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Original Article

Electricity consumption and economic growth of Vietnam in 1986-2020

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Abstract: Energy consumption and economic growth have an inseparable relationship, affecting the development situation in all aspects of a country. A well-coordinated relationship between energy consumption and economic growth will help the economy develop strongly. This is based on the assumption that energy is being used optimally, avoiding excessive energy consumption, which would lead to energy depletion, with the result that the economic situation remains undeveloped or there is slow development. Electricity plays an important role for each country in the world in general and Vietnam in particular. Vietnam is a developing country; along with that is the great contribution of electric energy to production/business activities, and the daily life of each person. Electricity is an input to help operate machines, improve productivity, and achieve high efficiency in economic activities. Production and business activities will be stalled, negatively affe cting economic growth in countries including Vietnam when countries lack electricity. This article assesses the impact of electricity consumption on Vietnam's economic growth in the period 1986-2020. The estimated results of the ARDL (Autoregressive Distributed Lag) model show that electricity consumption has an impact on economic growth in the short term and long term.

Keywords: Electricity consumption, economic growth, impact of electricity consumption, Vietnam.

1. Introduction

According to Samuelson (1948) and Rostow (1990), a developed economy should have prerequisites such as energy sources, transport, infrastructure, telecommunications, etc. - i.e. input factors of production and business activities. Input materials such as electric power, coal, gas, and petroleum, as well as other

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renewable energy sources, all play an important role in the economic growth of a country.

Electricity plays an important role for each country in the world in general and Vietnam in particular. Vietnam is a developing country, in which electricity makes a great contribution of electric energy to production/business activities and in the daily life of each person. Electricity is an input material to help operate machines, improve productivity, and achieve high efficiency in economic activities. Moreover, without electricity, production and business activities will be stagnant, negatively affecting the economic growth of any country, especially Vietnam. Nowadays, we can see that the demand for electricity is increasing, and it also plays a very important role for the Vietnamese economy.

In from 1986 to 2020, Vietnam was one of the dynamic economies; the growth rate was quite high in the overall picture. For the region in the period 1986-2010 it averaged 7%/year; for the period 2011-2015 it averaged 6%/year, and for the period 2016-2020, 5.99%/year (Vu, 2021). In the period 1986-2020, energy was one of the sectors that played a key role in socio-economic development in Vietnam. Typically, the electricity industry has gradually built and developed in terms of production capacity and efficiency in industry management. A specific example is that in 1986, Vietnam's per capita electricity consumption was only 68kW/h, 4.7 times lower than the Philippines and 6.4 times lower than Thailand, in 2018. This index of Vietnam is approximately 2,3kW/h , nearly three times higher than the Phi lippines and 85% of Thailand. In the global picture of developing countries, Vietnam's electricity industry has made remarkable progress on indicators of power supply reliability and loss management in transmission and distribution. In particular, Vietnam's remarkable success in bringing electricity to the countryside has been written into a research report by the World Bank and disseminated to other countries giving valuable lessons from this meaningful effort. In addition, Vietnam's electricity industry has also played a pioneering role in improving Vietnam's business environment over the past five years. In the World Bank's global "Doing Business" ranking for 2020, Vietnam ranks 27th in the electricity access index, much higher than 70th in the overall index (Vu, 2021).

Some typical studies on the impact of energy consumption on economic growth, such as Romer (1980), used endogenous growth theory to analyze the positive impact of energy on economic growth. Through the production function, Cobb-Douglas shows that GDP is a function of labor (L), capital (K), R (natural resources) and T (technological progress) or GDP = f(L, K, R, T). Then through technological progress economic growth will promote that technology can only be realized when there is an energy source. For example, operating a power plant without an electric power source, the plant cannot operate. It proves that energy use indirectly promotes technology, thereby creating an impetus for growth.

From an empirical perspective, there are a number of studies that have demonstrated the impact of energy on economic growth. Toman and Jemelkova (2003) point out that energy development is an important component of economic development along with giving several ways in which energy affects the development process. The effects may be especially significant in low-developed countries, where the overall opportunity costs of inefficient forms of energy are high. Ciarreta (2006) has discovered a short-run unidirectional relationship (the criterion for which the effect is not high) between energy consumption and economic growth in Spain with the Granger-VECM causality test. Lau and Chye (2011) found a causal relationship from energy consumption to GDP per capita of 17 ASEAN countries in the period 1980-2005 through a causal relationship. This result is also consistent with the study of Damette and Seghir (2013), Karanfil and Li (2014).

