} = \alpha_{1j} + \sum_{q=1}^{k} \theta_{21iq} \Delta GSDP_{it-q} + \sum_{q=1}^{k} \theta_{22iq} \Delta EC_{it-q} + \lambda_{2i} e_{it-1} + e_{2it} \tag{6b}$$

where Δ is the first-difference operator; *k* is the lag length which is determined on the basis of likelihood ratio tests and *e* is the serially uncorrelated error term. In the GSDP Eq. (6a), short-run causality from energy usage to GSDP was tested, based on $H_0 : \theta_{12iq} = 0 \forall iq$. In the energy consumption Eq. (6b), short-run causality from GSDP to energy usage was tested, based on $H_0 : \theta_{21iq} = 0 \forall iq$.

The null hypothesis of no long-run causality in Eq. (6a) and (6b) was tested by examining the significance of the *t*-statistic for the coefficient on the respective error correction term represented by λ .

3. Data source and description

This study used annual time series data for 17 major states of India. The sample includes Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal. Annual data for real GSDP from agriculture and allied sectors (2004-05=100), electricity consumption for agricultural purposes were obtained from Directorate of Economics and Statistics, Ministry of Agriculture, Government of India. The unit for GSDP is expressed in Rupees lakh. The empirical period depends on the availability of data, but overall, the data cover the 1993-94 to 2013-14 periods. All variables are in natural logarithms. To investigate the linkage between GSDP and electricity consumption at regional level, we divide 17 major states of India into 4 regions (East, West, North and South region) according to geographical location of the states. These regions differ in their stages of agricultural development. Details about different regions are given in Table 1.

4. Empirical results

Before conducting the co-integration analysis of the panel data, we conducted a panel unit root test. As indicated earlier, four panel unit tests were employed in the study. Table 2 shows the results pertaining to four panel unit root tests with and without trend at national level. The empirical result of panel unit root tests at regional level are shown in Table 3-6. Results clearly indicate that both the series are integrated of order one as the level series are nonstationary while the first differenced series are stationary.

Granger (1981) showed that when the series becomes stationary only after being differenced once (integrated of order one), they might have linear combination that are stationary without differencing. In the literature, such series are called co-integrated. Having established the fact that the energy consumption and GSDP series are integrated of the first order, the test for the long-run relationship between both variables using Pedroni's heterogeneous panel cointegration test, which allows for cross-sectional interdependence with different individual effects was conducted. Pedroni (1999) suggested two types of residual-based tests. As for the first type, four tests are distributed as being standard normal asymptotically and are based on pooling the residuals of the regression for the within-group; they are the panel v-statistic, panel rho-statistic, panel PP-statistic and the panel ADF-statistic. With the second type, three tests are also distributed as being standard normal asymptotically but are based on pooling the residuals for the between-group; they are the group rho-statistic, group PP-statistic and the group ADF-statistic. These statistics are based on estimators that simply average the individually estimated coefficients for each member, and each of these tests is able to accommodate individual specific short-run dynamics, individual specific fixed effects and deterministic trends, as well as individual specific slope coefficients (Pedroni, 2004). The number of observations available when testing the stationarity of the residual series in a level regression is greatly increased in a panel framework and this can substantially increase the power of the co-integration tests.

Table 7 and Table 8-11 presents the detail results of panel co-integration tests at national level and regional level respectively. These tests reject the null of no co-integration when they have large negative values except for the panel v-statistic which rejects the null of co-integration when it has a large positive value. The finite sample distribution for the seven statistics has been tabulated by Pedroni (2004) via Monte Carlo Simulation. At national level, inspection of the tests results, shown in Table 7, reveals rejections of the null of no co-integration for all tests except the panel v-statistic and group rho-statistic with no intercept and trend and panel and group rho-statistic with intercept and trend. However, according to Pedroni (2004), rho-statistics tend to under reject the null in the case of small samples. Therefore, one may conclude that two variables are in fact co-integrated. In other words, the results confirm that energy consumption and real GSDP in the major states of India share a long-run steady-state co-integrating relationship after allowing for the state-specific effects. Table 8-11 reveals that, at regional level also there is co-integration between real GSDP and energy consumption.

The next step is to estimate this relationship. A long-run relationship is determined using the fully modified ordinary least squares (FMOLS) technique for heterogeneous co-integrated panels (Pedroni, 2000). Table 12 provides the results of the national and regional level panel FMOLS tests where the dependent variable is GSDP and explanatory variable is electricity consumption. All of the coefficients are statistically significant at the 1 per cent level, and the effect is positive. Since the variables are expressed in natural logarithms, the coefficients can be interpreted as elasticities. The results indicate that a 1 per cent increase in electricity usage leads to a 0.12 per cent increase in real GSDP in our sample of Indian states. It is evident that greater electricity use tends to raise the output from state-specific aggregate productivity shocks. To conclude, the national level and regional level panel co-integration test results clearly indicate that there exists a co-integrated relationship between GSDP from agriculture and allied sector and electricity consumption for major states in India.

