Working Paper No. 66

The Dynamic Causal Relationship between Electricity Consumption and Economic Growth: Empirical Evidence from Odisha, India

Shibalal Meher

Nabakrushna Choudhury Centre for Development Studies, Bhubaneswar
(an ICSSR institute in collaboration with Government of Odisha)

July 2016

The Dynamic Causal Relationship between Electricity Consumption and Economic Growth: Empirical Evidence from Odisha, India

Shibalal Meher*

Abstract

This paper investigates empirically the causal relationship between electricity consumption and economic growth in the state of Odisha in India for the period 1980-2014. Based on co-integration and vector error correction modelling, the study establishes unidirectional long run Granger causality running from economic growth to electricity consumption, indicating that economic growth in Odisha stimulates electricity consumption in the long run, thereby supporting the conservation hypothesis. The analyses of variance decomposition and impulse response function confirm the direction of causality in a dynamic context. This finding has important policy implications for the state of Odisha. Due to the lack of feedback effect from electricity consumption to economic growth, demand side management measures can be adopted to reduce electricity consumption, which would not affect future economic growth in the state.

Key words: Electricity Consumption**,** Economic Growth, Co-integration, Vector Error Correction Model, Variance Decomposition, Impulse Response Function.

JEL Codes: C32, C52, Q43

Acknowledgements: The present paper is a revised version of the paper presented in the 52nd Annual Conference of The Indian Econometric Society (TIES), held at the Indian Institute of Management, Kozhikode from 4th to 6th January 2016 and in NCDS on 8th March 2016. I am thankful to the participants for their useful comments. The views expressed in the paper are that of the author and not the institution he belongs.

* Reader in Industrial Economics, Nabakrushna Choudhury Centre for Development Studies, Bhubaneswar. E-mail: shibalal.ncds@gov.in; smeher62@rediffmail.com

Contents

1 Introduction **3**

2 Overview of Electricity Consumption and Economic Growth in Odisha **5**

3 Data and Methods **6**

3.1 Unit Root Test *6*

3.2 Co-integration Test *7*

3.3 Granger Causality Test *7*

4 Results and Discussion **8**

5 Conclusions **12**

References **13**

1 Introduction

The causal relationship between electricity consumption and economic growth has become a debatable issue, particularly since the pioneering work of Kraft and Kraft (1978). The importance of this issue in recent times is due to electricity crisis on the one hand and increasing greenhouse gas emissions on the other. In order to meet the electricity crisis, many countries are involved in generating thermal electricity using carbon based fuels. This produces large fraction of carbon dioxide contributing to the greenhouse gas emissions leading to climate change. As there is international effort towards mitigating carbon dioxide emissions and power sector is the largest emitter of carbon dioxide, one of the policy suggestions is to conserve electricity.

Since there is close relationship between electricity consumption and economic growth, there is a need to establish their causal relationship so as to suggest policy direction. However, the electricity consumption and economic growth debate has produced conflicting outcomes. The relationship is usually explained by four major conflicting hypotheses, viz. conservation hypothesis, growth hypothesis, feedback hypothesis and neutrality hypothesis. According to the conservation hypothesis, causality is running from economic growth to electricity consumption [Ghosh (2002), Narayan and Smyth (2005), Wolde-Rufael (2006), Yoo (2006), Mozumder and Marathe (2007), Chen et al. (2007), Shahbaz and Feridun (2011)]. This indicates that a country is not dependent on electricity for growth and the policy of conserving electricity consumption may be implemented with little or no adverse effect on economic growth.

According to growth hypothesis, causality is running from electricity consumption to economic growth [Aqeel and Butt (2001), Shiu and Lam (2004), Wolde-Rufael (2004), Altinay and Karagol (2005), Wolde-Rufael (2006), Yoo (2006), Chen et al. (2007), Gupta and Sahu (2009), Masuduzzaman (2012), Javid et al. (2013)]. This suggests that electricity consumption plays an important role in economic growth. Any restriction on the use of electricity may adversely affect economic growth while increase in electricity consumption may contribute to economic growth.

According to feedback hypothesis, there is bi-directional causality between electricity consumption and economic growth [Yang (2000), Jumbe (2004), Morimoto and Hope (2004), Yoo (2005)]. This implies that electricity consumption and economic growth complement each other. Conserving electricity consumption may adversely affect economic growth.

