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Nexus Between Infrastructure, Capital Formation and Per Capita Income of Odisha During 2004-05-2023-24

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ABSTRACT

In Odisha, infrastructure has influenced positively on gross capital formation which finally acted as catalyst to enhance per capita state domestic product in Odisha in a sustainable manner during 2004-05-2023-24. This analytical axiom has been econometrically tested by Auto Regressive Distributed Lag model with the help of Reserve Bank of India data during the specified period where per capita electricity availability(kwh) per year as infrastructure, and gross capital formation (in lakh rupees) per year are independent variables and per capita net state domestic product (in Rs) which is the indicator of development is considered as dependent variable. The ARDL (1,3,3) model is automatically selected where Akaike Information Criterion (AIC) became the least. The estimated equation of ARDL (1,3,3) revealed that one per cent increase in per capita availability of electricity has enhanced net per capita state domestic product by 0.706% per year significantly while gross capital formation has inverse influence on per capita net state domestic product in successive four years insignificantly. The long run cointegration was found by the F-Bounds test where the calculated F statistic (6.7917) is greater than the tabulated values of I (0) and I (1) at the significance level of 1%,5% and 10% respectively. The estimated error correction equations revealed that the incremental per capita availability of electricity in first period impacted on incremental per capita net state domestic product positively while the relation is negative in successive next two years. All are significant at 5% level. The relation between increment of gross capital formation and increment in per capita net state domestic product is negative and significant in the first year while the relation is positive in next two years where second year is significant and third year is insignificant. The cointegrating equation has been approaching towards equilibrium significantly at the adjustment rate of 41.29% per year. The cointegrating relationship states that one percent increase in per capita availability of electricity per year induced positively on per capita net state domestic product by 3.56% per year and one percent increase in gross capital formation per year induced negatively on per capita net state domestic product by 0.432% per year, all of which are significant at 5% level. The ARDL is stable because CUSUM (cumulative sum) line passes inside ±5% significant bounds. The residual test ensures that the model has no heteroscedasticity and serial correlation problems while Q-Q plots (Quantile-Quantile) rejected its normal distribution property. The model showed significant because AIC=-2.76 which is the least, R 2 =0.996, F=199.05, and DW(Durbin-Watson) =1.52 respectively. Even, the estimated Error Correction Model is highly significant where all coefficients except one are significant. Thus, both per capita availability of electricity and gross capital formation contain short and long run association with net per capita state domestic product of Odisha during 2004-05-2023-24 in both positively and negatively during the process of development as verified by ARDL model although OLS (ordinary least square) confirmed that one percent increase in per capita electricity availability per year enhanced the gross capital formation by 2.211% per year significantly.

Keywords: *Per Capital Availability of Electricity, Gross Fixed Capital Formation, Per Capita State Domestic Product, ARDL, Cointegration*

Introduction

Infrastructure comprises electricity(energy), roads, railways, telecommunications, irrigation, water supply, sanitation, ports, airports, storage, oil and gas, IT respectively. It comprises both hard and soft infrastructure. It can be classified as social infrastructure and economic infrastructure. In Millennium Development Goals, the role of infrastructure in reducing poverty has been prioritized. Even in Sustainable development Goal seven, the target of providing energy for all within 2030 has been recognized considering energy as basic physical input. Infrastructure enhances growth through capital formation and generating output and employment. It promotes sustainable and inclusive economic growth.

Across all countries of the world, World Bank (1994) examined the relation between GDP per capita in 1990 PPP and infrastructure stock per capita in 1990 prices and found that 1% increase in the stock of infrastructure is associated with a 1% increase in gross domestic product.

Taking it granted, government of Odisha has started 18 new projects in PPP model constructing roads spending Rs 6000 crores in which 12 projects are very large. Government set up Biotech Park, SEZ for IT/ ITES and integrated commercial complex through PPP model. Odisha Industrial Corporation has facilitated infrastructure development projects in industries including MSME and IT parks. Government of Odisha finalized "Disaster Resilient Power Systems for Odisha" especially for coastal region to enable disaster resilient power infrastructure which will reduce poverty and generate income in rural Odisha. Government has launched the program of [i] Biju Gram Jyoti Yojana to improve power system in Odisha, [ii]provision of 43% renewable energy within 2030, [iii]Odisha Conclave 2022 assured additional 10GW energy by 2030.

