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ASSOCIATION OF ELECTRICITY CONSUMPTION, ECONOMIC GROWTH AND FDI IN INDIA

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ABSTRACT

India is one of the largest producer and consumer of electricity in the world owing to being one of the most populous country in the world signifying the demand for electricity is only set to grow further. World has witnessed an era of economic growth aided pertinently by electricity consumption and growing demand. With FDI indorsed downright to this vital utilities sector, it becomes imperative to cognize the relationship of Electricity Consumption, Economic Growth and FDI in India. In this study we investigate the causal direction of relationship among Foreign Direct Investment, Electricity Consumption and Economic Growth in India by using time-series data for the period 1986–2021 and employing econometric models. We find two uni-directional causalities running from Electricity Consumption to Economic Growth and Economic Growth to FDI and a bi-directional causality between Electricity Consumption and FDI. The results of the study provide a novel perspective for policy makers while formulating policies related to the power sector and foreign direct investments in India. The focus of Policy makers should be on enabling electricity service providers to offer best services to commercial and non-commercial participants as it aids in Economic growth of the country. For enhanced economic growth a country like India must have good and world-class infrastructure, efficient and effective regulatory mechanism equitable for all stakeholders, an improved living standard for people of all economic strata and a stable, healthy business friendly environment coupled with policy stability through stable government.

INTRODUCTION

Today, any person's day to day activities without the use of electricity is unimaginable. Technology and innovations has played a major role in a country's economic growth and has resulted in better quality of life aided imperceptibly by electricity and its consumption. No wonder researchers and policy makers agree on the importance of this topic (Ghosh, 2002; Kanjilal & Ghosh, 2021; Kumari et al., 2018; Tiwari et al., 2021).

Studies in literature have acknowledged both facets of a) Electricity Consumption (EC) of a particular country contributing to the Economic Growth (EG) in that country (Yuan et al., 2007; Tang, 2008; Wolde-Rufael, 2004) b) Economic Growth (EG) contributing to Electricity Consumption (EC) of a particular country (Ghosh 2002; Dramani et al., 2012; Akinwale et al., 2013; Hu & Lin 2008). Studies in literature have also established bi-directional causality between EG in terms of Gross Domestic Product (GDP) and EC (Girish, 2016; Girish et al., 2018). For an emerging economy and developing nation like India, Foreign Direct Investment (FDI) plays a key role. Affirmative linkages between EG and FDI have been acknowledged by various authors (Ghazali, 2010; Attari et al., 2011; Khan & Khan, 2011; Choe, 2003). Very few studies in literature have analyzed the causality midst EG, FDI and EG particularly for Indian context (Pao & Tsai, 2011; Kuo et al., 2014). Therefore, it is imperative to explore the relationship among Foreign Direct Investment (FDI), Energy Consumption (EC) using Electricity as proxy and Economic Growth (EG) using GDP data in India.

In this study we investigate the causal direction of relationship among Foreign Direct Investment, Electricity Consumption and Economic Growth in India by using time-series data for the period 1986–2021 and employing econometric

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models. The results of the study provide a novel perspective for policy makers while formulating policies related to the power sector and foreign direct investments in India.

LITERATURE REVIEW

Few authors have shepherded research to discover causality amid EC, FDI and EG for different countries. Mutafoglu (2012) in their study found long-term association among CO2 emissions FDI and EG by considering data from 1987-2009 for Turkey. They found uni-directional causality EG Granger causing FDI nevertheless not vice-versa. Essien (2011) in his study found uni-directional causality from EC to FDI for long and short-run by considering 1980-2009 data for Nigeria.

Pao and Tsai (2011) in their study found uni-directional causality flowing from EC to CO2, EC to GDP and one-way causal path flowing from EC to FDI for Brazil, India, China and Russia by considering data for 1980-2007. Kuo et al. (2014) in their study found uni-directional causality flowing from GDP to EC and EG to FDI by considering data from 1971-2010 for Germany. Tiwari et al. (2021) in their study analyzed the causal association amid GDP, FDI and EC in India. But the data was limited from 1981-2013.

