

# Do Electricity Consumption and Trade Openness Boost Economic Growth in Nepal: An Empirical Analysis from Bounds Test to Cointegration Approach

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**Abstract** Electric power is considered an important input that affects economic growth especially in developing countries. This study examines the autoregressive distributed lag model to examine the relationship between electricity consumption, international trade openness, and economic growth in Nepal using the time series data from 1971 to 2014. The cointegration test results suggest the presence of a long run cointegration relationship among electric power consumption, trade openness, and economic growth in Nepal. The estimated results of the long run suggest that both the electric power consumption and trade openness have a significant positive relationship relating to economic growth. The estimated error correction term coefficient is significant at a 1% significance level with an expected sign. The empirical findings of this study indicate that increased electricity consumption and trade openness are favorable for Nepal's economic growth. Therefore, it is recommended to have policies in place that support sustainable energy production and more international trade openness by tapping on sectors where Nepal has comparative advantage.

**Keywords** Economic Growth, Trade Openness, Electricity Consumption, Autoregressive Distributed Lag, Nepal

## 1. Introduction

Electric power is considered a crucial input factor to foster economic growth because of its varied role in production, transportation, etc (Dinç & Akdoğan, 2019). The electricity sources can vary from coal, natural gas to solar, wind, geothermal, or hydropower. Not only is electricity a necessary input material for socioeconomic development, but its consumption is also used as a metric to evaluate a country's living standards (Benkraiem, Lahiani, Miloudi, & Shahbaz, 2019). Consequently, the topic of relationship between electricity consumption and economic growth is well researched (Zortuk & Karacan, 2018). A substantial body of literature is based on the question that whether economic growth leads to electricity consumption or electricity consumption causes economic growth (Aydin, 2019) (Rahman & Velayutham, 2020) although there are varying results about the results. Developed countries typically exhibit higher levels of electricity consumption are more developed than the countries with the low electricity (Mahi, Phoong, Ismail, & Isa, 2019). The consumption of electricity is typically higher in industrial sector than that in agriculture (Sharma, Bhattarai, & Ahmed, 2019). To

execute a prudent electricity development policy, it is important to know the nature of relationship between electricity consumption and economic growth that will help us recalibrate our policies in energy, economic, and environmental spheres (Sbia, Shahbaz, & Ozturk, 2017).

Electricity represents the main source of energy for Nepal. Just like other developing countries Nepal has also been experiencing a general growth in demand for electricity over the years. The demand of electricity in Nepal is increasing at minimum 10% per annum (Parajuli, Østergaard, Dalgaard, & Pokharel, 2014) because of its growing population, rural electrification, rapid urbanization, and proliferation of electric appliances. Nepal is a lower income economy that has abundance of hydropower resource (Alam F., et al., 2017). As of June 30, 2020, there were 85 hydropower projects in operation with a total installed capacity of 1,120.469 MW and 226 projects under construction with an aggregate capacity of 7,956.661 MW (Nepal Electricity Authority, n.d.). Investment in electricity generation is important, however a detailed information about the influence of electricity consumption is equally important to know whether it is the key driver of economic growth.

This paper examines whether there exists a cointegration relationship between economic growth and electricity consumption in case of Nepal. This relationship provides the foundation to the electricity development and economic growth (Arminen & Menegaki, 2019). Previous studies

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have used Johansen's technique to study the cointegration with varying results. It contributes to the existing literature by providing an empirical work through evaluating the relationship between economic growth and electricity consumption in Nepal by applying the ARDL model. The remaining parts of this paper is structured as follows: section 2 presents the relevant literature, section 3 presents data and methodology, section 4 presents empirical results and discussion, and section 5 specifies the conclusion of the paper.

## 2. Literature Review

Electricity represents the main source of energy and basic policy attention to achieve sustainable development (Anwar, Zhou, Asmi, Wang, & Hammad, 2019). The electricity consumption and economic growth relationship has featured as an issue of massive attention between economic researchers and policymakers recently (Zhong et al., 2019). Energy-growth nexus is a relatively new topic, and there have been several studies that investigated the relationship between electricity consumption and economic growth. Scholars have used either the ARDL model to cointegration approach to estimate the long and short run relationship or they have used the vector error correction model VECM to explore the causality relationship direction. By applying ARDL and causality test Ozturk et al. (2018) checked the causal relationship among electricity consumption per capita, foreign direct investment, trade openness, and real GDP in Turkey (Ozturk & Ozturk, 2018). The empirical results of ADRL in long run reveal that electricity consumption is positively connected with per capita real GDP. Marques et al (2017) used the ARDL regression to test the dynamics of energy-growth nexus by drawing evidence from four different regions of the world and underscored the heterogenous impact of electricity consumption, trade openness, and economic growth (Marques, Fuinhas, & Marques, 2017). Likewise, Ohlan (2018) used the ARDL regression and VECM to examine the nexus between electricity consumption, trade openness, and economic growth in India.

