Does the energy-environmental Kuznets curve hypothesis sustain in the Asia-Pacific region?

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8 August 2017

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Abstract

As mitigating the effects of energy consumption on the environment is a crucial issue for the Asia-Pacific region, this study investigates the energy-environmental Kuznets curve (EEKC) hypothesis among the 19 Asia-Pacific regions. The study also test the hypothesis for the low-, middle-, and high-income groups of the region. The panel regression and cointegration models are used for this purpose. Both models suggest that the EEKC hypothesis does sustain for the whole Asia-Pacific region. However, the test performed on the income groups revealed that the hypothesis only holds for the high-income group and the low- and middle-income groups do not satisfy the hypothesis. This is likely indicating that the transition in the energy consumption along the EEKC is only occurring in the developed countries of the Asia-Pacific region.

Keywords: Energy-environmental Kuznets curve, energy consumption, GDP per capita, Asian-Pacific region, panel regression model, panel cointegration model

JEL classifications: O53, Q56

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1. Introduction

Since the beginning of this century, the level of energy consumption in the Asian region has been growing at an unprecedented speed (see Figure 1) and now the Asian region is the world's largest energy consumer. As the current climate change is largely related to the anthropogenic emissions of carbon dioxide resulted from increased fossil fuel energy use (EIA, 2016, p.136), this surge in the energy consumption in the Asian region is increasingly placing pressure on the environment. Consequently, the Asian region needs to find ways to reduce its level of fossil fuel energy use while attaining economic growth. To gain more useful information for constructing an effective energy policy to meet this goal, more studies need to be done to understand the relationship between economic growth and energy consumption and how this relationship will lead to environmental pressure.

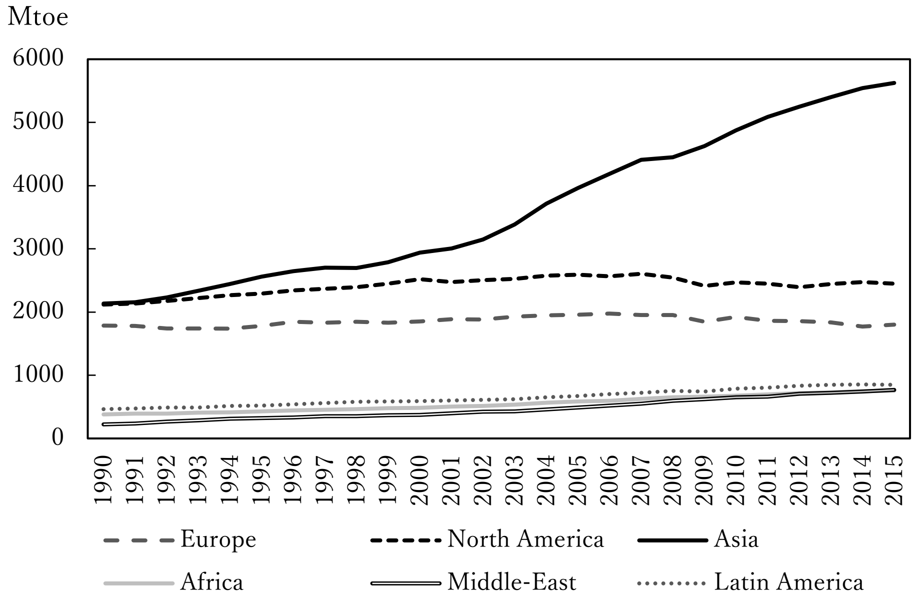


Figure 1 Total energy consumption by region
Source: Enerdata (2017)

The relationship between economic growth and environmental pressure has been investigated with the framework of environmental Kuznets curve (EKC) hypothesis. The EKC hypothesis is first introduced by an empirical study conducted by Panayotou (1993). He finds an inverted U-shaped relationship between economic development and environmental degradation. Since this study, many empirical studies have found that an environmental pressure can become smaller once a certain level of economic growth is achieved when there is a shift from fossil fuel energy intensive industry to a less fossil fuel energy intensive industry (Dinda, 2004; Ahmed and

Long, 2013; Jebli et al., 2016). Many of these previous studies have used the amount of pollution materials or the levels of greenhouse gas emissions as indices for environmental pressure. Recently studies started to use the level of energy consumption as an indicator of environmental pressure. At the moment, although the energy-environmental Kuznets curve (EEKC) hypothesis has been tested for the whole world, there are only few region-specific studies examining this hypothesis. A study of Pablo-Romero and De Jesús (2016) is among those few studies testing the hypothesis for the Latin American region, but there are still a few region-based studies focusing in the Asian region.