According to neutrality hypothesis, there is absence of causality between electricity consumption and economic growth (Wolde-Rufael, 2006). Here, electricity conservation policies may be pursued without affecting the economic growth.

The summary of above studies devoted to test the causal relationship between electricity consumption and economic growth is presented in Table 1. The majority of these studies test causality in the times-series context. The causality results are varied across countries and even within each individual/group country. These diverse results arise due to the use of different data set, alternative econometric methodologies and different countries' characteristics.

Table 1: Summary of Earlier Studies devoted to Test Causality between Electricity Consumption and Economic Growth

Authors	Countries	Methodology used	Period	Direction of Causality
Conservation Hypothesis				
Ghosh (2002)	India	Standard Granger Causality test	1950–1997	EG → EC
Narayan and Smyth (2005)	Australia	Cointegration	1966-1999	EG → EC
Wolde-Rufael (2006)	Cameroon Ghana Nigeria Senegal Zambia Zimbabwe	A modified version of Granger Causality and Cointegration test	1971–2001	EG → EC
Yoo (2006)	Indonesia Thailand	Hsiao's Granger	1971-2002	EG → EC
Mozumder and Marathe (2007)	Bangladesh	Co-integration test and Vector Error Correction model	1971–1999	EG → EC
Chen et al. (2007)	India Malaysia Philippines	Cointegration, Granger Causality	1971-2001	EG→ EC
Shahbaz and Feridun (2011)	Pakistan	ARDL Bounds test	1971-2008	EG→ EC
Jiranyakul (2014)	Thailand	ARDL Bounds Test	2000Q1-2014Q2	EG→ EC
Growth Hypothesis				
Aqeel and Butt(2001)	Pakistan	Hsiao's version of Granger Causality method	1955–1996	EC→ EG
Shiu and Lam (2004)	China	Error-correction model	1971–2000	EC→ EG
Wolde-Rufael (2004)	Shanghai	A modified version of Granger Causality	1952–1999	EC→ EG
Altinay and Karagol (2005)	Turkey	Standard Granger Causality test	1950–2000	EC→ EG
Wolde-Rufael (2006)	Benin Congo, DR. Egypt Gabon Morocco Tunisia	A modified version of Granger Causality and Cointegration test	1971–2001	EC→ EG
Yoo (2006)	Malaysia Singapore	Hsiao's Granger	1971-2002	EC→ EG
Chen et al. (2007)	China Hong Kong Indonesia Korea Singapore Taiwan Thailand	Cointegration, Granger Causality	1971-2001	EC→ EG

Continued

Table 1: Summary of Earlier Studies devoted to Test Causality between Electricity Consumption and Economic Growth

Authors	Countries	Methodology used	Period	Direction of Causality
Gupta and Sahu (2009)	India	Granger Engel Causality	1960-2006	EC→ EG
Masuduzzaman (2012)	Bangladesh	Co-integration and Vector Error Correction Model	1981-2011	EC→ EG
Javid et al. (2013)	Pakistan	Engel-Granger Co-integration	1960-2008	EC→ EG
Feedback Hypothesis				
Yang (2000)	Taiwan	Standard Granger Causality test	1954–1997	EC ↔EG
Jumbe (2004)	Malawi	Granger causality and Error-correction model	1970–1999	EC ↔EG
Morimoto and Hope (2004)	Sri Lanka	Standard Granger Causality test	1960–1998	EC ↔EG
Yoo (2005)	Korea	Error-correction model	1970–2002	EC ↔EG G
Neutrality Hypothesis				
Wolde-Rufael (2006)	Algeria Congo, Rep. Kenya South Africa Sudan	A modified version of Granger Causality and Cointegration test	1971–2001	No causality

The earlier studies are carried out at the country level. However, the studies devoted to causal relationship between electricity consumption and economic growth are very few in India and non-existent at the state level. Further, the states in India have dissimilar economic growth and electricity characteristics. Therefore, there is a need to understand the relationship between economic growth and electricity consumption at the state level in India in order to suggest policy direction. An attempt has been made here to study the dynamic causal relationship between electricity consumption and economic growth in the state of Odisha, which is the pioneer of electricity reform in India.