Electricity consumption and economic growth relationship is also found in (Bashier, 2016), using 51 countries from 1971-2005. Countries were divided into three income groups' i.e. lower income, middle income and upper income. The relationship is explored by applying panel integration and panel causality test. The consequence of the results is that there is relation between economic growth and electricity consumption for all income group countries. The author found causality running from GDP to electricity consumption in the short run while it is opposite in the long run. It also found that limited access to modern electricity services could boost economic growth. The dynamic relationship is investigated the in 12 oil exporting countries from 1990-2010 and found a long run relationship between economic growth and electricity consumption. In the short

run unidirectional casualty runs from electricity consumption to growth rate, while in the long run there is determination of electricity consumption trend (Sikdar & Mukhopadhyay, 2018). The literature revealed that economic growth causes electricity consumption proxies by electricity and petroleum products consumed in transition countries, using the vector autoregressive method. This finding is not inconsonance with the results of (Galadima & Aminu, 2020), who reported a bidirectional relationship between electricity consumption disaggregated into (electricity, oil and coal), and economic growth for Nigeria. The casual relationship between electricity use and economic growth has also been studied in South Asian context (Alam, et al., 2015). Some panel data analysis have suggested existence of conservation hypothesis (Rahman & Velayutham, 2020) (Hassan, Xia, Latif, Huang, & Ali, 2019) i.e. existence of a unidirectional causality from GDP to electricity, while other have expressed an existence of unidirectional causality from electricity to GDP.

The relationship between international trade and economic growth has also been studied widely. For instance, Ma et al. (2019) found that trade openness had contributed positively to gross domestic product in the provinces of China by Ma et al. (2019). On the other hand, Khobai et al. (2018) found mixed results between the openness and economic growth in case of Ghana and Nigeria 1980-2016. In case of Nepal, (Pradhan, 2010) used the error correction model to suggest that there is a unidirectional causal relationship between electricity consumption and growth in Nepal. With regards to the demand-supply dynamics of electricity, government faces a unique situation because it faces a surplus of energy generated in the wet season, while it has to import the short fall in electricity sector during the dry season. This also requires a need to make effective use of the available energy resources. At the same time, there are concerns that intensive use of electricity may be potentially harmful to the environment. So, it is necessary to explore the impact of the use of electricity resources on economic growth in Nepal.

## 3. Material and Method

### 3.1. Data

The study uses annual time series data from Nepal over the period 1971 - 2014. The three variables used are Real GDP per capita (constant 2010 US\$) used to measure income, Electricity consumption per capita kWh used as proxy for electricity consumption, and trade as a percentage of GDP used as proxy for trade openness. This study uses GDP per capita (at constant 2010 US\$) as a proxy for income or economic growth. We also use trade volume as a percentage of GDP as a proxy for trade openness, although some scholars prefer to use customs duties on imports, duties on exports, taxes on international trade, the degree of degree of integration in global markets, etc. instead. These data are collected from World Bank Development Indicators (World

Bank 2020). Furthermore, these variables are converted into logarithmic form for our analysis.

**Table 1.** Descriptive summary or feature of variables

	ln RGDP	ln ELEC	ln TROP
Mean	22.75659	3.501818	3.595455
Median	22.74500	3.635000	3.730000
Maximum	23.67000	4.990000	4.160000
Minimum	21.95000	1.750000	2.610000
Std. Dev.	0.538866	0.942928	0.384559
Skewness	0.067789	-0.346062	-0.873953
Kurtosis	1.670235	1.996802	3.228141
Jarque-Bera	3.275536	2.723314	5.696581
Probability	0.194413	0.256236	0.057943

Table 1 represents the summary statistics of the variables. It depicts the sample size, mean values of the GDP per capita, Electric power consumption, and Trade Openness.