Government of Odisha planned to install total renewable energy of 2473.63 MW where 1582MW in power projects, 315.5MW in wind power,576.11MW in solar power, and 0.04MW in Biomass projects that will enable sustainable development process.

This paper concentrated on the provision of electricity per capita of Odisha that are related to gross capital formation which finally catapult per capita net state domestic product of Odisha during the survey period from 2004-05 to 2023-24 using the data of Reserve Bank of India. This relationship was examined through Auto Regressive Distributed Lag model.

Literature review

Infrastructure is considered as an input of the production process where it can catapult accumulation of factors through human capital development. Agenor and Moreno-Dodson (2006) mentioned that infrastructure affects growth and capital stock. Fourie (2006) showed that infrastructure investment is a good policy tool to reduce poverty level and to rise standard of living since investment in the sectors of transport, water, sanitation, irrigation, telecommunications, energy respectively able to benefit the welfare of the poor people directly. This infrastructure growth effect due to output and employment generation through redistribution effect of infrastructure is interpreted by Ali and Pernia (2003). Fan et al(2002) examined that irrigation infrastructure has positive impact on elasticity of agricultural GDP significantly. Also, Balisacan and Pernia (2002) also found out that a one percent increase in the proportion of irrigated farm area to total farm area leads to a 0.23-0.31% increase in the mean per capita consumption expenditure of the bottom 20% of the population. Deininger and Okidi (2003) examined logit regression model and concluded that access of electricity had not chance of falling into poverty of 20%. Through Granger causality test between investment in infrastructure and GDP on panel data of 67 countries during 1960-1990, Canning and Pedroni (1999) found strong causality between infrastructure and GDP. Heintz et al. (2009) studied in USA between infrastructure investment and GDP during 1950-79 and found a significant positive impact. Bhowmik (2016) examined by cointegration analysis in Bihar during 1990-91-2014-15 and found that investment in infrastructure especially in power sector had insignificant positive impact on SDP per capita, net capital formation and growth of SDP.

Nayak(2015) examined cross section study on rural infrastructure compositing into physical, social and financial infrastructure index in 2001through principal component analysis and concluded that physical infrastructure index got highest weight followed by social and financial in which the ratio of developed district/worst district in physical infrastructure was found 5.73:1. There is vertical inequality in physical infrastructure among the coastal, western and southern regions of the state. In case of social infrastructure there is north south disparity. Health infrastructure is better in some coastal district. Among low, medium and high categories of financial infrastructure there is disparity in district levels. Above all, there is disparity in rural infrastructural in Odisha. World Bank (1994) examined in 85 districts in 13 states in India and found that farmers access to markets have increased due to lower transport cost and led to agricultural expansion extensively through higher yield including expansion of banks and its lending. Even, more transport facilities reduce regional variations of food prices which can ameliorate poverty.

Thus, the role of infrastructure is dominant in the sustainable development process in a dynamic economy.

Objective of the paper

The paper tries to examine the relationship between the per capita net state domestic product, gross capital formation and per capita availability of electricity of Odisha from 2004-05 to 2023-24 taking RBI data to find out the infrastructure impact on growth as well as causal effects of capital formation by applying Auto Regressive Distributed Lag model.

Methodology and Sources of data

The data on net per capita state domestic product of Odisha (in Rs), gross capital formation (in Rs crores) and per capita availability of electricity (in KWH) from 2003-04 to 2023-24 were collected from Reserve Bank of India.

Regression of trend line was done using log(x)=a+bt where x=independent variable, t =time, a and b are constants. Ordinary Least Square regression model was done through log(x)=a+blog(y_i) for all values of i=1,2,3,…….n- where x=dependent variable, y_i=independent variable, a and b_i are constants. Dickey and Fuller (1979) test was applied for confirmation of stationarity and non-stationarity of the series. Breusch and Pagan (1979) test was used to find out the heteroscedasticity problem and serial correlation problem. Page (1954) model was used for CUSUM test in order to get stability. The model of Wilk and Gnanadesikan (1968) was used to depict Q-Q plot to assure normality.

Pesaran and Shin (1999) model was applied for estimation of Auto Regressive Distributed Lag during 2004-05-2023-24. The Bounds test was applied following the model of Pesaran, Shin and Smith (2001).

Observations of the models

Per capita electricity availability in Odisha has been increasing at the rate of 4.16% per annum significantly from 2004-05 to 2023-24 which is estimated below.

$$Log(x_1) = 5.992 + 0.0416t + u_i$$

(153.57)*(12.79)*

Where R^2=0.90, F=163.61*, DW=0.69, AIC=-2.02, n=20, *=significant at 5% level, x_1 =per capita availability of electricity in Odisha(kwh), t=time, u_i=random error.