The remaining sections of the paper are organized as follows. Section 2 provides an overview of electricity consumption and economic growth in Odisha. Section 3 presents the methodological issues. Section 4 brings the empirical results and analysis, while section 5 provides the conclusions.

2 Overview of Electricity Consumption and Economic Growth in Odisha

Odisha, one of the poorest states in India, is first to initiate power sector reform with effect from 1st April 1996. By the end of March 2014, about 93.4 per cent of its villages were electrified as against all India average of 95.7 per cent (Govt. of Odisha, 2015). However, the access to electricity for households in Odisha is very low (43 per cent) compared to the all-India average (67 per cent). If the estimated demand of electricity is compared with availability, the state has had consistent surplus since 2000-01. However, the shortage of supply of electricity is observed during the peak demand period. During 2013-14, the peak demand was 3300 Megawatt (MW) while the amount met during the peak hours was 2600 MW, resulting in a deficit of 21.2 per cent (Govt. of Odisha, 2015). Further, the access electricity to all households with the existing generation of electricity would result in shortage of electricity. Therefore, in order to access electricity to all households in the state, it is required to generate more electricity. But this will put increasing pressure on the generation of electricity from thermal power plants, as the generation from hydro power in the state has stagnated and that from renewable energy is very low, i.e. less than one per cent. This would result in increasing emission of carbon dioxide leading to climate change. Hence, one of the policy options is to adopt demand side management of electricity.

However, per capita electricity consumption in the state is very low, with 3.28 per cent annual growth during the period 1980-2014. But, there is higher growth of electricity consumption in recent years. Initially from 1980-81 to 1995-96, it had a growth rate of 4.95 per cent. But it grew at a higher rate of 6.66 per cent from 2001-02 to 2013-14, after a negative annual growth rate of 3.39 per cent from 1995-96 to 2001-02 (Table 2). At the same time, per capita Gross State Domestic Product (GSDP), representing economic growth, grew at the annual rate of 3.28 per cent over the period 1980-81 to 2013-14, with a higher growth rate of 6.41 per cent from 2001-02 to 2013-14 (Table 2). The growth of per capita GSDP therefore shows a close association with the growth of per capita electricity consumption; either economic growth is causing electricity consumption or vice versa. If causality is running from GSDP to electricity consumption, then Odisha's economic growth is independent of electricity consumption and hence, electricity conservation measures can be implemented. On the other hand, if causality is running from electricity consumption to economic growth (GSDP), then economic growth of Odisha is dependent on electricity consumption and hence, electricity conservation measures can be detrimental to economic growth. Therefore, there is a need to examine the causal relationship between electricity consumption and economic growth in Odisha before adopting any policy measures for conservation of electricity.

Table 2: Annual Growth of PCEC and PCGSDP in Odisha (%)

	PCEC	PCGSDP
1980-81 to 1995-96	4.95	1.62
1995-96 to 2001-02	-3.39	2.80
2001-02 to 2013-14	6.66	6.41
1980-81 to 2013-14	3.28	3.28

3 Data and Methods

The present study utilises data on per capita electricity consumption and per capita gross state domestic product (proxy for economic growth) at 2004-05 prices in logarithmic form over the period from 1980-81 to 2013-14 to study the causal relationship between electricity consumption and economic growth in Odisha. The per capita electricity consumption and gross state domestic product data have been collected from various issues of the Economic Survey of Odisha. The models used to test for stationarity, co-integration and causality of the variables are presented in the following.

3.1 Unit Root Test

Time series data are often found to be non stationary in their levels and thus produce spurious results when used for regression analysis. Where time series data are found to be non stationary the method of differencing approach is applied to the series until they become stationary. The present study has used the Augmented Dickey Fuller (ADF) model to test the unit root or stationarity of the variables. The variables are integrated of the order p, that is $I(p)$, if they are stationary at pth difference and of the order 0 denoted as $I(0)$ if they are stationary at levels. The ADF test is based on the following regression equations:

$$\Delta PCEC_t = \gamma_0 + \alpha_1 PCEC_{t-1} + \sum_{i=1}^{m} \gamma_i \Delta PCEC_{t-i} + \varepsilon_t \qquad \text{----------- (1)}$$

$$\Delta PCGSDP_t = \gamma_0 + \alpha_2 PCGSDP_{t-1} + \sum_{i=1}^{N} \beta_i \Delta PCGSDP_{t-i} + \nu_t \qquad \text{----------- (2)}$$

In both equations, the null hypotheses are that $PCEC_t$ and $PCGSDP_t$ have unit roots, i.e. $H_0 : \alpha_1 = \alpha_2 = 0$.