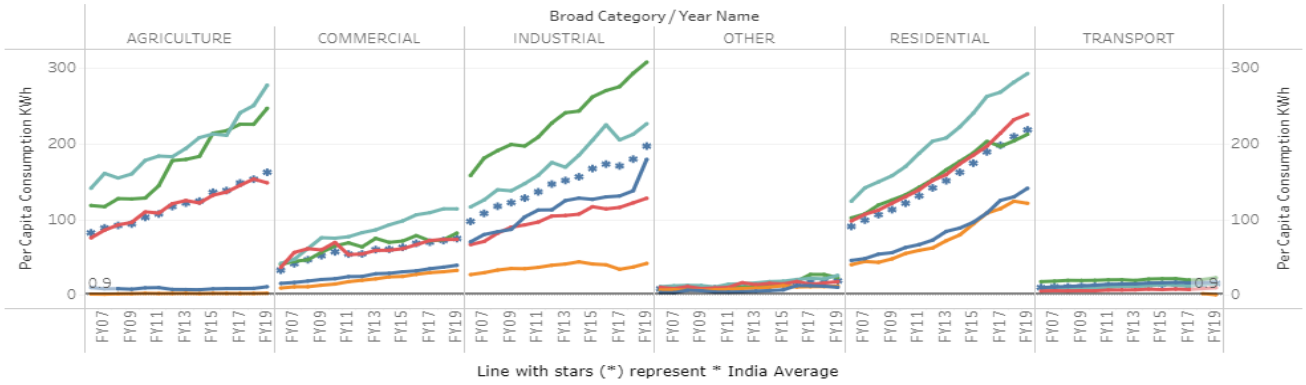

Figure 1. Sector Wise Per Capita Consumption of Electricity in India
Source: NITI Aayog (2021)

Table 1. Year-wise Total Electricity Generated in India

Year	Total Electricity Generated in India including Renewable Sources (in Billion Units)	Growth Percentage
2009-10	808.498	7.56
2010-11	850.387	5.59
2011-12	928.113	9.14
2012-13	969.506	4.46
2013-14	1,020.20	5.23
2014-15	1,110.39	8.84
2015-16	1,173.60	5.69
2016-17	1,241.69	5.8
2017-18	1,308.15	5.35
2018-19	1,376.10	5.19
2019-20	1,389.10	0.95
2020-21	1,381.83	-2.49
2021-22	1.491.859	7.96

Source: Central Electricity Authority (CEA)

Figure 1 provides details of Sector Wise Per Capita Consumption of Electricity in India. We find an increasing trend in usage of electricity for Industrial, Residential and Agricultural purposes in the last few years. It is believed that Transport segment will contribute to electricity consumption owing Electric vehicle policy and battery charging requirements in the next few years. Table 1 elucidates year-wise Total Electricity Generated in India where we observe a trend of consistent growth year on year except during Covid-19. Table 2 highlights the Total Installed Generation Capacity in India (as on June 2022). We observe the contribution of Private sector generators to the tune of 49.5% which includes participants through FDI.

Table 2. Total Installed Generation Capacity in India (as on June 2022)

Sector	Installed Generation Capacity (in MW)	Percentage of Total
Central Sector	99,005	24.60%
State Sector	1,04,969	26.00%
Private Sector	1,99,785	49.50%
Total	**4,03,760**	

Source: Central Electricity Authority (CEA)

MATERIALS AND METHODS

In this study we investigate the causal direction of relationship among Foreign Direct Investment, Electricity Consumption and Economic Growth in India. In our study we use time-series data for the period 1986–2021 as provided by the World Bank database for India.

In Stage 1 – we authenticate the Stationarity of time-series data using Augmented Dickey Fuller Test (ADF Test). The Null hypothesis for ADF Unit root test is that the data is non-stationary. Stationarity of data is verified using ADF unit root test considering 3 regression models with Trend and without Trend: a) Constant intercept but no Trend b) Trend and constant intercept c) No Trend nor constant intercept. Optimum lag length is set on the basis of Akaike Information Criterion (AIC) and Schwartz Bayesian information Criterion (SBC).

In Stage 2 - we employ Johansen Co-Integration test, Granger causality and Vector Error Correction Model (VECM) for deciphering causal direction of relationship among Foreign Direct Investment, Electricity Consumption and Economic Growth in India. Co-integration approach is helpful in investigating long-term relationship amid variables and identify number of co-integrating equations amid variables. Long-term equilibrium association will be symbolized if there exists at least one co-integrating equation.

Johansen and Juselius (1990) present Maximum-Eigen Value test and Trace-value test to estimate existence of co-integration among the variables being studied. VECM necessitates the data partaking no unit root and actuality of at least one co-integration equation implying manifestation of long-term relationship among variables. When variables are established to be co-integrated at that juncture short-run and long-run causal relationship can be verified deploying Vector Error Correction Model (VECM). The Granger causality helps investigate causal directions between the variables.

RESULTS AND DISCUSSION

Data of EG, FDI and EC as per Augmented Dickey Fuller unit-root test were found to be non-stationary at level. The data had to be transformed to be stationary at first difference. Table 3 represents the empirical results of the ADF unit root test. We find EG (GDP) and FDI time-series have significant p-value at 5% levels, whereas EC has significant p-value at 10% level.