### 3.2. Model Specification

This paper investigates the impact of electricity consumption and trade openness on economic growth in Nepal by applying the Auto Regressive Distributed Lag (ARDL) model, which is a useful tool to examine the interrelationship among macroeconomic variables. Several studies in the past have used this approach for studying the long run relationship between energy consumption, trade openness, and economic growth (Zeren & Akkuş, 2020; Rauf, Zhang, Li, & Amin, 2018). An economic production function can be expressed in a functional form as the right side of  $Q_t = f(X_1, X_2, X_3, X_4 \dots X_n)$  where  $Q_t$  is the quantity of output, while  $X_1, X_2, X_3, X_4, \dots X_n$  are the quantities of factor inputs (such as capital, labor, land or raw materials). Since this study focuses on the dynamic relationships between economic variables, electricity consumption and trade openness, we will apply the following functional form, which is also used by numerous other studies as highlighted above:

$$RGDP_t = f(ELEC_t, TROP_t) \quad (1)$$

Where RGDP refers to real gross domestic product per capita; ELEC represents electricity consumption per capita; and TROP signifies trade openness, while  $t$  refers to time. This relationship is transformed into the logarithmic linear econometric model as following:

$$\ln RGDP_t = \ln ELEC_t + \ln TROP_t + \varepsilon_t \quad (2)$$

Here  $RGDP_t$  denotes economic growth,  $t$  is for time period,  $\alpha_0$  is intercept,  $\alpha_1$  is the elasticity of Electric power used with respect to economic growth, and  $\mu_t$  is the error term. Since the data are yearly figures, we need to apply the unit root test to check the stationary of the variables. Augmented

Dickey–Fuller (ADF) test, an augmented version of the Dickey–Fuller test. Thereafter, ARDL co-integration test is used to examine the existence of a long run relationship between the variables. The ARDL cointegration approach was developed by Pesaran and Shin (Pesaran, Shin, & Smith, 2001). This approach has three distinct advantages. Firstly, this approach can be effectively used to estimate the long-run and short-run relationship simultaneously. Secondly, the method can be applied even when the variables have mixed integration orders. And thirdly, the method is found to yield better results for finite data sets. Since we are using a 30 years period, this method is suitable for our study. In addition, the ARDL model take care of endogeneity issue by adding lags of dependent as well as in-dependent variables in the model. The Autoregressive distributed lag (ARDL) model is written as

$$\begin{aligned} \Delta \ln RGDP_t = & \alpha_0 + \sum_{n=1}^p \gamma \ln RGDP_{t-i} + \\ & \sum_{n=1}^q \beta_1 \ln ELEC_{t-i} + \sum_{n=1}^q \beta_2 \ln TROP_{t-i} + \\ & \delta_1 \ln RGDP_{t-1} + \delta_2 \ln ELEC_{t-1} + \delta_3 \ln TROP_{t-1} + \varepsilon_{1t} \quad (3) \end{aligned}$$

Where,  $\ln RGDP$  and  $\ln EC$  are variables of the study, while  $\varepsilon_t$  is the white noise term. We have also chosen the optimal lag length based on Akaike Information Criterion (AIC). Once the long-run relationship is confirmed, we can capture the short-run dynamics by converting Eq. (1) into an error correction specification (ECM) as follows:

$$\begin{aligned} \Delta \ln RGDP_t = & \alpha_0 + \sum_{n=1}^p \gamma \Delta \ln RGDP_{t-i} \\ & + \sum_{n=1}^q \beta_1 \Delta \ln ELEC_{t-i} + \sum_{n=1}^q \beta_2 \Delta \ln TROP_{t-i} \\ & + \phi ECM_{t-i} + \varepsilon_{1t} \quad (4) \end{aligned}$$

Where  $\phi$  captures the speed of adjustment,  $ECM_{t-i}$  represents disequilibrium or the error correction term, and  $\Delta$  denotes first difference. The error correction coefficient indicates the speed of re-adjustment to the long-run equilibrium after short-run shocks lead to disequilibrium. After ECM, we finally conduct some diagnostic tests including the cumulative sum (CUSUM) of recursive residual and cumulative sum of squares (CUSUMSQ) of recursive residual tests to examine the stabilization of estimated coefficients in the long run and short run.