3.2 Co-integration Test

To determine the causal relationship between the variables, the test for co-integration is required. Using the methodology developed in Johansen (1991, 1995), VAR-based co-integration tests has been performed to test for the existence of co-integration and the number of co-integrating vectors. The presence of co-integrating vector is a sufficient condition to estimate a Vector Error Correction Model (VECM).

3.3 Granger Causality Test

According to Granger's theorem when the variables are co-integrated, the simple Granger causality is augmented with the Error Correction Term (ECT), derived from the residuals of the appropriate co-integration relationship to test for causality. A vector error correction (VEC) model is a restricted VAR designed for use with non-stationary series that are known to be co-integrated. The VEC has co-integration relations built into the specification so that it restricts the long-run behaviour of the endogenous variables to converge to their co-integrating relations while allowing for short-run adjustment dynamics. The co-integration term is known as the error correction term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments. Thus we estimate a VECM for the Granger causality test for the variables under study. The VECM representation used here takes the following forms:

$$\Delta PCEC_t = \alpha_0 + \sum_{i=1}^{m} \alpha_{1i} \Delta PCEC_{t-i} + \sum_{i=1}^{n} \alpha_{2i} \Delta PCGSDP_{t-i} + \alpha_3 ECT_{t-1} + \varepsilon_t \qquad \text{----------- (3)}$$

$$\Delta PCGSDP_t = \beta_0 + \sum_{i=1}^{p} \beta_{1i} \Delta PCGSDP_{t-i} + \sum_{i=1}^{q} \beta_{2i} \Delta PCEC_{t-i} + \beta_3 ECT_{t-1} + \nu_t \qquad \text{----------- (4)}$$

Where PCGSDP is per capita gross state domestic product, PCEC is per capita electricity consumption, and α_3 and β_3 are adjustment coefficients. ECT_{t-1} expresses error correction term, Δ indicates first difference operator, ε_t and ν_t are mutually uncorrelated white noise errors, while *t* denotes the time period. Eq. (3) is used to test causation from economic growth to electricity consumption, while eq. (4) is used to test causation from electricity consumption to economic growth.

This approach allows us to distinguish between 'short-run' and 'long-run' Granger causality. The Wald F-tests of the 'differenced' explanatory variables give us an indication of the 'short-term' causal effects, whereas the 'long-run' causal relationship is implied through the significance or otherwise of the t-test(s) of the lagged error correction term that contains the long-term information since it is derived from the long-run co-integrating relationship.

Causal relationships are examined here in three ways (Masih and Masih, 1997):

(i) Short-run or weak Granger causalities are detected through a joint Wald F-test for the significance of the coefficients of each explanatory variable. The weak Granger causality is interpreted as short-run causality in the sense that dependent variable responds only to short-run shocks.

(ii) Long-run causalities are examined through the standard t-test for the significance of the relevant coefficients of the lagged error correction term. Negative and statistically significant values of the coefficients of the error correction term indicate the existence of long-run causality. The coefficient of error correction term gives the speed of adjustment.

(iii) Strong Granger causalities are detected through a joint Wald F-test for the joint significance of the coefficients of error-correction term and each explanatory variable.

4 Results and Discussion

The standard ADF test was used to test for stationarity of the variables. The test results given in Table 3 show that the two variables, $PCEC$ and $PCGSDP$, are non-stationary at levels but stationary at first difference, i.e., the series are integrated of first order, i.e. I(1). In other words, it can be said that both the series have common integration order. Since both the variables have common integration order we can proceed for co-integration test, i.e. long-run relationship between the two variables.

