DYNAMIC HYDROELECTRICITY CONSUMPTION AND ECONOMIC GROWTH IN APEC COUNTRIES AND INDIA

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Abstract

This study is to analyze the effect of economic growth on hydroelectricity consumption in APEC countries and India. The study uses panel data from 1994 to 2016 with 391 total samples, where the variables in the study are economic growth and hydroelectricity consumption. Panel ARDL is utilized to analyze both short-run and long-run economic growth effects on hydroelectricity consumptions. The results show that there is a positive and significant effect of economic growth on hydroelectricity consumptions in APEC countries and India. To minimize the productions of carbon dioxide, it is recommended to optimize hydroelectricity consumptions in this area because this area is the highest carbon dioxide producers in the world. It is crucial to achieving sustainability in productions and consumptions in this region.

Keywords: hydroelectricity, economic growth, APEC, Panel ARDL

JEL classification: Q01, Q32, Q35, Q43

1. Introduction

Asia Pacific region is the highest producers of carbon dioxide in the world (BP Statistical Review, 2017) because the economic growth in this region is very significant in the world, so energy consumption in this region is also massive from electricity generation to support productions and consumptions. APEC Energy Demand and Supply Outlook (2016) reported that this area used coal and oil as primary energy generations where these nonrenewable resources are fossil fuels. This is the primary generation of carbon dioxide in this area. Meanwhile, another problem is the availability of oil, and coal is minimal and continuously decreases. Renewable resources are essential as future green energy not only in this area but also around the world.

Renewable energy is vital nowadays, and mixed energy use increased from time to time. Inglesi-Lotz (2016) stated that the use of renewable and green energy is essential to achieve the world's safety in energy availability as well as the green world for the next generations. Green energy also produces high economic growth, both short-run and long-run perspectives. The work of Ito (2017) found that (i) renewable energy consumptions have a significant positive effect on emission reductions and positive impact on economic growth; (ii) nonrenewable energy has a long-run negative and significant impact on economic growth; and (iii) there is substitution between nonrenewable and renewable energy.

Furthermore, Cherni and Jouini (2017) found that economic growth increases nonrenewable energy consumptions and carbon dioxide in Tunisia. However, a decrease in nonrenewable energy causes low economic growth. To overcome this problem, it is better to use renewable energy sources such as hydroelectricity. It is supported by the work of Payne and James (2011) showed that there is short-run one-way direction from economic growth to renewable energy consumption and bi-direction in long-run between economic growth and renewable energy consumption in 16 developing countries.

Another research about hydroelectricity consumption and economic growth was conducted by Apergis et al., (2016) in 10 highest hydroelectricity consumptions by using structural break tests, i.e., 1988, 2000, and 2009. They found that pre-1988 period, there is one-way direction causality between real per capita GDP and per capita hydroelectricity consumption.

Meanwhile, the post-1988 period, there is bi-directional between hydroelectricity consumption and per capita GDP both in short-run and long-run. This means that there is an increase in hydroelectricity consumption caused by economic growth. The rise in hydroelectricity implies that there is a decrease in productions of carbon dioxide, hence greener environment.

Haley (2015) stated that hydroelectricity decreases carbon dioxide and increases innovation in high technology, such as electric vehicles (EV). The use of hydroelectricity in APEC counties and India increases from day to day because gov carbon governments in this area aim to decrease carbon dioxide and increase green energy. Only 16 countries of 21 APEC countries use hydroelectricity because of some reasons such as technology availabilities, water, and oil reserves.

China is the highest hydroelectricity consumption among APEC countries with an increasing trend from time to time. The increase in hydroelectricity power because of economic growth and income per capita in China. The second is Canada, the hydroelectricity consumption increase from year to year even though Canada has per capita GDP fluctuated that is not consistent with hydroelectricity consumption. The third is South Korea, this country fluctuated hydroelectricity consumption from 1994 until 2016, and per capita GDP differently increased from time to time. These results show that hydroelectricity consumptions are not consistent to per capita GDP growth in APEC countries. Based on these, it is very interesting in analyzing the effect of economic growth on hydroelectricity consumption in APEC countries and India.