To fill this gap, this study will consider whether the EEKC hypothesis sustains in the Asia-Pacific region during the 1984-2014 period. In this study we use data for the 19 regions that belong to the Asia-Pacific area so the Asia-Pacific region in this paper means the region containing these 19 regions. If we verify that this hypothesis can be applied to the Asia-Pacific region, we estimate the income level at the turning point of the energy consumption. For this objective, we examine the relationship between energy consumption and economic development for the Asia-Pacific region.

Whether the Asia-Pacific region follows the EEKC hypothesis depends on how its major energy source shifts along its GDP per capita. For example, if the region continues to rely its main energy source heavily on coal and petroleum as its income level increases, it is less likely that we will find any decline in its energy consumption along its GDP per capita. If this is the case, it is less likely that the region will satisfy the EEKC hypothesis. On the other hand, if the region shifts its energy source to a non-fossil fuel based energy source or adopts energy saving technology as its GDP per capita increases, this region will likely meet the condition of the EEKC hypothesis. In this case, we will be able to estimate the GDP per capita at the turning point of the EEKC where the energy consumption starts to decrease as GDP per capita increases.

Analyzing the EEKC hypothesis for the Asia-Pacific region is particularly interesting because this region contains both developing and developed countries and is a region on the verge of energy transition. If we find that an EEKC hypothesis holds in this region, it would imply that there is an energy transition at some point where the level of energy consumption of the region starts to decline as its economy grows. When this is the case, it is likely that an economic growth becomes the key for reducing the regional energy consumption and achieving an economic growth of the region will automatically mitigate the environmental pressure. However, if the study shows that the EEKC hypothesis does not sustain in this region, it would suggest that there is no turning point for energy use in the region. In this case, it will mean that an economic growth does not help reduce the regional energy consumption and an economic growth will not lesson pressures on the environmental. Hence, a special treatment like introducing energy policy that shrinks its regional energy consumption is required for this case such as enhancing energy saving technology in the region.

In the next section, we briefly show some previous studies testing the EEKC hypothesis. In the third section, we discuss the methods and data of this study. The fourth section reveals the results of the analyses performed in this study. Finally, in the last section, we provide our conclusions of the study.

2. Previous Studies

Suri and Chapman (1988) is one of the early studies to test the environmental Kuznets curve (EKC) hypothesis with respect to energy consumption itself. Before this study, most of the studies investigating the energy EKC hypothesis did not use the data for energy consumption and used energy related pollutants as variables to represent the environmental pressure. Suri and Chapman (1988) use the energy consumption and GDP data for the 33 countries of all parts of the world over the 1971-1991 period. They find that the downturn in the inverted-U curve is related to the change in the trades of manufactured goods. They conclude that the increase in the imports of the manufactured goods plays an important role in reducing the energy use of a country.

Luzzati and Orsini (2009) also perform a study to investigate the relationship between energy consumption and GDP per capita to identify the existence of the EKC hypothesis. They used data for 113 countries including the oil producing countries over the 1971-2001 period and find no evidence of an inverted-U pattern between the energy consumption and GDP per capita.

Among studies testing the EEKC hypothesis on a certain region of the world, Pablo-Romero and De Jesús (2016) investigate this hypothesis for the Latin America and the Caribbean. They use the energy consumption and the Gross Value Added (GVA) per capita data for the 22 Latin American and Caribbean countries over the 1990-2011 period. Their study indicates that the EEKC is not supported for the region.

Our study is different from these previous studies in two respects. First, this study is one of the first studies to investigate the EEKC for the Asia-Pacific region, which is one of the fastest growing regions in terms of economy and energy consumption, and hence it is a region of high importance to achieve economic development without causing a high environmental pressure. Second, although most previous studies test the EEKC using panel regression models, our study also applies the panel cointegration models to confirm the EEKC, which can take heterogeneous country effects into account in the estimation.