Table 3: Unit Root Tests for Individual Series of PCEC and PCGSDP variables

Variable	ADF Test	
	Level	First Difference
PCEC	-0.6919	-6.9188*
PCGSDP	0.5028	-7.741905*

*Rejects null hypothesis of unit root at the 0.01 level.

In order to test the co-integration of the variables the Johansen's methodology is used. Since the LR test statistic for co-integration depends on the assumptions made with respect to deterministic trends, we need to make an assumption regarding the trend underlying the data. From the summary of all 5 trend assumptions, the choice of the assumption of 'no deterministic trend' in data (no intercept or trend) is determined (Table 4). Assuming no deterministic trend, the empirical findings show that there is existence of one co-integrating vector or long-run equilibrium relation between $PCEC$ and $PCGSDP$ during the period 1980-2014. The trace test shows that the likelihood ratios (trace statistics) for the null hypothesis having no co-integration is higher than the critical value at the 5 per cent level of significance, indicating that there is one co-integrating equation (Table 5). Similarly, the maximum Eigen value statistics for the null hypothesis having no co-integration is higher than the critical value at the 5 per cent level of significance, indicating that there is one co-integrating equation. Hence, according to likelihood ratio and maximum Eigen value statistics tests $PCEC$ and $PCGSDP$ series are co-integrated. Thus, a long-run equilibrium relationship between these two series is co-integrated.

Table 4: Selected (0.05 level)* Number of Co-integrating Relations by Model

Data Trend	None	None	Linear	Linear	Quadratic
Test Type	No intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	1	0	0	0	0
Max-Eigen	1	0	0	0	0

*Critical values based on MacKinnon-Haug-Michelis (1999)

Table 5: Johansen Cointegration Test Results

Trace Test			
Hypothesised No. of CE(s)	Trace statistic	5 per cent critical value	Prob.**
None*	15.43193	12.32090	0.0146
At most 1	3.000759	4.129906	0.0985
Maximum Eigen Test			
Hypothesised No. of CE(s)	Max-Eigen statistic	5 per cent critical value	Prob.**
None*	12.43117	11.22480	0.0305
At most 1	3.000759	4.129906	0.0985

Trace and Max-Eigen tests indicate 1 cointegrating equation at the 0.05 level
*denotes rejection of the hypothesis at the 0.05 level
** MacKinnon-Haug-Michelis (1999) p-values

The existence of co-integrating relationship between PCEC and PCGSDP suggests that there must be Granger causality in at least one direction, but fails to signify the direction of causality between the two variables. Since the variables are co-integrated, the vector error correction models (VECM) are estimated in order to find the direction of causality between the variables. The VECM not only provides an indication of the direction of causality, but also enables to distinguish between short-run and long-run Granger causality.

Table 6 provides for the results of Ganger causality test. It is seen from the table that the coefficient of error correction term is significant in one equation where PCEC is the dependent variable, implying that long run causal relationship is running from economic growth to electricity consumption. The reverse long run causality does not exist as the error correction term is not significant where PCGSDP is the dependent variable. Thus, data on Odisha supports the conservation hypothesis, i.e. economic growth in Odisha stimulates electricity consumption in the long run but the reverse is not true. Here the disequilibrium is corrected in the long run at the speed of 40.89 per cent. The lack of feedback effect from electricity consumption to economic growth indicates that restrictions on the use of electricity may not adversely affect economic growth. Thus, electricity demand side management measures can be adopted to reduce electricity consumption in the state, without affecting future economic growth.

Table 6: Granger Causality Test

	Short-run (or weak) causality		Long-run causality	Joint short- and long-run (or strong) causality	
	D(PCEC)	D(PCGSDP)	ECT_{t-1}	D(PCEC),ECT	D(PCGSDP),ECT
D(PCEC)	-	0.1987 (0.8210)	-0.4089* (-2.7058)	-	2.5926 (0.0751)
D(PCGSDP)	1.9565 (0.1624)	-	0.0755 (0.7114)	1.4136 (0.2622)	-

*Significant at the 0.05 level

The results obtained herein can be explained in two possible ways. First, electricity consumption in Odisha is very low. Given the relatively low level of electricity consumption, electricity is not expected to be a major determinant of economic growth. Secondly, the productive sectors in the Odishan economy are agriculture, industry and service sectors. Agriculture and service sectors which constitute two-third of the GSDP are less energy intensive. On the other hand, the industrial sector, which is most energy intensive and is preordained to be the channel through which electricity consumption leads to growth, has only the share of one third of the GSDP. The structure of the distribution of electricity consumption has also tilted away from the industrial sector towards the residential sector. This suggests that in the event of restriction on electricity consumption, the economy is less likely to be adversely affected.