Gross capital formation in Odisha during 2004-05-2023-24 has been increasing at the rate of 8.70% per year significantly which is estimated below.

$$Log(x_2) = 13.566 + 0.0870t + u_i$$

(52.98)*(4.07)*

Where R^2=0.479, F=16.60*, DW=0.822, AIC=1.74, n=20, x_2 =gross capital formation of Odisha (in lakh rupees), *=significant at 5% level, t=time.

Net per capita state domestic product of Odisha has been rising at the rate of 11.51% per annum significantly from 2004-05 to 2023-24. The estimated equation is given below.

$$Log(x_3) = 9.717 + 0.1151t + u_i$$

(374.28)*(53.15)*

R^2=0.99, F=2825.002, DW=1.335, n=20, *=significant at 5% level, x_3 = net per capita state domestic of Odisha, t=time.

The OLS estimate states that a one per cent increase in net per capita availability of electricity per annum and gross capital formation per annum induced 2.69% increase and 0.0790% decrease in net per capita domestic product per annum significantly in the former case and insignificantly in the latter case.

$$Log(x_3) = -5.2627 + 2.695log(x_1) - 0.0790log(x_2) + u_i$$

(-4.52)* (9.48)* (-0.796)

R^2 =0.919, F=97*.73, n=20, DW=0.85, *=significant at 5% level.

The Quantile-Quantile plot of the residual implies that it is not normally distributed which is depicted in Figure 1.

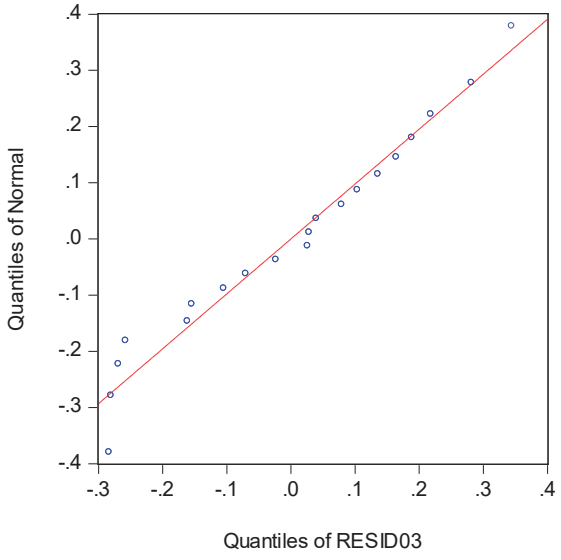

Figure 1: Quantile-Quantile plot of residual

Source-Plotted by author

The Breusch-Pagan-Godfrey Heteroskedasticity Test assures that the residual has no heteroscedasticity problem because n R^2=2.1356 whose probability Chi-square(2)=0.3438 and its F(2,17)=1.0161 whose probability is 0.3829 while it has serial correlation problem where

n R^2 = 6.8907 whose probability Chi-square(1)=0.0087 and F(1,16)=8.4103 whose probability is 0.0104.But the estimated regression model is found stable because Cumulative Sum line passed through ±5% significant level which is shown below in Figure 2.

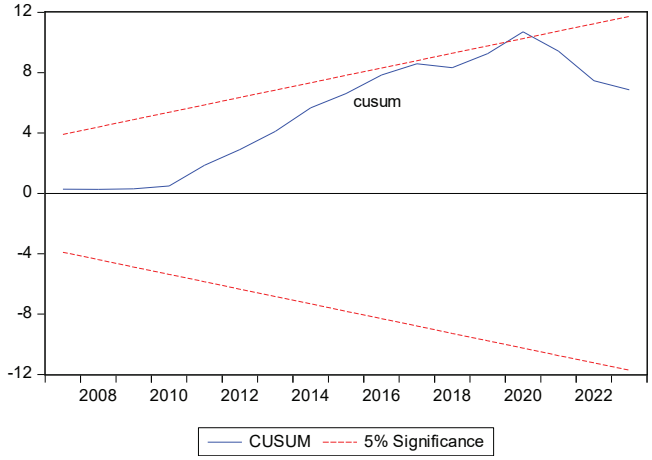

Figure 2: Cumulative Sum line

Source-Plotted by author

The unit root test assumes that per capita availability of electricity(x_1) and per capita net state domestic product (x_3) contain unit root but gross capital formation (x_2) has no unit root. The values of Augmented Dickey Fuller (ADF) both tabulated and observed have been given below in the Table 1.