Some recent studies like Bekun (2019) for Nigeria and Rafidani et al. (2022) for the French economy also conclude that energy consumption will also affect economic growth in these countries.

2. Model and methodology

2.1. Model

Based on the studies of Wolde-Rufael (2006), Ouedraogo (2013) and Enu and Havi (2014), economic growth (GDP) is a function of consumption of electricity (EC), capital (K), labor (L) or GDP = f (EC, K, L) (1).

In addition, according to some studies by Hubler (2010), Alfaro et al. (2010), Haitao (2011), FDI investment increases the efficiency of power use by restructuring production, technology transfer and other forms. However, it depends greatly on the host country's ability to absorb capital. So we can rewrite equation (1) as GDP = f(EC, K, L, FDI) (2).

To minimize the degree of fluctuation (large error) in equation (2), we take ln on both sides of the equation. (The purpose of taking ln is to minimize the volatility of the equation when performing quantification).

From (2) we take the natural logarithm of both sides and bring the equality into the following regression equation: LnGDP = LnEC + LnK + LnL + LnFDI (3).

Equation (3) is an empirical research model that analyzes the impact of electricity consumption on economic growth.

Table 1: Variables definition and justification

Variables	Definition of variable	Empirical justification of variable	Data	Expectation
GDP	Gross Domestic Product (Million USD)	Rafał (2014), Lu, (2017), Sebastian et al. (2022)		
K	Gross fixed capital formation (Million USD)	Bekun (2019), Kolin (2021), Sebastian et al. (2022)	World Development Indicators (WDI)	(+)
L	Labour (Million USD)	Bekun (2019), Kolin (2021), Sebastian et al. (2022)	World Development Indicators (WDI)	(+)
EC	Total Energy consumption (Consumption of primary energy) (kWh/per - capita)	Bekun (2019), Kolin (2021), Sebastian et al. (2022)	U.S. Energy Information Administration (EIA)	(+)
FDI	Foreign Direct Investment (Million USD)	Amoako and Insaidoo (2021), Ibraheim (2015), Polat (2018)	World Development Indicators (WDI)	(+)

Source: Constructed by authors.

2.2. Methodology

The ARDL model stands for Autoregressive Distributed Lag, roughly translated as the autoregressive distribution delay model. The ARDL model is also used to test the cointegration relationship and dynamic estimation of short-run and long-run relationships. ARDL is a combination of VAR (vector autoregression) and least squares (OLS) regression models.

The ARDL model can be represented as follows:

DYt = m + α1*DYt−1 + α2*DYt−2 + … + αn*DYt−1 + β0*DXt + β1*DXt−1+ … + βn*DXt−n + β2n*Xt−1 + ut

Where: DYt and DXt are stationary variables, and ut is the white noise part; DYt−n and DXt−n are stationary variables at the lags; Xt−1 are undifferentiated independent variables at lag 1- long-run effects, if any.

The implementation process includes:

Step 1: Testing the delay of the stationary calculation. Economic variables normally have a certain lag when considering the effects of other variables. The research is determined based on information standards LR, FPE, AIC, SC, HQ. The delay that makes the above statistics take the smallest value is considered as the optimal delay of the stationarity and also the optimal delay of the model.

Step 2: Testing for stationarity based on lag: Non-stationary time series data is due to trend or seasonality, etc. But the requirement of the ARDL model is that the series must be stationary (with mean, variance and covariance). Variance is constant at all times). The stationary series test method is to use the unit root test according to the extended Dickey-Fuller (ADF) test criteria.

Step 3: Testing the long-run relationship of the model by the BOUND test. If the F-statistic exceeds the upper bound of the F-stat distribution table, the hypothesis Ho is rejected, that is, there is a long-run relationship between the variables in the model. Otherwise, if the value of the F-statistic is below the lower bound, the null hypothesis Ho is not rejected (there is a no long-run relationship between the variables in the model) and if the F-statistic is between the values up to upper and lower bounds, it is not possible to draw conclusions about the relationship between the variables.

Step 4: Using the error correction model (ECM) to estimate the short-run impact of variables on economic growth.

Step 5: Using diagnostic test and stability test to be sure about ARDL and ECM compatibility.