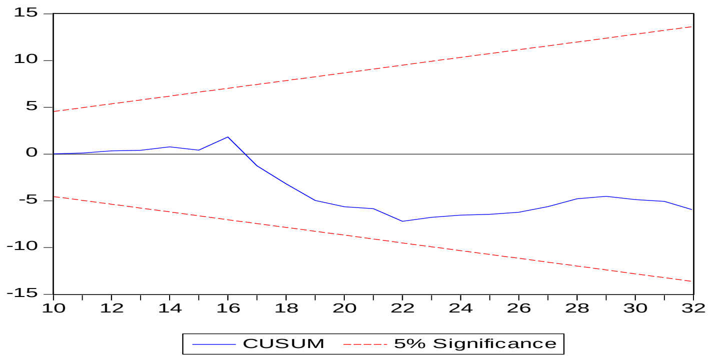
Table 6 also shows the result of short run causality. In the first equation where PCEC is the dependent variable, the joint F-value of lagged PCGSDP is not found to be significant, meaning thereby that there is no short run (weak) Granger causality from PCGSDP to PCEC. Similarly, in the second equation, the joint F-value of lagged PCEC is not found to be significant, indicating that there is no short run (weak) Granger causality from PCEC to PCGSDP. Hence, none of the lagged coefficients of the two variables are jointly significant, indicating that there is no short run causality between electricity consumption and economic growth in Odisha. It is also observed that the joint F-valueof the error correction terms and explanatory variables are not significant in any equation indicating that there is no 'strong' Granger causality between the two variables.

The study applies a number of diagnostic tests to test for the efficiency of the VEC model used in eq. (3). The results are presented in Table 7. The tests suggest that there is no serial correlation in the error term. The Regression Equation Specification Error Test (RESET) indicates that the model is correctly specified and there is no functional problem. The model passes the Jarque-Bera normality tests, signifying that the errors are normally distributed. Moreover, the ARCH test denotes that the errors are homoskedastic and independent of regressors. The regression equation also appears stable over the period of estimation as the CUSUM test statistics does not exceed the bounds of 5 per cent level of significance (Figure 1).

Table 7: Diagnostics Tests

Test Statistics	LM Test	F Test
Serial Correlation	CHSQ(2) = 0.153971 [0.9259]	F (2,23) = 0.057403 [0.9443]
Heteroscedasticity (ARCH)	CHSQ(2) = 3.480852 [0.1754]	F (2,26) = 1.773221 [0.1897]
Normality	3.590061 (0.1661)	NA

Figure 1: Plot of Cumulative Sum of Recursive Residuals



Granger causality test suggests which variables in the model have statistically significant impacts on the future values of each of the variables in the system. However, the result will not be able to indicate how long these impacts will remain effective in the future. This paper conducts variance decomposition and impulse response function proposed by Koop et al. (1996) and Pesaran and Shin (1998) to study the dynamic relationship between Odisha's electricity consumption and economic growth. The unique feature of these approaches is that the results from these analyses are invariant to the ordering of the variables entering the VAR system.