3. Methods and data

We first set up a standard test model for the EEKC hypothesis:

$$\ln(\mathrm{EC})_{it} = \alpha_i + \gamma_t + \beta_1 \ln(\mathrm{GDP})_{it} + \beta_2 \ln(\mathrm{GDP})^2_{it} + \varepsilon_{it} \quad (1)$$

where EC is the total energy consumption per capita, α_i is an intercept parameter that varies across i countries or regions, γ_t is a parameter that varies by years, β_1 and β_2 are the coefficients to be estimated, and GDP is the GDP per capita. Finally, ε_{it} is a random error term of the model and *t* is the time in years investigated in the study. We hypothesized that the EEKC hypothesis will be satisfied if $\beta_1 > 0$ and $\beta_2 < 0$ in equation (1).

First we tested this hypothesis for the whole Asia-Pacific region analysed in this study. Then, we also performed the test on three income groups: the low-income group having an average GDP per capita below 1000 USD, the middle-income group with an average GDP per capita between 1000-3000 USD, and finally the high income-group possessing an average GDP per capita above 5000 USD. The details of these income groups are discussed later in this section.

For testing the EEKC hypothesis, we used two different panel models. One is the panel regression model and the other is the panel cointegration model.

For the panel regression model, we initially picked the pooled-OLS, fixed-effects, and random-effects models. Then, we configured which model is the statistically appropriate model among these three regression models. For this purpose we performed the specification tests for identifying the most suitable model and this is done in the following three steps. First, the Wald F test is conducted to see if the fixed-effects model is preferred to the pooled-OLS model. Second, we applied the Breusch-Pagan (1980), Honda (1985), and King-Wu (1997) Lagrange Multiplier (LM) tests for panel models to see whether the random-effects model is more suitable than the pooled-OLS model. In the third step, we performed the Hausman (1978) test to identify the appropriate model between the fixed- and random-effects models.

For the panel cointegration model, we applied the Pedroni (2000, 2001) group-mean Fully Modified OLS (FMOLS) and Dynamic OLS (DOLS) models. The group-mean FMOLS and DOLS is used because it is known that they allow for heterogeneity and cross sectional dependence in the cointegration vectors (Pedroni, 2001). The lag length for the DOLS model is identified by the Schwarz information criterion (SIC). To conduct the FMOL and DOLS estimation, we performed the panel unit root and panel cointegration tests because all the variables in equation (1) must be cointegrated in order to use these cointegration models. Thus, if the unit root and cointegration tests suggests that the variables are not cointegrated in any of the econometric models, we cannot apply the FMOLS and DOLS models to equation (1). For the panel unit root tests we used the Levin-Lin-Chu (2002), Breitung (2000), Im-Pesaran-Shin (2003) tests with intercept and trend included in the test models. The appropriate lag length for the unit root test models are identified by the SIC. Once the order of integration of the time series data are configured with these stationarity tests, we performed the Pedroni (1999, 2004) and Kao (1999) panel cointegration tests. Both the Pedroni and Kao tests are residual based cointegration tests but the Pedroni tests are more complete because this test allows for heterogeneous coefficients in the panel model while the Kao test does not consider such heterogeneity coefficients in its model.

The energy consumption and GDP per capita data are obtained from the World Development Indicators (WDI) of the World Bank and we used the annual data for the analyses. The energy consumption per capita is measured in kilograms of oil equivalent (kgoe) while the GDP per capita is in current US dollars. We used the yearly data for the 1984-2014 period and the analyses are performed on the natural log of the energy consumption and GDP per capita. The countries and regions of Asia-Pacific region we used for the panel data are Australia, Bangladesh, Brunei Darussalam, China, Hong Kong, India, Indonesia, Japan, Nepal, Malaysia, Mongolia, New Zealand, Pakistan, Philippines, Republic of Korea, Singapore, Sri Lanka, Thailand, and Vietnam. As the data of the year 1984 was missing in the WDI for Mongolia and Vietnam and that of the year 2014 lacked for Vietnam, we used the 1985-2014 period for Mongolia and the 1985-2013 period for Vietnam.