3. Research model analysis results

3.1. Descriptive statistics and correlation analysis

Descriptive statistics

Table 2: Descriptive statistics of variables

	LNGDP	**LNEC**	**LNK**	**LNL**	**LNFDI**
Mean	3.989803	6.020829	2.332134	3.752311	7.226891
Median	3.677600	6.071200	2.579600	3.741800	7.577600
Maximum	5.838400	7.776500	4.190600	4.023500	9.687800
Minimum	1.839500	4.262700	-0.800200	3.397500	-3.218900
Std. Dev.	1.192561	1.144332	1.532080	0.208013	2.767952
Skewness	-0.006044	-0.043034	-0.650156	-0.132381	-2.085765
Kurtosis	1.881121	1.622778	2.253476	1.656790	7.549650
Jarque-Bera	1.825888	2.776883	3.278491	2.733370	55.56392
Probability	0.401341	0.249464	0.194126	0.254951	0.000000
Sum	139.6431	210.7290	81.62470	131.3309	252.9412
Sum Sq. Dev.	48.35488	44.52287	79.80719	1.471160	260.4930
Observations	35	35	35	35	35

Source: Computed by authors using EViews 10.0.

Table 2 shows that: (i) The variable LnGDP has a mean of 3.989803 and a standard deviation of 1.192561. This proves that the value of LnGDP is quite dispersed, or has relatively strong fluctuations over the years; (ii) The LnEC variable has a mean of 6.020829 and a standard deviation of 1.144332. This proves that the value of LnEC is quite dispersed, or has relatively strong fluctuations over the years; (iii) The LnK variable has a mean of 2.332134 and a standard deviation of 1.532080. This proves that the value of LnK is quite dispersed, or has relatively strong fluctuations over the years; (iv) The variable LnL has a mean of 3.752311 and a standard deviation of 0.208013. This proves that the value of LnL has not changed significantly over the years; (v) The LnFDI variable has a mean of 7.226891 and a standard deviation of 2.767952. This proves that the value of LnFDI is highly dispersed, or has strong fluctuations over the years.

Correlation analysis

Table 3 shows that the correlation between LnGDP and LnFDI is quite strong (correlation value is 0.626768 < 0.7). The remaining pairs of variables have a strong correlation because the correlation values are all greater than 0.7, even > 0.9. Thus, we conclude that there is a strong correlation relationship between the variables. At the same time, the variables LnEC, LnK, LnL and LnFDI all have a positive relationship with LnGDP.

Table 3: Correlation matrix of variables

	LNGDP	**LNEC**	**LNK**	**LNL**	**LNFDI**
LNGDP	1.000000	0.940340	0.864275	0.930656	0.626768
LNEC	0.940340	1.000000	0.965152	0.993190	0.779596
LNK	0.864275	0.965152	1.000000	0.976674	0.886357
LNL	0.930656	0.993190	0.976674	1.000000	0.815872
LNFDI	0.626768	0.779596	0.886357	0.815872	1.000000

Source: Computed by authors using EViews 10.0.

3.2. Testing the optimal delay of the model

Based on the optimal delay results of the model shown in Table 4, the optimal delay is 2 through the analysis of LR, FPE, AIC and HQ standards are the smallest.

Table 4: Model optimal latency

Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	-6.627705	NA	1.39e-06	0.704709	0.931453	0.781002
1	210.7921	355.7779	1.22e-11	-10.95710	-9.596637*	-10.49934
2	249.3320	51.38652*	6.03e-12*	-11.77770*	-9.283519	-10.93848*

Note: *indicates lag order selected by the criterion; LR: sequential modified LR test statistic (each test at 5% level); FPE: Final prediction error; AIC: Akaike information criterion; SC: Schwarz information criterion; HQ: Hannan-Quinn information criterion.

Source: Computed by authors using EViews 10.0.

3.3. Stationary test

After determining the optimal delay of the model to be 2, then conducting the stationarity test with the extended unit root test (ADF), we get the following results:

Table 5 shows that the variables ln GDP, lnL LnEC stop at first difference I(1) with a significance level of 1% and 5%. The remaining variables lnK and ln FDI all stop at original difference I(0) with a significance level of 1%. Thus, the variables all have stops at the most prominent and first-differences at 1% and 5% significance levels and all have no time trend - satisfying the initial condition of the ARDL method.

Meanwhile, at the intercept and the trend, the variable lnEC does not stop at the first difference, so it does not satisfy the initial conditions of the ARDL method, so this case is eliminated.