## 4. Empirical Results and Discussion

The study uses EViews 11 for conducting the empirical tests. We will first examine the stationarity or dynamic properties of the time-series variables by performing unit root tests, before proceeding with the estimation of the model. The Augmented Dickey–Fuller (1979) and the Phillips–Perron (1988) tests are the most commonly employed techniques for unit root tests used in time series econometric studies. Table-2 below contains the results of the ADF stationarity tests:

**Table 2.** Stationarity test results

Variables	Augmented dickey fuller test statistic (At Level)	Augmented dickey fuller test statistic (At first difference)	Phillips-Perron Test statistic (At Level)	Phillips-Perron Test Statistic (At first difference)
ln RGDP	0.4434	0.000	0.1413	0.0000
ln ELEC	0.5366	0.000	0.6568	0.0000
Ln TROP	0.6412	0.000	0.6412	0.0000

Null hypothesis: data is not stationary/ variable has a unit root. Our test result indicates that variable ln RGDP has unit root at level I(0) but it becomes stationary at 5% level of significant at first difference I(1). Since all of the variables are stationary at the first differences, and none of the

variables are integrated of order two I(2) or above, it is appropriate to proceed with the estimation of the ARDL model and perform the Bounds Test for cointegration. We will also perform the optimal lag selection, the results as under

**Table 3.** Optimal lag selection results

Lag	LogL	LR	FPE	AIC	SC	HQ
0	4.884261	NA	0.000183	-0.094213	0.032453	-0.048415
1	201.7100	354.2863	1.53e-08	-9.485500	-8.978836*	-9.302307
2	213.3755	19.24815	1.35e-08	-9.618777	-8.732116	-9.298188
3	225.9264	18.82623*	1.15e-08*	-9.796318*	-8.529659	-9.338334*
4	229.4884	4.808720	1.58e-08	-9.524419	-7.877762	-8.929040

Optimal lags = 3 based on AIC. This study employs Akaike Information Criterion (AIC) to determine the optimal number of lags to be included in the test equation. Below in Table 4, the estimated ARDL unrestricted or conditional model of equations (1) and (2) are presented respectively. The model has the natural logarithm of Real GDP per capita (lnY) as its dependent variable. Next, we apply the autoregressive distributed lag bounds (ARDL) test to estimate equation above and examine the presence of long run cointegration. Table 4 contains the result of ARDL bounds testing for cointegration. If the F statistic is greater than the I(1) values, then there is a cointegration. If the F-statistic falls into the bounds then the cointegration test becomes inclusive, in this case, following Kremers et al. (1992) and Banerjee et al. (1998), the error correction term will be a useful way for establishing cointegration. Table 4 below lists the critical values of the Bounds Test calculated by Pesaran et al. (2001):

**Table 4.** Bounds tests results

Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	18.95191	10%	2.63	3.35
k	2	5%	3.1	3.87
		2.5%	3.55	4.38
		1%	4.13	5

The value of F-stat is significantly greater than the critical value of upper and lower bounds at 1% and 5% level of significance; therefore, we concluded that the null hypothesis of no cointegration can be rejected. In other words, this represents the existence of a long run co-integration relationship between economic growth, electricity consumption, and trade openness.

Table 5 (i) indicating long-run results of ARDL model findings confirmed that there is a positive and significant relationship between lnEc and lnRGP at 5% level of significance, showing that an increase in electricity consumption positively affects real GDP. More specifically, it implies that if we increase Electricity consumption by 1%, it will lead to increase in RGDP by 0.41% in the long run. The results show that in the long run, the electricity consumption has a positive and significant effect on economic growth.

**Table 5 (i).** Long run coefficients of ARDL

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ln ELEC	0.702298	0.075424	9.311369	0.0000
ln TROP	0.069826	0.190391	0.366748	0.7161
C	20.79019	0.488239	42.58204	0.0000
EC = lnRGDP - (0.7023*lnELEC + 0.0698*lnTROP + 20.7902)				

Next, we conduct the error correction model (short run model) that includes one period lagged error term ECt-1. As displayed below, the coefficient of ECt-1 is highly significant and negative in our model. This indicates that if the variables are not at their long run equilibrium values, there will be a quick adjustment for these variables to return to their long-run equilibrium values. The short run results indicate, electricity consumption does have a significant impact since much of Nepal's electricity consumption is driven by household use with rapid urbanization and rural electrification. The coefficient of energy consumption with respect to economic growth in the error-correction model is in line with previous findings in Pradhan (2010) but in contrast to (Nepal & Pajja, 2019). The use of electricity in Nepal has been traditionally limited to lighting purposes.