Table 1 depicts the summary statistics of the energy consumption and GDP per capita for the whole Asia-Pacific region investigated in this study. Comparing the maximum and minimum of the energy use and GDP per capita in the table, it is clear that the disparity in the levels of energy consumption and income are quite large among the 19 Asia-Pacific regions. Thus, in order to verify the EEKC among regions with closer energy consumption and income levels, we also analysed the EEKC hypothesis for three income groups: the low-, middle-, and high-income groups.

Table 1. Summary statistics of energy consumption and GDP per capita for the whole Asia-Pacific region

	Energy use per capita (kgoe)				GDP per capita (USD)			
	Mean	Max	Min.	Std. Dev.	Mean	Max	Min.	Std. Dev.
Whole region	2088.33	9695.71	103.91	2118.36	9873.14	67652.68	97.16	13685.00

Table 2. Summary statistics of energy consumption (kgoe) and GDP (USD) per capita for low-income group

	Energy use per capita (kgoe)				GDP per capita (USD)			
Country	Mean	Max	Min.	Std. Dev.	Mean	Max	Min.	Std. Dev.
Bangladesh	149.13	222.68	103.91	35.64	459.40	1086.80	208.93	230.06
India	429.54	636.72	306.93	93.74	652.67	1569.94	282.32	418.91
Nepal	338.08	414.90	304.26	32.00	313.76	703.18	156.75	182.89
Pakistan	446.50	525.62	343.53	51.78	649.32	1320.55	335.05	323.73
Vietnam	412.87	677.67	269.30	145.33	625.61	1907.56	97.16	505.14
Average	354.47	677.67	103.91	137.07	539.03	1907.56	97.16	370.89

Table 2 shows the summary statistics of regions that belong to the low-income group, consisting regions whose average GDP per capita during 1984-2014 is under 1000 USD. As seen in the table, all the regions in this income group have energy consumption per capita under 1000 kgoe. This indicates that these regions not only have a low level of GDP per capita but also have small energy consumption per capita compared to other Asia-Pacific regions of this study. Figure 1 is the plots of GDP and energy consumption per capita for this low-income group regions. It is discernible from the figure that most of the energy consumption per capita for these regions tend to increase as their GDP per capita grows.

Figure 1. GDP (USD) and energy consumption (kgoe) per capita for low-income group

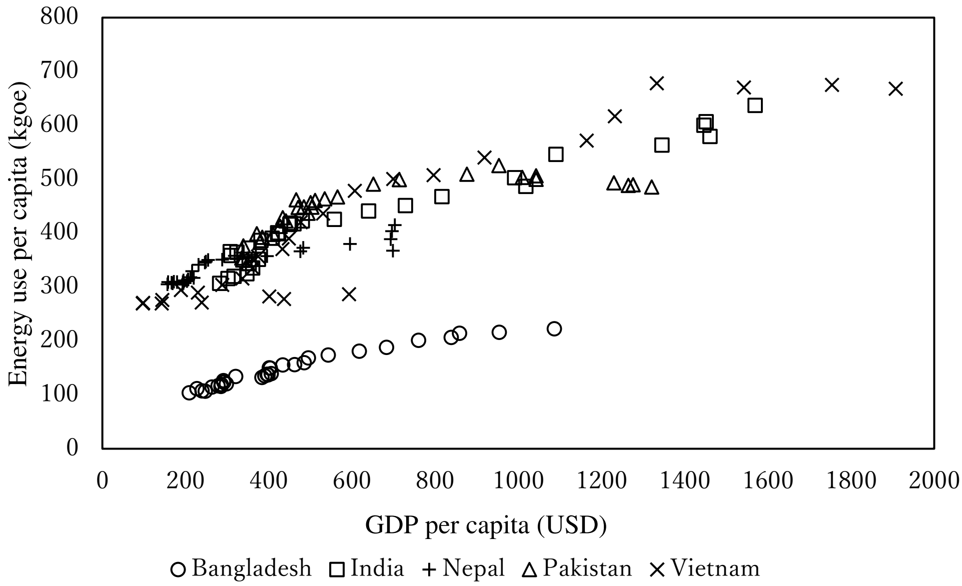
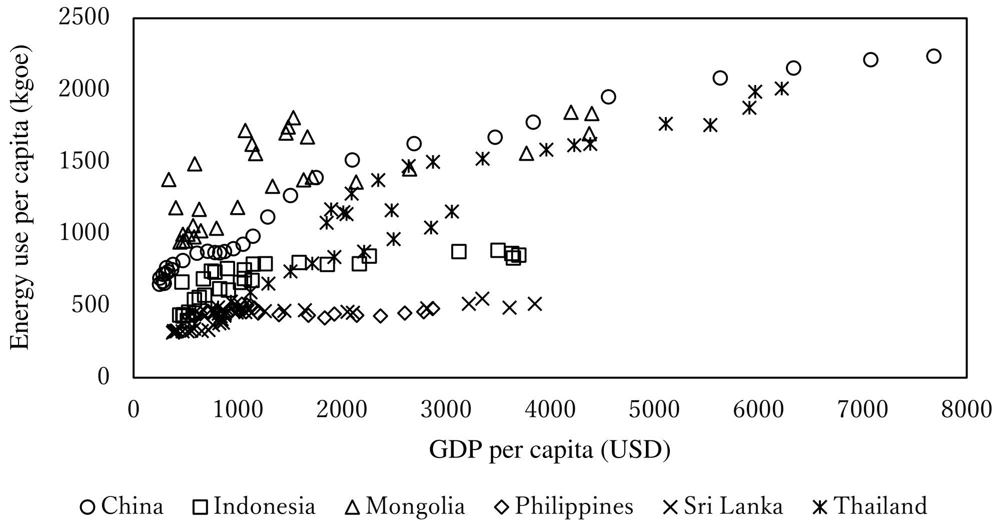