Table 5: Stationary test

Variables	**I(0)**	**I(1)**
Constant, No trend		
lnGDP	-0.021542	-4.720280
	(0.9500)***	(0.0006)***
lnK	-3.938268	-3.574755
	(0.0047)***	(0.0119)**
lnL	-2.157957	-3.752501
	(0.2246)*	(0.0077)***
lnEC	-0.462414	-3.599808
	(0.8863)*	(0.0112)**
lnFDI	-5.642320	-1.847888
	(0.0001)***	(0.3514)*
Constant, Linear Trend		

lnGDP	-6.077691	-4.925995
	(0.0001)*	(0.0019)*
lnK	-0.997842	-4.639379
	(0.9311)***	(0.0040)*
lnL	0.462047	-4.189479
	(0.9987)***	(0.0119)*
lnEC	-1.904347	-3.494205
	(0.6297)***	(0.0566)***
lnFDI	-5.261932	-1.623697
	(0.0009)*	(0.7601)***

Notes: *, ** and *** at 10%, 5% and 1% significa nce level. The mark in parentheses is probability.
Source: Computed by authors using EViews 10.0.

3.3. Co-intergration test

With the model optimal lag of 2, the author tests the long-term cointegration relationship between the variables through the Bound test. The condition to be satisfied is that the value of F must lie on the upper bound of the test. The results of Table 6 show that at the 1%, 5% and 10% significance levels, the F-statistics are all located at the upper bound of the envelope. This shows that the variables have a long-term relationship with each other.

Table 6: Bound of the test

F-Bounds Test		**Null Hypothesis: No levels relationship**		
Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	30.94288	10%	2.2	3.09
k	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37

Source: Computed by authors using EViews 10.0.

3.4. Results of long-term estimation of ARDL model

At the 5% level of statistical significance, the ARDL model shows that there are two variables that have a statistically significant influence on economic growth, including: Electricity consumption and FDI. Meanwhile, two variables K (capital) and labor (L) have no impact on GDP in the long run, showing that in the long run natural factors such as capital or human power (labor) tend to decrease gradually and have no significance for GDP growth. This is true in the period 1986 - 2020 because in this period capital and labor factors do not contribute much to long-term economic growth.

Table 7: Long-term estimation of ARDL regression model with dependent variable lnGDP

Variables	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
lnK	-0.010078	0.336136	-0.029982	0.2423
LnL	4.353637	2.202163	1.976982	0.3136
lnEC	0.078917*	0.392909	0.200852	0.0005
lnFDI	0.207949*	0.109729	1.895104	0.0402
Constant	-14.28478*	6.456551	-2.212448	0.0367

Note: *5% significance level.
Source: Computed by authors using EViews 10.0.

Table 8: Long-term estimation of ARDL regression model with dependent variable D(lnGDP)

Variables	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(LNK)	-0.745380	0.117364	-6.350987	0.0000
D(LNFDI)	0.126635	0.028025	4.518640	0.0001

D(LNFDI(-1))	0.107601	0.016645	6.464517	0.0000
ECT_{t-1}	-0.527538*	0.035221	-14.97785	0.0000

Note: *1% significance level.

Source: Computed by authors using EViews 10.0.

3.5. Results of short-term estimation of ARDL model

At the 5% level of statistical significance, the ARDL model shows that there are two variables that have a statistically significant influence on economic growth, including: K and FDI, while consumption EC power and L had no effect on GDP growth (not statistically significant). This is very true because in the short term the contribution of electricity (EC) and labor is very limited and has almost no impact.

The significance level of the adjusted error (ECT) shows evidence of a causal relationship in at least one direction. The adjusted error lagged variable cluster (ECTt-1) is negative and significant at the 1% significance level. The coefficient -0.527538 indicates a high rate of convergence to the equilibrium, implying that the deviation to the long-run equilibrium is adjusted by 52.7538% per year.

3.6. Diagnostic test

Table 9 shows the results of diagnostic testing of the model, including test of variance, functional form, series correlation and normal distribution. Most p_values are greater than 0.05. The results show that the Ho hypothesis cannot be disproved for the most part. This proves the fit of the model.

Table 9: Diagnostic test

	t-Statistic	P_value
Serial correlation LM test	0.718415	0.4986
Heteroskedasticity test	2.156124	0.0696
Normality test	5.770877	0.055580
(Functional Form)	1.923706	0.1698

Source: Computed by authors using EViews 10.0.

Finally, through cumulative total residual (CUSUM) and residual adjusted cumulative sum (CUSUMSQ) tests, the stability of the model was examined. The CUSUM curve is within the critical limit at the 5% significance level. However, the CUSUMSQ curve is outside the 5% line at some points but within the 1% line, confirming the stability of the estimated coefficients at the significance level 1%.