Table 1: Unit root test

Variables	ADF statistic	Tabulated value of ADF (at 5% significant level)	Result
log(x_1)	-0.9035	-3.029	unit root, non-stationary
dlog(x_1)	-4.045	-3.04	No unit root, stationary
log(x_2)	-3.329156	-3.029	No unit root, stationary
log(x_3)	-1.294249	-3.04	unit root, non-stationary
dlog(x_3)	-5.754468	-3.049	No unit root, stationary

Source-Calculated by author

Therefore, the ARDL estimate has no constraints to execute the analysis.

Automatic selected ARDL (1, 3, 3) model is estimated below during 2004-05-2023-24 in Odisha.

$$log(x_3)_t = 0.587log(x_3)_{t-1} + 0.706log(x_1)_t - 0.1701log(x_1)_{t-1} + 0.364log(x_1)_{t-2}$$

(2.94)* (2.55)* (-0.54) (1.06)

$$+0.571log(x_1)_{t-3} - 0.115log(x_2)_t - 0.00017log(x_2)_{t-1} - 0.036log(x_2)_{t-2} - 0.0269log(x_2)_{t-3} - 2.18$$

(1.55) (-2.05)* (-0.003) (-0.72) (-0.58)

Where n=17, R^2=0.996, loglikelihood=33.507, F=199.054, AIC=-2.7655, SC=-2.2754, DW=1.525, * represents significant at 5% level.

The model implies that a one percent increase in per capita electricity(kwh) per year led to 0.706% increase in per capita state domestic product per year at level while it decreases 0.170% in previous year, and increases by 0.364%, and 0.571% in second and third year which are insignificant. A one per cent increase in gross capital formation per year led to 0.115% decrease in net per capita state domestic product which is significant at 10% level while in previous three years, the rates were -0.000179%, -0.036147% and -0.026969% per year which were insignificant.

Among the top 20 models, the selected ARDL (1,3,3) model is the best where AIC is the least which is shown below in Figure 3.

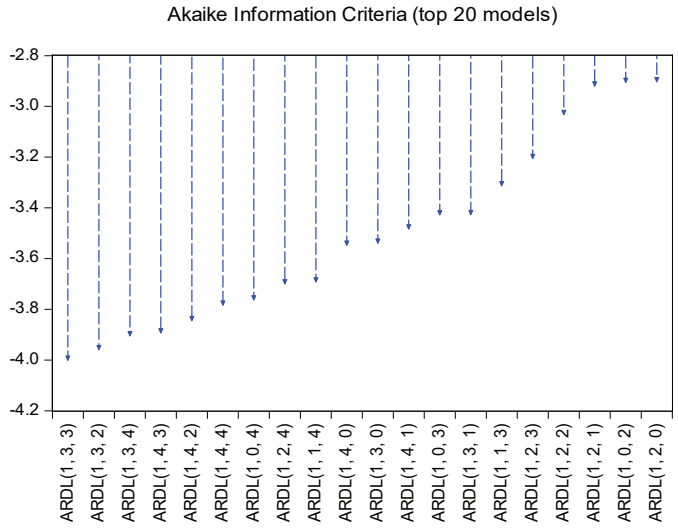

Figure 3: Akaike Information Criteria in ARDL in top 20 models

Source-Plotted by author

The paper found that F= 6.791755 according to the Bounds test which is greater than the tabulated values of I(0) and I(1) under 1%,5% and 10% significant levels and the value of AIC is the least. So, H0 is accepted for long run cointegration, so that, ARDL Error Correction Model is estimated below.

$$Dlog(x_3)_t = 0.706dlog(x_1)_t - 0.935dlog(x_1)_{t-1} - 0.571dlog(x_1)_{t-2} - 0.115dlog(x_2)_t$$

(4.50)* (-3.49)* (-2.67)* (-3.45)*

$$+0.0631 dlog\left(x_2\right)_{t-1} + 0.0269 dlog\left(x_2\right)_{t-2} - 0.4129 ECT$$

(1.95)* (0.90) (-6.22)*

R^2=0.724, loglikelihood=33.507, DW=1.525, AIC=-3.1185, SC=-2.77, n=17, *=significant at 10% level.