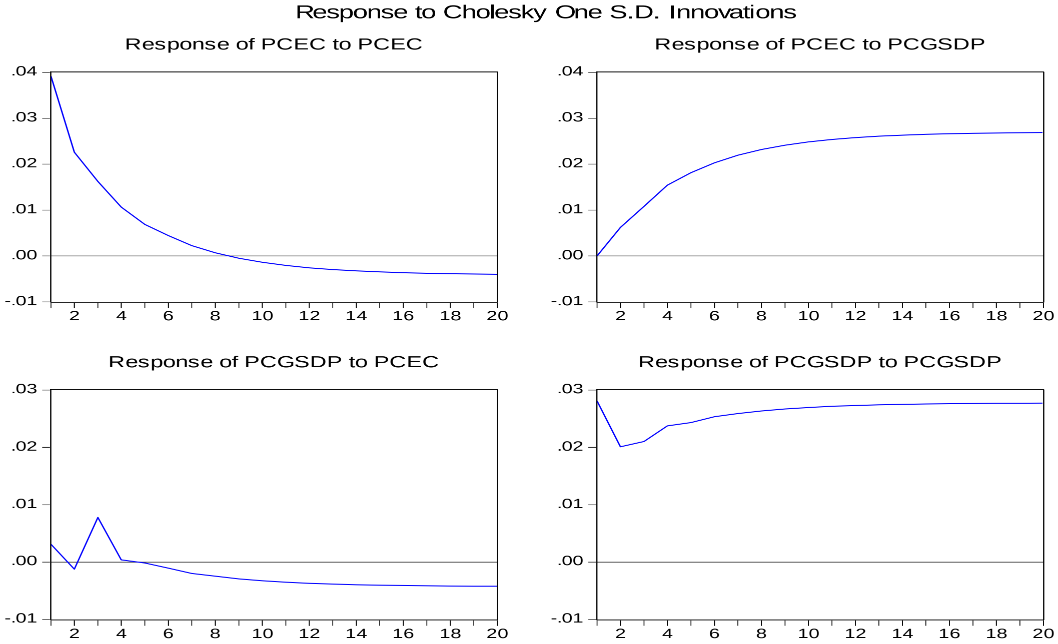
Variance decomposition gives the proportion of the movements in the dependent variables that are due to their own shocks versus shocks to the other variables. The results of variance decomposition over a period of 20-year time horizon for the variables are presented in Table 8. The results of the variance decomposition are similar to the outcomes of causality analysis. The variance decomposition of electricity consumption reveals that economic growth explains variation in electricity consumption in an increasing proportion during the 20-year time horizon and after 20 years it explains 79.81 per cent of the variation. On the other hand, electricity consumption explains a very negligible proportion (1.85 per cent) of variation in economic growth even after 20 years. This confirms the existence of a unidirectional causality from economic growth to electricity consumption in Odisha.

Table 8: Findings from Forecast Error Variance Decomposition

Years	Variance Decomposition of PCEC		Variance Decomposition of PCGSDP	
	PCEC	PCGSDP	PCEC	PCGSDP
1	100.00	0.00	1.21	98.79
5	77.36	22.64	2.51	97.49
10	42.66	57.34	1.61	98.39
15	27.36	72.64	1.71	98.29
20	20.19	79.81	1.85	98.15

Figure 2 shows impulse response analysis of the two variables. The results show that 20 years analysis of one standard deviation positive shocks in economic growth will change the electricity consumption to rise positively, indicating that there is existence of causality from economic growth to electricity consumption. On the other hand, one standard deviation positive shocks in electricity consumption will only marginally reduce the economic growth. This confirms the existence of unidirectional causality from economic growth to electricity consumption in Odisha.

Figure 2: Findings from Impulse Response Function



5 Conclusions

Per capita electricity consumption and per capita GSDP (economic growth) are found to be non-stationary at their level form but stationary at first difference. Both the series are co-integrated, revealing the existence of a long-run relationship between electricity consumption and economic growth in Odisha. The vector error-correction (VEC) model established the unidirectional long-run Granger causal relationship running from economic growth to electricity consumption, suggesting that economic growth in Odisha stimulates electricity consumption in the long run thereby supporting the conservation hypothesis. The analyses of variance decomposition and impulse response function confirm the direction of causality in a dynamic context. This finding has important policy implications in the state of Odisha. The lack of feedback effect from electricity consumption to economic growth indicates that electricity demand side management measures can be adopted to reduce electricity consumption, which would not affect future economic growth in the state.

References

Altinay, G., and Karagol, E. (2005). Electricity Consumption and Economic Growth: Evidence from Turkey, *Energy Economics*, 27(6), 849-856.

Aqueel, A., and Butt, M. S. (2001). The Relationship between Energy Consumption and Economic Growth in Pakistan, *Asia-Pacific Development Journal*, 8(2), 101-110.

Chen, S.T., Kuo, H.I., and Chen, C.C. (2007). The Relationship between GDP and Electricity Consumption in 10 Asian Countries, *Energy Policy*, 35(4), 2611–2621.