2. Literature Review

Some studies on economic growth and hydroelectricity have been conducted both in developed and developing countries. For example, Ziramba (2013) analyzed the economic growth effect on hydroelectricity consumption in three African countries, i.e., Egypt, Algeria, and South Africa. The results showed that there is neutrality hypothesis in Egypt, causality in Algeria, and conservation in South Afrika. This means that the government in Egypt should implement conservation policies on hydroelectricity consumptions. Meanwhile, this policy can be applied in Algeria because there is causality evidence in this country.

The work of Solarin and Ozturk (2015) confirmed that there are long-run causality relationships between economic growth and hydroelectricity in Indonesia, Argentina, and Venezuela. Furthermore, there is a one-way direction between economic growth and hydroelectricity in Brazil, Chile, Columbia, Ecuador, dan Peru. Meanwhile, hydroelectricity consumption has a positive and significant effect on economic growth in the long-run in Latin America.

Bildrici (2016) analyzed the relationship between economic growth and hydroelectricity consumption, where the results showed that there is short-run causality in OECD countries as high-income countries. Whereas, there is conservation evidence in Brazil, Finland, France, Mexico, the US, and Turkey. This means that conservation policy of hydroelectricity could be implemented with a minimal detrimental effect on the environment and with moderate economic growth. The same results also showed by the work of Koengkan (2017) in Latin America from 1966 to 2015.

Koçak and Şarkgüneşi (2017) also analyzed energy consumption and economic growth in the Black Sea and Balkan countries and found that there is a long-run equilibrium between energy consumption and economic growth. This result is consistent with the work of Khobai and Roux (2018) and Kahia et al., (2017). Based on the results, sustainable economic growth could be achieved through renewable energy.

Meanwhile, the study of Maleddu and Pulina (2018) showed that efficiency in energy consumption is achieved by higher government expenditure on renewable energy. This means that there is a positive significant effect of green energy on economic growth. However, the work of Pao et al. (2019) in Group of Twenty find that there is also a negative and significant effect of economic growth on hydroelectricity consumptions. Based on this, the results of economic growth and hydroelectricity consumptions are mixed, but most of them have positive and significant effects of economic growth on hydroelectricity consumptions.

The previous literature showed that economic growth has a significant effect on economic growth in developed countries and some developing countries. However, the study of economic growth and hydroelectricity consumption is still rare, especially in APEC countries and India. Based on this, it is challenging study about economic growth effect of hydroelectricity consumption in APEC countries and India both in short-run and long-run effects.

3. Research Method

This study explores the effect of economic growth on hydroelectricity in APEC countries and India. India is selected because this country has relatively high economic growth and produces elevated carbon dioxide. To decrease carbon dioxide, it is crucial to utilize hydroelectricity in APEC countries and India because this area provides the highest carbon dioxide in the world.

Panel ARDL model is used in this study with data from 1994 to 2016 or 391 samples. The data are collected from BP statistical Review and World Bank. The relationship between economic growth and hydroelectricity consumption is modeled as follows:

$$\Delta lnHY_{j,t} = \alpha_{0i} + \sum_{i=1}^{n} \alpha_{1i}\Delta lnHY_{j,t-i} + \sum_{i=1}^{n} \alpha_{2i}\Delta lnY_{i,t-i} + \beta_{11}lnHY_{j,t-1} + \beta_{21}lnY_{j,t-1} + u_{j,t} \quad (1)$$

where *HY* is hydroelectricity consumption, *Y* is economic growth, α_1 and α_2 are short-run coefficients, β_1 and β_2 are long-run coefficients, *t* is time series from 1994 to 2016, *i* is countries (17 countries), and μ is error terms.