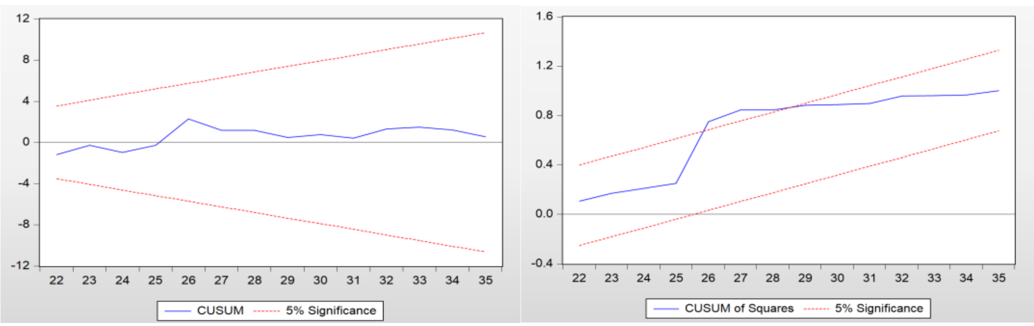

Figure 1: The results of testing the stability of the estimated coefficient

Source: Constructed by authors.

4. Conclusion and recommendations

4.1. Conclusion

From the results of the model analysis in section 3, it can be concluded that electricity consumption has a positive effect on Vietnam's economic growth in the long run with a regression coefficient of 0.078917. It cannot be denied that electricity is considered as a revolution in the history of human development, a factor that has contributed significantly to the development of industries such as transportation, communication, and manufacturing. Empirical research on the relationship between power consumption and economic growth has been carried out by many authors, but the results are not consistent. The pioneer in this study was Kraft and Kraft (1978). Although it is widely believed that electricity is an input to the production process, many empirical studies have failed to find evidence to support this view. Apergis and Tang (2013), argue that the influence of electricity consumption and growth depends on the stage of development of the country. In particular, this author also concludes that the effect of electricity consumption on economic growth is only significant for developed and developing countries, but for less developed countries, this relationship does not occur.

4.2. Policy implications, recommendations

Firstly, promote the development of a competitive electricity market by attracting investment in the power sector, especially PPP. Although in June 2020, the National Assembly passed the PPP investment law, there are still some limitations that hinder investors when participating - such as: the cumbersome and rigid PPP project process (Article 11), the procedures for setting up an enterprise (Article 44) or on the request for equity contribution (Article 77). This requires an adjustment of mechanisms and policies to promote PPP in power projects, such as building an information disclosure mechanism within the legal framework on electricity, which can be (i) information about power projects approval must be sent directly to the list of power plants in operation; (ii) the information on the project list must be clearly displayed on the website of the Electricity Regulatory Authority (Ministry of Industry and Trade) and the website of Vietnam's PPP; (iii) Investment procedures need to be transparent, clear and posted on official websites of the Ministry of Industry and Trade and Vietnam's PPP; (iv) develop feasible projects in line with international practices. In addition, it is necessary to develop a financial support mechanism for PPP projects, which can be obtained from sources such as (i) lending institutions; (ii) investor's equity; (iii) state support capital, of which preferential capital support from the state is very important because PPP projects on electricity often have large investment capital.

Secondly, control electricity consumption reasonably through the application of modern science and technology and digital transformation. Build an official website on electricity (https://cskh.cpc.vn/) to connect electricity meters to the management center, to monitor electricity consumption, and at the same time build centers to monitor and control abnormally increased power output.

Thirdly, strengthen coordination among ministries, branches and localities in order to carry out propaganda to change thinking and awareness in electricity production and consumption, and adopt appropriate allocation policies for each sector and region.

Fourthly, develop preferential mechanisms and policies to attract investors to promote the development of electricity from renewable energy, focusing on the development of biomass, wind and solar power projects (According to Decision 2068/QĐ-TTg dated 25 November 2015). This will account for about 15% of total electricity generation in 2030). These incentives can focus on taxes, investment capital and technical infrastructure...

Fifthly, as for the legal framework on electricity, ensure that the information disclosure process is transparent and complete. This is reflected in the List of Electricity Development Planning on power projects approved in the list jointly implemented by the Ministry of Planning and Investment, the Ministry of Industry and Trade and the Ministry of Finance. Therefore, to ensure information disclosure, the Government must ensure: (i) information about power projects is publicized on the website of the Electricity Regulatory Authority - Ministry of Industry and Trade; (ii) information on investment procedures is given in the latest legal documents and soft copies of those procedures; (iii) there are approved bidding documents; (iv) guidance information is provided on projects in accordance with international standards and practical experience in managing projects from countries around the world.

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