The error correction model states that incremental per capita availability of electricity negatively affected on the increment of net state domestic product in all years significantly while the increment of gross capital formation affected negatively and positively in two years significantly but affected positively in third year insignificantly.

The estimated cointegration equation is given below.

$$EC = -0.4129 log\left(X_3\right) - \left(3.5639 log\left(X_1\right) - 0.4325 log\left(X_2\right) - 5.3000\right)$$

(-6.22)* (11.69)* (-3.34)

The cointegrating equation revealed that one percent increase in per capita availability of electricity per year and gross capital formation per year led to 3.56% increase and 0.432 per cent decrease in per capita net state domestic product per year in Odisha during 2004-05-2023-24 significantly. The estimation also implies that the cointegrating equation has been converging towards equilibrium at the speed of adjustment of 41.29% per annum which is significant. It is shown in Figure 4.

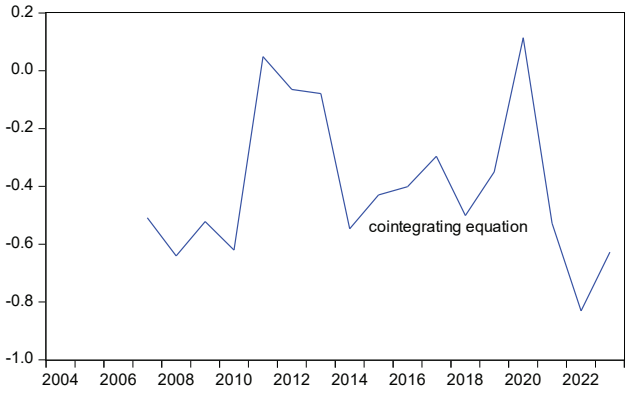

Figure 4: Cointegrating equation

Source-Plotted by author

This ARDL(1,3,3) model has no heteroscedasticity problem as tested by Breusch-Pagan-Godfrey where nR^2=11.029 whose probability of Chi-square(9)=0.2737 and F(9,7)=1.4369 whose probability is 0.3235.Even,the model does not suffer from serial correlation problem since Breusch-Godfrey Serial Correlation LM Test showed that nR^2=0.116704 whose probability of Chi-square(1)= 0.7326 and F(1,6)= 0.041475 whose probability is 0.7326.

The stability is assured for the ARDL (1,3,3) model because the residual's cumulative sum line passes through ±5% significant lines which is depicted in Figure 5 below.

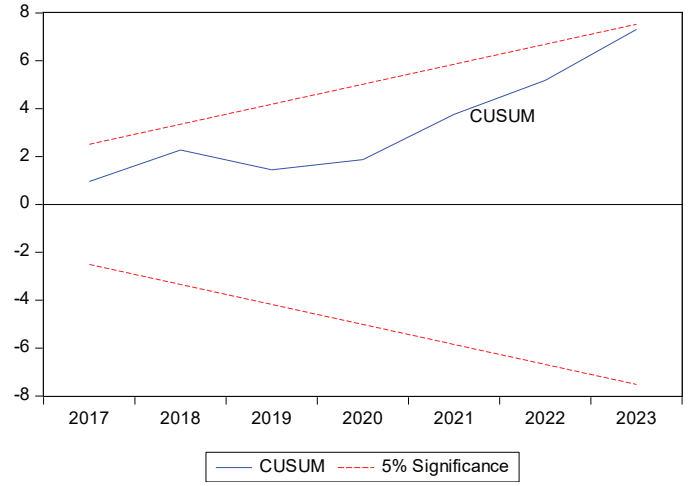

Figure-5: Cumulative sum line

Source-Plotted by author

The residual of ARDL (1,3,3) does not follow normal distribution because its Quantile-Quantile plot did not merge on the normal distribution line. It is shown below in Figure 6.