4. Research Findings and Discussion

4.1. Model Validity Test

Panel unit root test is conducted to test data stationarity before panel ARDL model estimated. Table 1 shows unit root test both individual intercept and individual intercept and trend where the variables have different stationarities, *I(0)* and *I(1)*. For example, variable *HY* is stationer at level; meanwhile, *GDPC* is stationer after first difference. Based on these results, the panel ARDL model is suitable in this study because the variables have different stationarities.

Table 1. Panel Unit Root Test

	LLC	IPS	ADF-Fisher	PP-Fisher
Individual intercept				
GDPC	-0.872 (0.191)	2.785 (0.997)	17.545 (0.991)	12.514 (0.999)
HY	4.824 (1.000)	1.336 (0.909)	47.227 (0.0130)*	85.503 (0.000)**
ΔGDPC	-5.037 (0.000)**	-5.798 (0.000)**	94.952 (0.000)**	145.256 (0.000)**
ΔHY	-12.758 (0.000)**	-14.344 (0.000)**	232.065 (0.000)**	360.862 (0.000)**
Individual intercept and trend				
GDPC	-1.252 (0.105)	-0.816 (0.207)	37.291 (0.320)	14.050 (0.999)
HY	0.362 (0.641)	-1.321 (0.093)	55.4106 (0.001)**	102.981 (0.000)**
ΔGDPC	-3.271 (0.000)**	-3.447 (0.000)**	65.702 (0.000)**	135.915 (0.000)**
ΔHY	-12.621 (0.000)**	-13.260 (0.000)**	204.041 (0.000)**	1898.94 (0.000)**

Sources: Estimated Results, 2018.

Note: *, ** represent 95 and 99 percent level of significance, respectively.

Cointegration test is conducted to evaluate whether the variables in the model have long-run equilibrium, so they are eligible in panel ARDL model. Table 2 presents the cointegration test for the variables in the model. The results show that there is cointegration between economic growth and hydroelectricity consumption. This means that economic growth and hydroelectricity have short-run converge to long-run equilibrium; hence, panel ARDL is valid to be employed in the study.

Table 2. Panel Cointegration Test

Pedroni Cointegration Test	Statistic	Weighted Statistic
Panel v-Statistic	1.6841 (0.046)*	-0.714144 (0.762)
Panel rho-Statistic	-4.913 (0.000)**	-3.913 (0.000)**
Panel PP-Statistic	-6.653 (0.000)**	-7.114 (0.000)**
Panel ADF-Statistic	-1.469 (0.070)	-5.047 (0.000)**
Group rho-Statistic	-1.483 (0.0689)	
Group PP-Statistic	-5.779 (0.000)**	
Group ADF-Statistic	-3.634 (0.000)**	
KAO Cointegration Test	t-Statistic	
ADF	5.722(0.000)**	

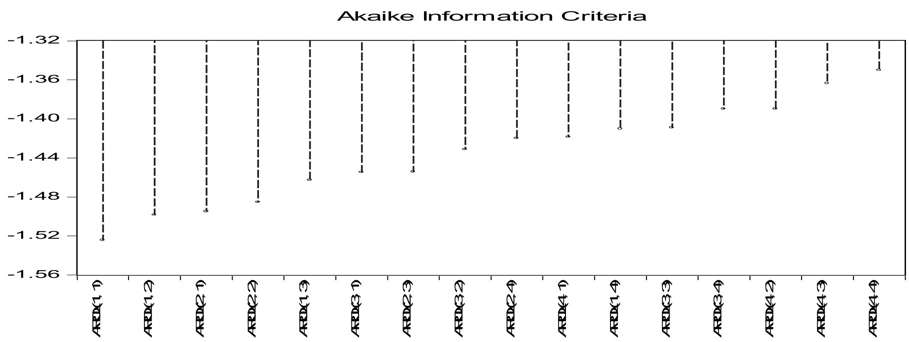
Sources: Estimated Results, 2018.