Ghosh, S. (2002). Electricity Consumption and Economic Growth in India, *Energy Policy*, 30(2), 125-129.

Government of Odisha 92015). *Odisha Economic Survey 2014-15*, Planning and Coordination Department.

Gupta, G., and Sahu, N.C. (2009). Causality between Electricity Consumption & Economic growth: Empirical Evidence from India, MPRA Paper No. 22942, 1-18.

Javid, A. Y., Javid, M. and Awan, Z. A. (2013). Electricity Consumption and Economic Growth: Evidence from Pakistan, *Economics and Business Letters*, 2(1), 21-32.

Jiranyakul, K. (2014). Causal Linkages between Electricity Consumption and GDP in Thailand: Evidence from the Bounds Test, MPRA Paper No. 60625, 1-10.

Johansen, S. (1991). Estimation of Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models, *Econometrica*, 59, 1551-1580.

Johansen, S. (1995). Likelihood-based Inference in Cointegrated Vector Autoregressive Models, Oxford: Oxford University Press.

Jumbe, C. B. L. (2004). Co-integration and Causality between Electricity Consumption and GDP: Empirical Evidence from Malawi, *Energy Economics*, 26(1), 61-68.

Koop, Gary, Pesaran, M.H., and Potter S.M. (1996). Impulse Response Analysis in Nonlinear Multivariate Models, *Journal of Econometrics*, 74(1), 119-147.

Kraft, J., and Kraft, A. (1978). On the Relationship between Energy and GNP, *Journal of Energy and Development*, 3(2), 401-403.

MacKinnon, James G., Haug, Alfred, and Michelis, Leo (1999). Numerical Distribution Functions of Likelihood Ratio Tests for Cointegration, *Journal of Applied Econometrics*, 14(5), 563-577.

Masih, A.M.M., and Masih, R. (1997). On the Temporal Causal Relationship betweenEnergyConsumption, Real Income, and Prices: Some new Evidence from Asian-Energy DependentNICs based on a Multivariate Cointegration/Vector Error-Correction Approach, *Journal of Policy Modeling*, 19(4), 417-440.

Masuduzzaman, Mahedi (2012). Electricity Consumption and Economic Growth in Bangladesh: Co-Integration and Causality Analysis, *Global Journal of Management and Business Research*, 12(11), 47-56.

Morimoto, R., and Hope, C. (2004). The Impact of Electricity Supply on Economic Growth in Sri Lanka, *Energy Economics*, 26(1), 77-85.

Mozumder, P., and Marathe, A. (2007). Causality Relationship between Electricity Consumption and GDP in Bangladesh, *Energy Policy*, 35(1), 395–402.

Narayan, P. K., and Smyth, R. (2005). Electricity Consumption, Employment and Real Income in Australia: Evidence from Multivariate Granger Causality Tests, *Energy Policy*, 33(9), 1109–1116.

Pesaran, H.M., and Shin, Y. (1998). Generalized Impulse Response Analysis in Liner Multivariate Models, *Economic Letters*, 58(1), 17-29.

Shahbaz, M., and Feridun, M. (2011). Electricity Consumption and Economic Growth: Empirical Evidence from Pakistan, Retrieved on 23.6.2015 from http://www.ciitlahore.edu.pk/Papers/430-8589004552818369558.pdf

Shiu, A., and Lam, P. (2004). Electricity Consumption and Economic Growth in China, *Energy Policy*, 32(1), 47–54.

Wolde-Rufael, Y. (2004). Disaggregated Industrial Energy Consumption and GDP: The Case of Shanghai, 1952-1999, *Energy Economics*, 26(1), 69-75.

Wolde-Rufael, Y. (2006). Electricity Consumption and Economic Growth: A Time Series Experience for 17 African Countries, *Energy Policy*, 34(10), 1106–1114.

Yoo, S. H. (2005). Electricity Consumption and Economic Growth: Evidence from Korea, *Energy Policy*, 33(12),1627-1632.

Yoo, S. H. (2006). The Causal Relationship between Electricity Consumption and Economic Growth in ASEAN Countries, *Energy Policy*, 34(18), 3573–3582.