Once we determined that the two variables are co-integrated, we performed a panel-based error correction model to examine short-run and long-run causality between energy consumption and agricultural growth. Table 13 presents long-run and short-run causality results. The estimation of a panel vector error correction model indicates the presence of long-run causality from energy consumption to agriculture and allied GSDP at 1 per cent level of significance leading support of the growth hypothesis. The Wald test indicates that, there is no any short-run causality. The positive impact of energy consumption on agricultural growth suggests that energy consumption plays an important role in the agricultural growth process.

4. Conclusions

Energy is one of the important components of modern agricultural production. In recent years, Indian agriculture has become energy intensive due to intensive mechanization, commercialization and diversification towards high-value crops. In this paper, we examined the energy growth linkage in Indian agriculture. Since the time series analysis may yield unreliable and inconsistent results with the short time spans of typical datasets, we employed new heterogeneous panel co-integration and panel-based error correction model techniques to investigate the relationship between electricity consumption and GSDP across the 17 states of India. Energy consumption is found to cause GSDP in the long-run, but not in the short-run, there is unidirectional causality from energy consumption to GSDP.

From a policy perspective, the results in this study are consistent with the energy-dependent growth hypothesis, suggesting that energy consumption is a major factor influencing agricultural growth both directly and indirectly. Our results provide solid support in favour of quantum of energy consumption had a significant impact on growth in Indian agriculture across states. This means that increased energy use leads to agricultural growth. Thus, GSDP is fundamentally driven by energy, hence any energy conservation measures at this stage may compromise agricultural growth. Moreover, this clearly calls for investment in energy related infrastructure in least developed states/regions in order to achieve inclusive and high agricultural growth in the country.

Table 1: Division of 17 states of India in four region

S. No.	**Region**	**States**
1	East	Assam, Bihar, Odisha,, West Bengal
2	West	Gujarat, Madhya Pradesh, Maharashtra, Rajasthan,
3	North	Haryana, Punjab, Himachal Pradesh, Jammu & Kashmir, Uttar Pradesh
4	South	Andhra Pradesh, Karnataka, Kerala, Tamil Nadu,

Table 2: Panel unit root test results at national level

	GSDP		**EC**	
	statistic	Prob.	statistic	Prob.
Level				
Levin, Lin & Chu	-2.17	0.014	0.24	0.595
Im, Pesaran and Shin	-1.34	0.089	1.06	0.857
ADF-Fisher Chi-square	45.10	0.096	41.02	0.189
PP - Fisher Chi-square	55.47	0.011	32.40	0.545
1st difference				
Levin, Lin & Chu	-15.77	<0.01	-17.10	<0.01
Im, Pesaran and Shin	-14.21	<0.01	-15.6165	<0.01
ADF-Fisher Chi-square	188.78	<0.01	246.164	<0.01
PP - Fisher Chi-square	269.01	<0.01	343.927	<0.01

Table 3. Panel unit root test results for East region

	GSDP		**EC**	
	statistic	Prob.	statistic	Prob.
Level				
Levin, Lin & Chu	-0.78	0.215	-2.75	0.054
Im, Pesaran and Shin	-0.39	0.347	-1.57	0.057
ADF-Fisher Chi-square	10.04	0.262	15.27	0.054
PP - Fisher Chi-square	19.42	0.012	16.96	0.030
1st difference				
Levin, Lin & Chu	-10.70	<0.01	-4.37	<0.01
Im, Pesaran and Shin	-8.43	<0.01	-4.85	<0.01
ADF-Fisher Chi-square	43.92	<0.01	34.88	<0.01
PP - Fisher Chi-square	71.12	<0.01	75.47	<0.01

Table 4. Panel unit root test results for West region

	GSDP		EC	
	statistic	Prob.	statistic	Prob.
Level				
Levin, Lin & Chu	-0.03	0.484	-0.18	0.4268
Im, Pesaran and Shin	-0.14	0.443	0.09	0.5374
ADF-Fisher Chi-square	8.14	0.419	6.20	0.6244
PP - Fisher Chi-square	8.10	0.423	3.06	0.93
1st difference				
Levin, Lin & Chu	-6.24	<0.01	-6.05	<0.01
Im, Pesaran and Shin	-7.10	<0.01	-4.49	<0.01
ADF-Fisher Chi-square	49.28	<0.01	32.50	<0.01
PP - Fisher Chi-square	67.88	<0.01	34.20	<0.01