Note: *, ** represent 95 and 99 percent level of significance, respectively.

4.2. Lag Optimal

Before the panel ARDL estimated, it is imperative to determine lag optimal in the model. Lag optimal is estimated by using Akaike Information Criteria, as presented in Figure 1. The best lag in this analysis is 1,1. Based on this, the panel ARDL model will be estimated with optimal lag is 1,1.

Figure 1. Akaike Information Criteria



4.3. Estimated Panel ARDL for Hydroelectricity Consumption

Panel ARDL model is valid if the estimated error correction term (ECT) of the model is negative and significant. Based on the estimated result in Table 3, the ECT is negative and significant with the coefficient is -0.405. This means that the panel ARDL model can be used in this study. The magnitude of ECT is -0.405 means that if there is a shock in economic growth, the hydroelectricity consumption needs 4.86 months to achieve equilibrium.

Table 3. Estimated Panel ARDL of *Hydroelectricity Model*

Estimated	Variable	Coefficient	t-Statistic
(*Long Run*)	GDPC	0.096	6.523(0.000)**
	C	1.101	3.423(0.000)**
(*Short Run*)	ΔGDPC	0.176	2.435(0.015)**
	ECM(-1)	-0.405	-5.218(0.000)**

Sources: Estimated Results, 2018.

Note: *, ** represent 95 and 99 percent level of significance, respectively.

Table 3 shows that economic growth has a positive and significant effect on hydroelectricity consumption both in long-run and short-run. In the long-run, if economic growth increase by 1 percent, hydroelectricity consumption will increase by 0.096; by assumption, other variables are constant. Meanwhile, in the short-run, the effect of economic growth on hydroelectricity consumption is more significant than long-run. The short-run coefficient is 0.176 means that if economic growth increase by 1 percent, the hydroelectricity consumption will increase by 0.176, other variables are assumed constant. This means that the short-run effect is more significant than the long-run one, where the difference between short-run and long-run is 8 percent.

These results show that there is a one-way direction effect of economic growth on hydroelectricity consumption in APEC countries and India. These results are consistent with the previous studies of Payne and James (2011) and Apergis et al., (2016). From the results, it is essential for the government to increase hydroelectricity consumptions to decrease carbon dioxide problem in the world so that the next generation can enjoy a greener environment with higher economic growth and welfare.

4.4. Cross-section Short-Run Coefficients

The estimated model, as mentioned before, is the panel ARDL model, so the model has a short-run cross-section coefficient for each country in this study. Table 4 shows the short-run cross-section coefficients of each country, where some countries have not significant coefficients such as United State of America, Chile, Australia, Japan, Malaysia, New Zealand, South Korea, Thailand, and Vietnam. Even though the coefficients of these counties are not significant, the increase in economic growth in these countries has a positive effect on hydroelectricity consumption, because the coefficients are positively sloped. These results are consistent theoretically; however, they are not statistically because the contributions of hydroelectricity in certain countries are still relatively small compared to other sources of power.

For the United States, every increase one percent in economic growth will be followed by the increase in hydroelectricity consumption as 0.53 percent, ceteris paribus. The almost the same results are found in Chile, Malaysia, New Zealand, South Korea, Thailand, and Vietnam but with different consumption level of hydroelectricity. Meanwhile, the different results are found in Australia and Japan, where the increase in one percent of economic growth causes a decrease in hydroelectricity consumptions as 0.01 and 0.076 percent, respectively. These results are anomalies because these countries are developed countries where the contribution of hydroelectricity consumptions are higher than the developing ones.