Table 3. Summary statistics of energy consumption (kgoe) and GDP (USD) per capita for middle-income group

	Energy use per capita (kgoe)				GDP per capita (USD)			
Country	Mean	Max	Min.	Std. Dev.	Mean	Max	Min.	Std. Dev.
China	1167.23	2236.73	651.08	531.60	1885.61	7683.50	250.71	2195.06
Indonesia	676.87	886.26	393.51	155.37	1366.61	3700.52	442.15	1072.27
Mongolia	1368.97	1847.10	944.39	309.22	1458.34	4400.62	339.52	1229.58
Philippines	459.48	513.14	416.69	25.74	1255.91	2873.09	535.24	681.05
Sri Lanka	404.63	551.02	315.56	73.34	1265.11	3852.74	377.64	1048.66
Thailand	1184.65	2012.06	446.39	469.07	2788.91	6225.05	747.49	1622.96
Average	874.31	2236.73	315.56	495.22	1671.23	7683.50	250.71	1481.15

Table 3 illustrates the summary statistics for the middle-income group, which contains regions with an average GDP per capita above 1000 USD and below 3000 USD during 1984-2014. As seen in the table, six regions are categorized into this income group. None of these regions have energy consumption per capita of over 3000 kgoe and the group average energy consumption per capita level is way below that of the average of the 19 Asia-Pacific region (2088 kgoe). From Figure 2, similar to the case of low-income group, it is apparent that most of these regions have an upward trend in their energy consumption per capita as their GDP per capita increases.

Figure 2. GDP (USD) and energy consumption (kgoe) per capita for middle-income group