Table 3. Stationarity of Time Series - Augmented Dickey Fuller Test

	At Level		At First Difference	
	t-value	**p-value**	**t-value**	**p-value**
EG (GDP)	−0.59018	0.986	−4.9812	0.002*
FDI	−2.09780	0.5211	−3.985	0.045*
EC	2.0376	1	−3.65	0.087**

* Shows stationarity at 5% level. ** Shows stationarity at 10% level.

Table 4 divulges results of Johansen Co-Integration Test wherein values of trace test and Maximum Eigen value tests specify that amid the study variables (FDI, EC and EG) 2 equations are co-integrated to one-another at 5% significance level highlighting existence of long-term relationship amongst variables under study. Consequently, the study apparatuses VECM technique for investigating causal effects for long-run in addition to short run.

Table 4. Johansen Co integration Test

Hypothesized	**Eigen Value**	**Co integration Rank Test (Trace Value)**		
		Trace value	**Critical value**	**P-value**
None*	0.6945	44.9685	31.5467	0.00021*
At Most 1*	0.4251	16.8456	16.5471	0.04745*
At Most 2	0.0388	1.1874	3.9546	0.2967

Table 5 presents results of the Long-run Vector Error Correction Model (VECM). The coefficient value of EC if increased by one unit, then EG (in terms of GDP) will be affected by 0.326 units. Similarly, if FDI is upraised by one unit, then EG in terms of GDP will change by 2.6 units. The results point out that EC and EG in terms of FDI positively impacts GDP. The error correction term coefficient 0.023 displays that EG in terms of GDP will change by 23% towards equilibrium in the imminent year. R-Square (0.671) and Adjusted R-square (0.357) specifies change in EG in terms of GDP due to variation in EC and FDI. The F-statistic value (2.249) confirms that the overall model is good.

Table 5. Long Run Vector Error Correction Model (VECM) Results

Dependent variable: GDP			
Variables	**Coefficient**	**Standard Error**	**T-value**
EC	0.326	-0.0648	[−4.99]
FDI	2.60E-08	-1.60E-09	[−15.87]
C	258.65		
Coefficient (1)	−0.023	-0.675	[−0.039]
R-Square	0.671		

Adjusted -Square	0.357
F-Statistic	2.249
Akaike AIC	11.321

Table 6 offers results of short-run Granger causality. The results of the study give the impression that there exists two uni-directional causalities running from Electricity Consumption to Economic Growth and Economic Growth to FDI and a bi-directional causality between Electricity Consumption and FDI.

Table 6. Short Run Granger Causality

	Null Hypothesis	F-value	P- value	Decisions	Results	Conclusion
1	ELC doesn't granger cause to GDP	9.9525	0.0441	Reject	ELC →GDP	Unidirectional Causality
2	GDP doesn't granger cause to ELC	5.892	0.209	Accept	GDP ≠ ELC	ELC→GDP
3	FDI doesn't granger cause to GDP	3.288	0.512	Accept	FDI ≠ GDP	Unidirectional Causality
4	GDP doesn't granger cause to FDI	46.389	0	Reject	GDP → FDI	GDP→FDI
5	ELC doesn't granger cause to FDI	15.419	0.00389	Reject	ELC → FDI	Bidirectional Causality
6	FDI doesn't granger cause to ELC	11.062	0.0261	Reject	FDI→ELC	ELC↔FDI

The focus of Policy makers should be on enabling electricity service providers to offer best services to commercial and non-commercial participants as it aids in Economic growth of the country. Economic Growth playing role in FDI implicates that the Policy makers must pay keen attention to uphold high economic growth owing to its influence on FDI flows in India. For enhanced economic growth a country like India must have good and world-class infrastructure, efficient and effective regulatory mechanism equitable for all stakeholders, an improved living standard for people of all economic strata and a stable, healthy business friendly environment coupled with policy stability through stable government.

CONCLUSIONS

India is one of the largest producer and consumer of electricity in the world owing to being one of the most populous country in the world signifying the demand for electricity is only set to grow further. World has witnessed an era of economic growth aided pertinently by electricity consumption and growing demand. With FDI indorsed downright to this vital utilities sector, it becomes imperative to cognize the relationship of Electricity Consumption, Economic Growth and FDI in India. In this study we investigated the causal direction of relationship among Foreign Direct Investment, Electricity Consumption and Economic Growth in India for time-series data for the period 1986–2021 using econometric models. The findings of the study contribute to the existing literature by stressing the manifestation of two uni-directional causalities running from Electricity Consumption to Economic Growth and Economic Growth to FDI and a bi-directional causality between Electricity Consumption and FDI in Indian context. The results of the study provide discernments for policy makers while framing policies associated to the power sector and foreign direct investment.

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