Table 4. Cross Section Short-Run Coefficients

Negara	Cross Section Short-Run Equation		
	C	ΔGDPC	ECT(-1)
United States	1.868[2.40]	0.533[0.529]	-0.411[-10.66]**
Canada	5.262[4.02]	-0.210[-20.23]**	-1.078[-19.16]**
Mexico	2.228[9.68]**	0.237[4.63]*	-0.883[-25.24]**
Chile	0.964[6.12]**	0.126[2.119]	-0.447[-13.24]**
Peru	0.110[10.61]**	-0.142[-15.98]**	-0.036[-14.87]**
Russian Federation	1.449[2.73]	-0.009[-3.92]*	-0.336[-12.17]**
Australia	0.796[7.60]**	-0.010[-0.24]	-0.458[-14.20]**
China	-0.038[-1.146]	0.463[6.55]**	0.012[11.37]**
India	0.345[2.26]	0.467[5.85]**	-0.091[-9.29]**
Indonesia	0.643[6.53]**	-0.255[-6.44]**	-0.362[-9.74]**
Japan	2.400[5.86]**	-0.076[-2.371]	-0.709[-20.59]**
Malaysia	0.001[0.05]	0.035[0.39]	0.041[2.622]
New Zealand	1.415[6.86]**	0.031[2.144]	-0.641[-17.00]**
Philippines	0.653[16.24]**	0.748[9.24]**	-0.49[-23.58]**
South Korea	0.132[12.92]**	0.120[1.076]	-0.520[-13.77]**
Thailand	0.471[9.47]**	0.393[2.183]	-0.487[-11.64]**
Vietnam	0.023[1.145]	0.548[3.08]	0.002[1.01]
New Zealand	1.415[6.86]**	0.031[2.144]	-0.641[-17.00]**

Sources: Estimated Results, 2018.

Note: *, ** represent 95 and 99 percent level of significance, respectively.

Some other countries such as Canada, Peru, China, India, Indonesia, and the Philippines have very significant effects of economic growth on hydroelectricity consumptions compared to Mexico and the Russian Federation. However, economic growth in Canada has a negative and significant effect on hydroelectricity consumption. This result is not consistent with theoretical statement where economic growth has a positive effect on hydroelectricity consumption. The same results are also found in Peru, the Russian Federation and Indonesia. Two factors are affecting the negative effects of economic growth on hydroelectricity consumption. First, the use of renewable energy resources is still limited because the cost of these resources is still expensive. Second, the return on investment of hydroelectricity is very small compared to other fossil powers. The government should provide special incentives for investors in hydropower plants. By providing these incentives, the supply of hydroelectricity will increase, and the role of hydroelectricity power will increase. Hydroelectricity power is essential to ensure the sustainability of the environment and also to decrease global warming.

The consistent results are also showed in Mexico, China, India, and the Philippines, where these countries have positive and significant effects of economic growth on hydroelectricity consumptions. The increase by one percent of economic growth causes the increase in hydroelectricity consumptions as 0.23, 0.46, and 0.74 percent, respectively. These results are consistent with the studies of Solarin and Ozturk (2015), Bildirici (2016), and Koengkan (2017).

5. <u>Conclusions and Recommendations</u>

In general, the results show that there are short-run and long-run relationships between economic growth and hydroelectricity consumption. Some countries have positive and significant effects of hydroelectricity consumption on economic growth, but the other countries are negative and significant effects. In the long-run, the effect of economic growth on hydroelectricity consumption becomes smaller.

Furthermore, there are four categories of results in the study; the first is a positive and significant effect of economic growth on hydroelectricity consumption. Second, positive and not significant effect of economic growth on hydroelectricity consumption, third, negative, and significant effect. The last if negative and no significant effect of economic growth on hydroelectricity consumption.

It is suggested to the governments in the respective country to increase the use of hydroelectricity consumption and to decrease the fossil electricity power because fossil power harms the environment, especially coal power plant.

The limitations of the study are (i) there is no causality test between economic growth and hydroelectricity consumption; (ii) there should be balanced samples between developed and developing countries to capture the differences. Furthermore, it is imperative to increase the number of countries in the study because the results are mixed compared to other studies.

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