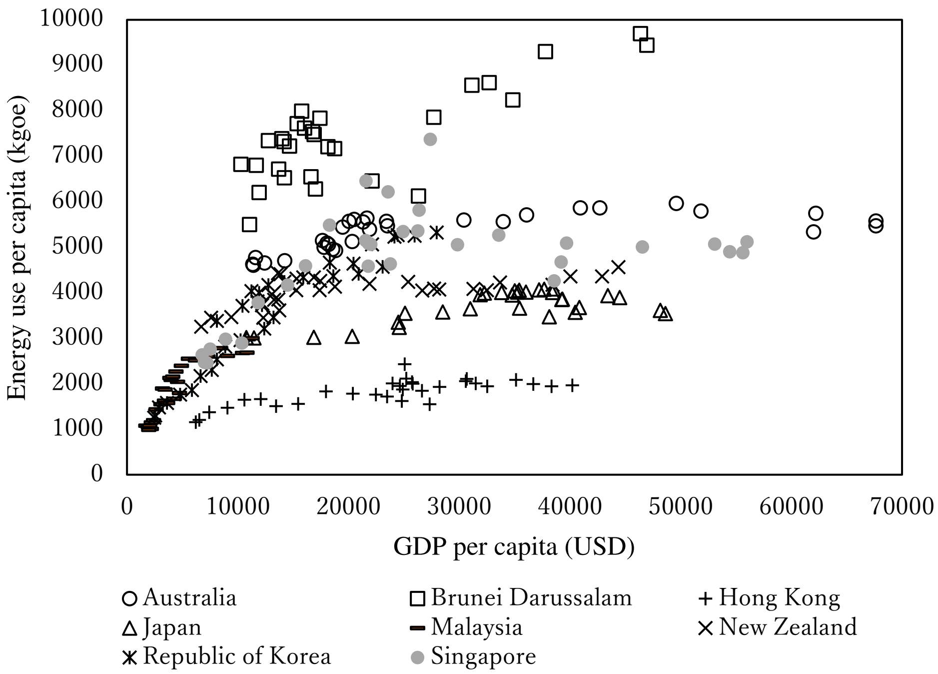


Finally, Table 4 depicts the summary statistics for the high-income group whose average GDP per capita is above 5000 USD during 1984-2014. As seen in this table, there are eight regions in this income group. All these regions consume energy above the average energy consumption level of the whole Asia-Pacific region and have a GDP per capita above 10,000 USD at some point during 1984-2014. Figure 3 illustrates the data of regions belonging to this income group. The figure tells us that except for Brunei and Malaysia, all the regions of this income group have a turning point in their energy consumption per capita as their GDP per capita increases. We believe the reason for Brunei and Malaysia not having a turning point in the figure is because these countries are petroleum exporting countries and such countries in general do not benefit from reducing their petroleum consumption. Petroleum exporting countries have plenty of cheap petroleum in their land so they have no incentive to use other energy sources than petroleum.

Table 4. Summary statistics of energy consumption (kgoe) and GDP (USD) per capita for high-income group

	Energy use per capita (kgoe)				GDP per capita (USD)			
Country	Mean	Max	Min.	Std. Dev.	Mean	Max	Min.	Std. Dev.
Australia	5336.05	5964.67	4602.96	403.93	29284.55	67652.68	11361.27	17500.22
Brunei	7466.88	9695.71	5499.11	1003.36	22211.28	46973.94	10280.77	11333.64
Hong Kong	1811.16	2431.88	1156.80	284.20	23340.14	40215.49	6208.23	9452.82
Japan	3703.11	4083.83	3005.24	352.05	33485.16	48629.20	10786.79	9440.74
Malaysia	1972.63	2999.90	986.29	646.31	5043.63	11305.90	1709.71	2962.66
New Zealand	4034.92	4559.89	3251.01	324.42	20986.47	44380.43	6713.60	10774.30
Rep. of Korea	3518.57	5323.13	1257.12	1304.35	13310.29	27989.35	2474.47	7530.92
Singapore	4665.71	7370.65	2455.48	1188.68	26338.81	56007.29	6793.55	15151.50
Average	4063.63	9695.71	986.29	1884.22	21750.04	67652.68	1709.71	13994.68

Figure 3. GDP and energy consumption per capita for high-income group



4. Results

The specification tests performed to select the most statistically appropriate model for the panel regression model for the whole region suggests that the fixed-effects model fits the best. The results of the Wald test in Table 5 suggests that the fixed-effects model is preferred to the pooled-OLS model and the LM test implies that the random-effects model is more applicable compared to the pooled-OLS model. Finally, the Hausman test indicates that the fixed-effects model is preferred to the random-effects model.

On the other hand, according to Table 5, the random-effects models are the best fit models for the low-, middle-, and high-income groups. For all these income groups, the Wald and LM tests indicates that either the fixed- or the random-effects model is the suitable model and the Hausman test points out that the random-effects model is preferred to the fixed-effects model.