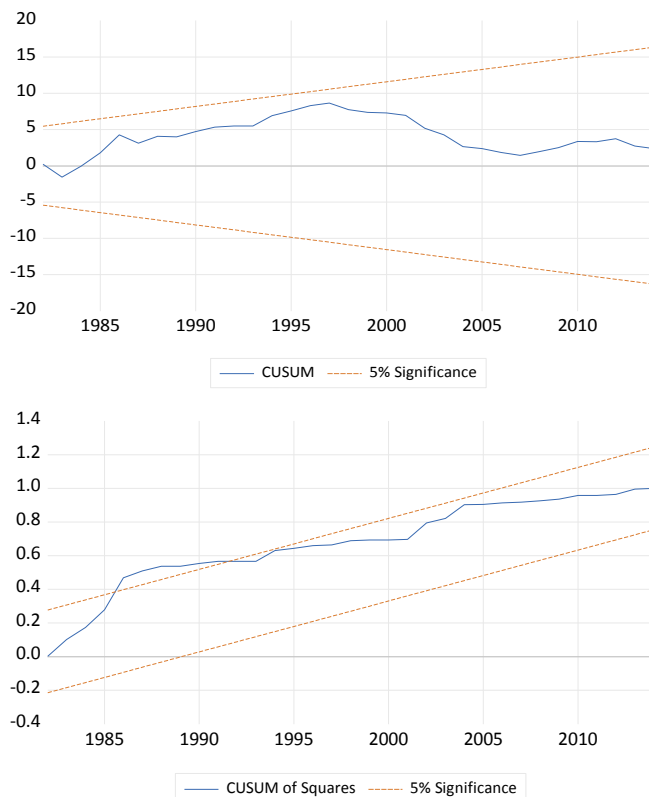
Increased consumption of electricity in industry and in diversified usages such as cooking, transportation, and numerous electrical appliances has a potential to significantly boost economic growth. The overall results expose that electricity consumption boost up the economic growth in Nepal in the long run. This is particularly significant given Nepal's comparative advantage in hydropower (Rana, 2020).

**Table 5(ii).** Results of Short Run Coefficients of ARDL i.e. the Error correction form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(lnRGDP (-1))	-0.553516	0.128680	-4.301481	0.0001
D(lnRGDP(-2))	-0.495076	0.132645	-3.732333	0.0007
D(lnTROP)	0.040893	0.033906	1.206071	0.2364
D(lnTROP(-1))	0.082260	0.032095	2.563014	0.0151
CointEq(-1)*	-0.097711	0.010745	-9.093913	0.0000
R-squared	0.470491	Mean dependent var		0.041463
Adjusted R-squared	0.411656	S.D. dependent var		0.024245
S.E. of regression	0.018597	Akaike info criterion		-5.017833
Sum squared resid	0.012450	Schwarz criterion		-4.808861
Log likelihood	107.8656	Hannan-Quinn criter.		-4.941737
Durbin-Watson stat	1.931071			

**Table 6.** Diagnostic Test results

Test statistic	Test statistic
Breusch-Pagan-Godfrey test for heteroskedasticity	0.3842
Bresusch-Godfrey test for serial correlation	0.9432
Jarque-Bera normality test	19.55



**Figures 1 and 2.** Cumulative Sum (CUSUM) and CUSUM of Squares

Our model has Durbin-Watson statistics relatively close to 2, indicating that it is free of serial correlation. Further, the test results of Breusch Godfrey Serial Correlation test LM Test indicate that our model passes at the 5 percent level of significance. It is also found that our model is free from heteroskedasticity. Finally, we carry out cumulative sum test for parameter stability: The recursive Cumulative Sum (CUSUM) and CUSUM of Squares, which were suggested by Pesaran and Shin (1997) to test the stability of the coefficients of the ARDL model, show that our regression coefficients are stable over time at 95% confidence interval.

## 5. Conclusions

This study examined the long run and short run relationship between electricity consumption, trade openness, and economic growth in Nepal using data from 1971 to 2014. It is observed from the Bounds test results that there exists a cointegration relationship between electricity consumption, international trade openness, and economic growth in Nepal. We also found from our empirical results that the electricity consumption and international trade openness have a positive and statistically significant long run relationship with economic growth at 1% and 5% level respectively. This implies that electricity consumption significantly influences the long run economic growth in Nepal, while trade openness does not seem to benefit the economic growth in the long run that underscores Nepal's huge trade deficits year on year. On the other hand, the electricity consumption in the short run represents an insignificant positive relationship with economic growth, while trade openness seems to influence the economic growth through second lag. Furthermore, it is observed that the coefficient of error correction term is statistically significant at 1% level with an expected sign. More specifically, the long run deviation from the equilibrium point due to the short run shock will be adjusted by 9.7 percent each year. We can draw one finding from this study that Nepal's economy benefits from increased electricity consumption per capita in the long run, and therefore policy designs to support development of more energy sources, particularly hydropower, will be beneficial. Likewise, it is recommended to incentivize local economic activities in which Nepal has competitive advantage such as tourism and services sector.

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