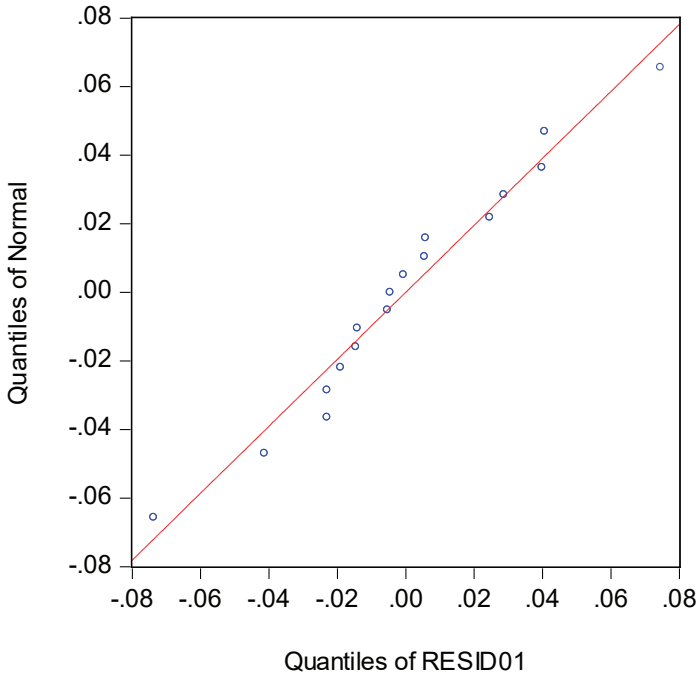

Figure 6: Quantile-Quantile plot

Source-Plotted by author

Finally, it was proved that there is cross correlation between per capita availability of electricity and gross

capital formation is positive and found as 0.75.The cross correlation between per capita availability of electricity and per capita net state domestic product is found positive with valued 0.96 and cross correlation between per capita net state domestic product and gross capital formation is positive as 0.70.On the other hand, Granger Causality test suggested that gross capital formation granger cause per capita availability of electricity, per capita net state domestic product granger cause per capita availability of electricity, and gross capital formation granger cause per capita net state domestic product of Odisha using lag 2 at null hypothesis H0=no granger causality is rejected during 2004-05-2023-24. Therefore, gross capital formation, per capita availability of electricity and net per capita state domestic product of Odisha from 2004-05 to 2023-24 are highly interrelated each other.

Limitations and future scope

If the sample size would become more larger, the result would be better in applying ARDL model. Besides, if capital formation can be broken as fixed and variable then analysis has to be broadened towards other dimensions. Other determinants like roads, railways, irrigation, telecommunication if taken for consideration in the model then additional results would reveal better planning framework for future. Thus, in macro-economic field, there are enough scopes for research in future for analysing energy and development in Odisha.

Conclusion

The paper concludes that per capita availability of electricity have grown at the rate of 4.16% per year, gross capital formation increased by 8.7% per year and net per capita state domestic product catapulted at the rate of 11.51% per year in Odisha during 2004-05-2023-24.The OLS estimates revealed that one percent increase in per capita availability of electricity and gross capital formation per year led to 2.69% increase and 0.079% decrease in net state domestic product per capita per year in Odisha during the same period. This OLS model is stable without serial correlation and heteroscedasticity. All these observations are significant. The estimated ARDL from 2004-05 to 2023-24 states that net state domestic product per capita is positively affected by per capita availability of electricity significantly at level and insignificant at first and third lag but negatively related in second lag while net state domestic product per capita is negatively affected by capital formation in the level significantly and insignificantly in other lags. The error correction estimates revealed that the incremental per capita availability of electricity in first period impacted on incremental net per capita state domestic product positively while the relation is negative in successive next two years. All are significant at 5% level. The relation between increment of gross capital formation and increment in per capita net state domestic product is negative and significant in the first year while the relation is positive in next two years where second year is significant and third year is insignificant.

The significant bounds test assured that there is long run cointegrating relationships among them in which cointegration equation states that net per capita state domestic product has positive cointegration with per capita availability of electricity and negative cointegration with gross capital formation significantly where the cointegrating equation has been converging towards equilibrium at the adjustment rate of 41.29% per annum. This model is stable and there is no heteroscedasticity and serial correlation but did not follow normal distribution as per Q-Q plots. Above all, Granger causality suggests that there is granger cause of gross capital formation and per capita availability of electricity, both granger cause of net state domestic product per capita significantly. Thus, the model demands sufficient investment in installing electricity and creating additional capital formation to boost net state domestic product per capital towards sustainable development. Government of Odisha has planned that the demand for electricity will increase by 5.2% per year within 2033-34 in comparison to 3.92% per year as projected by the report in which government will face a deficit of 8.7% of energy or 5600MU.Government of Odisha will have to meet additional requirement of energy amounting to 55MW in coal,4168MW in solar,1026MW in wind ,645 MW in hydro and 3393MW in DRE till 2033-34 (Government of India: Report on Resource Adequacy Plan for the state of Odisha,2024).

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