Table 5 Specification tests for the panel regression model

	Wald test		LM test			Hausman test
Test statistics	F-stat.	Chi-square	BP test	Honda	King-Wu	Chi-square
Whole region	311.11 ***	5599.97 ***	5674.2 ***	75.3 ***	75.3 ***	22.84 ***
Low-income group	674.04 ***	2696.15 ***	1820.6 ***	42.7 ***	42.7 ***	1.30
Middle-income group	223.8145 ***	1119.07 ***	1789.8 ***	42.3 ***	42.3 ***	1.49
High-income group	460.1772 ***	3221.24 ***	3199.3 ***	56.6 ***	56.6 ***	0.08

Note: *** indicates significant at the 1% level.

Table 6 Estimation results for panel regression models

	FE model	RE model		
	Whole region	Low-income	Middle-income	High-income
Intercept	3.81 ***	5.64 ***	6.79 ***	-9.14 ***
Ln(GDP)	0.53 ***	-0.28	-0.37	3.28 ***
$(\mathrm{Ln(GDP)})^2$	-0.01 ***	0.05 ***	0.05 **	-0.15 ***

Note: FE and RE represent fixed-effects and random-effects. *** and ** indicate significant at the 1% and 5% levels.

Hence, we used the fixed-effects model for testing the EEKC hypothesis for the whole region and the random-effects model for the low-, middle-, and high-income groups. Table 6 shows the results of the panel regression estimation. From table 6, it can be seen that the fixed-effects model for the whole region satisfies all the conditions of the EEKC hypothesis. This result implies that there is a turning point among the 19 Asia-Pacific regions investigated in this study where the energy consumption per capita starts to decrease as their GDP per capita exceeds a certain level. However, when we calculated the turning point by applying the estimated coefficients in Table 6 for the whole region, the GDP per capita at the turning point became about 98.1 million USD, which is an unrealistic value for a GDP per capita. Similarly, the model for the high-income group also indicates that the EEKC hypothesis holds among the regions having an average GDP per capita above 5000 USD. The GDP per capita at the turning point of this model was about 44,572 USD. This value is still higher than the average GDP of the high-income group but it is a more realistic value compared to the one obtained for the whole region model.

On the other hand, the models for the low- and middle-income groups did not meet the EEKC hypothesis because the coefficient for the GDP is not significant and that for the squared-GDP is positive. As seen in Figures 1 and 2, this is perhaps because most of the energy consumption of the regions in the low- and middle-income groups have an upward trend as their GDP grow and they do not seem to have a turning point in their energy consumption.

Table 7 Panel unit root tests

Whole region

	Level			First difference		
	LLC	Breitung	IPS	LLC	Breitung	IPS
Energy	-0.98	4.17	2.61	-13.93 ***	-6.98 ***	-14.71 ***
GDP	-4.78 ***	0.66	-3.18 ***	-8.15 ***	-8.12 ***	-11.34 ***
Squared-GDP	-1.51 *	1.40	1.07	-8.54 ***	-8.29 ***	-11.16 ***

Low-income group

	Level			First difference		
	LLC	Breitung	IPS	LLC	Breitung	IPS
Energy	-0.01	2.76	2.13	-8.27 ***	-6.27 ***	-9.52 ***
GDP	-4.59 ***	1.51	-4.04 ***	-2.39 ***	-3.80 ***	-6.86 ***
Squared-GDP	0.65	2.18	1.07	-2.24 **	-4.04 ***	-6.48 ***

Middle-income group

	Level			First difference		
	LLC	Breitung	IPS	LLC	Breitung	IPS
Energy	-0.43	1.62	2.13	-4.91 ***	-3.69 ***	-6.01 ***
GDP	-0.84	1.54	0.70	-5.06 ***	-5.10 ***	-6.44 ***
Squared-GDP	-0.49	2.40	1.57	-5.58 ***	-4.97 ***	-6.35 ***

High-income group

	Level			First difference		
	LLC	Breitung	IPS	LLC	Breitung	IPS
Energy	-1.16	3.07	1.22	-11.07 ***	-3.57 ***	-9.95 ***
GDP	-2.58 ***	-0.62	-2.28 ***	-6.42 ***	-5.13 ***	-6.45 ***
Squared-GDP	-2.55 ***	-0.66	-2.00 **	-6.64 ***	-5.26 ***	-6.56 ***

Note: The test includes both intercept and linear trend. ***, **, and * indicate significant at the 1%, 5% and 10% levels.