Table 5. Panel unit root test results for North region

	GSDP		EC	
	statistic	Prob.	statistic	Prob.
Level				
Levin, Lin & Chu	0.81	0.791	-0.56	0.284
Im, Pesaran and Shin	3.58	0.999	-0.40	0.343
ADF-Fisher Chi-square	1.28	0.999	11.81	0.291
PP - Fisher Chi-square	1.32	0.999	11.31	0.334
1st difference				
Levin, Lin & Chu	-11.30	<0.01	-9.04	<0.01
Im, Pesaran and Shin	-9.62	<0.01	-8.70	<0.01
ADF-Fisher Chi-square	82.38	<0.01	66.71	<0.01
PP - Fisher Chi-square	121.20	<0.01	57.95	<0.01

Table 6. Panel unit root test results for South region

	GSDP		EC	
	statistic	Prob.	statistic	Prob.
Level				
Levin, Lin & Chu	0.45	0.676	1.71	0.956
Im, Pesaran and Shin	0.61	0.730	3.12	0.999
ADF-Fisher Chi-square	5.02	0.754	3.30	0.913
PP - Fisher Chi-square	5.09	0.747	4.13	0.844
1st difference				
Levin, Lin & Chu	-7.01	<0.01	-8.84	<0.01
Im, Pesaran and Shin	-5.29	<0.01	-7.97	<0.01
ADF-Fisher Chi-square	36.60	<0.01	60.70	<0.01
PP - Fisher Chi-square	38.12	<0.01	92.19	<0.01

Table 7. Panel cointegration test result for different states of India

Test	Statistic	probability
Panel v-Statistic	4.52	<0.01
Panel rho-Statistic	-3.01	<0.01

Panel PP-Statistic	-5.74	<0.01
Panel ADF-Statistic	-4.39	<0.01
Group rho-Statistic	-1.34	0.08
Group PP-Statistic	-5.75	<0.01
Group ADF-Statistic	-4.75	<0.01

Table 8. Panel cointegration test result for East region

Tests	Statistic	probability
Panel v-Statistic	1.19	0.115
Panel rho-Statistic	-2.45	<0.01
Panel PP-Statistic	-5.06	<0.01
Panel ADF-Statistic	-1.36	0.08
Group rho-Statistic	-1.47	0.07
Group PP-Statistic	-4.84	<0.01
Group ADF-Statistic	-0.97	0.164

Table 9. Panel cointegration test result for west region

Tests	Statistic	probability
Panel v-Statistic	4.85	<0.01
Panel rho-Statistic	-3.65	<0.01
Panel PP-Statistic	-4.63	<0.01
Panel ADF-Statistic	-4.50	<0.01
Group rho-Statistic	-1.22	0.10
Group PP-Statistic	-3.01	<0.01
Group ADF-Statistic	-2.98	<0.01

Table 10. Panel cointegration test result for North region

Tests	Statistic	probability
Panel v-Statistic	7.88	<0.01
Panel rho-Statistic	-1.80	<0.01
Panel PP-Statistic	-2.63	<0.01
Panel ADF-Statistic	-4.00	<0.01
Group rho-Statistic	-0.58	0.28
Group PP-Statistic	-3.07	<0.01
Group ADF-Statistic	-3.45	<0.01

Table 11. Panel cointegration test result for South region

Tests	Statistic	probability
Panel v-Statistic	-0.27	0.60
Panel rho-Statistic	-2.61	<0.01
Panel PP-Statistic	-2.29	<0.01
Panel ADF-Statistic	-2.23	<0.01
Group rho-Statistic	-0.19	0.42
Group PP-Statistic	-1.62	0.05
Group ADF-Statistic	-1.21	0.11

Table 12: Fully modified ordinary least squares estimates

	Coefficient	t-Statistic	Probability
National level	0.125	2.646	<0.01
East Region	-0.271	-2.532	0.013
West Region	0.310	2.676	<0.01
North Region	0.233	3.955	<0.01
South Region	0.379	6.166	<0.01

Table 13: Panel causality Test (Dependent variable - GSDP)

	Long-run causality			**Short-run causality**	
	ECT	t-statistics	Probability	t-statistics	Probability
National level	-0.025	-2.48923	0.013	2.646	0.008
East Region	-0.052	-1.69665	0.0921	-2.532	0.013
West Region	-0.064	-1.07121	0.286	2.676	0.009
North Region	0.0013	0.561406	0.5753	3.955	<0.01
South Region	-0.035	-1.61441	0.1088	6.166	<0.01

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