Table 8 Panel cointegration tests

	Whole region	Low-income	Middle-income	High-income
Pedroni test	Test statistics	Test statistics	Test statistics	Test statistics
Panel v-Statistic	2.05 **	7.25 ***	1.96 **	-0.38
Panel rho-Statistic	0.94	-0.82	0.56	-0.36
Panel PP-Statistic	-1.87 **	-1.97 **	0.05	-2.54 ***
Panel ADF-Statistic	-3.46 ***	-1.92 **	-0.38	-3.05 ***
Group rho-Statistic	2.02	-0.36	1.41	1.54
Group PP-Statistic	-3.91 ***	-2.69 ***	0.53	-2.41 ***
Group ADF-Statistic	-2.35 ***	-2.69 ***	-0.59	-0.99
Kao test	Test statistics	Test statistics	Test statistics	Test statistics
t-statistic	-3.12 ***	-1.68 **	-1.62 *	-4.24 ***

Note: The test includes both intercept and linear trend. ***, **, and * indicate significant at the 1%, 5%, and 10% levels.

Table 9 Estimation results for the FMOLS and DMOLS models

	Whole region		Low-income		High-income	
	FMOLS	DOLS	FMOLS	DOLS	FMOLS	DOLS
Ln(GDP)	1.87 ***	1.79 ***	0.042	0.0887	3.66 ***	3.52 ***
$(\text{Ln(GDP)})^2$	-0.09 ***	-0.09 ***	0.008	0.0035	-0.19 ***	-0.18 ***

Note: The test includes both intercept and linear trend. *** indicates significant at the 1% level.

Next, I will discuss the results of the panel cointegration model estimation. Tables 7 and 8 show the results of the precondition tests for the cointegration model estimation. Table 7 illustrates the results of the stationarity tests performed on all the variables investigated in this study. From the table, the Breitung test suggests that all the test variables are integrated of order one, which means that at least at some levels, all the variables are stationary when first differencing them.

From Table 8, we can see that the majority of the Pedroni test statistics indicate that the null hypothesis of no cointegration is rejected for the whole region and low-income group models. The Kao test also suggests that the test variables are cointegrated in these models. Therefore, we conclude that the whole region and low-income group models strongly satisfy the preconditions of the cointegration model estimation. On the contrary, the results for the middle-income group model in the table implies that the test variables are not cointegrated and the Kao test also rejects the null hypothesis of no cointegration at the 10% significance level. Thus, it is likely that the variables for the middle-income group model are not cointegrated. Finally, the Pedroni test for the high-income group model also did not provide us with strong evidence of having a cointegrating relationship among the test variables. However, because at least the three test statistics in the Pedroni test and the Kao test suggest that the variables are cointegrated, we conclude that the variables in the high-income group are weakly cointegrated. Hence, we determine that the preconditions for the cointegration model estimation are met except for the middle-income group variables. Following this result, we estimated the FMOLS and DOLS models for the whole region, low-, and high-income groups.

Table 9 shows the results of the panel cointegration model estimation for the whole region, low-, and high-income groups. From the table, it is evident that the coefficients of whole region and high-income group models satisfy the condition of the EEKC hypothesis. This is consistent with the estimation of the panel regression model, which tells us that it is conceivable that the EEKC hypothesis does hold for the whole region and high-income group. As the whole region and high-income group models meet the EEKC hypothesis, we also estimated the GDP per capita at their turning points in these models. The estimated GDP per capita at the turning points for the whole region of the FMOLS and DOLS models become 20,169 and 17,336 USD while those for the high-income group are 19,537 and 19,456 USD.

It is noticeable from Table 4 that the estimated GDP per capita at the turning point for the high-income group model is less than the average GDP per capita of the high-income group (21,750 USD). This might be implying that the Asia-Pacific regions of the high-income group are already achieving an economic growth beyond the income level to satisfy the win-win situation (economic growth with decreasing energy consumption) of the EEKC hypothesis.

5. Conclusions

We investigated whether the EEKC hypothesis sustains in the Asia-Pacific region for the 1984-2014 period using a panel data including 19 regions of the Asia-Pacific region. Both the panel regression and cointegration models indicated that the EEKC hypothesis holds among the 19 regions of the Asia Pacific region. However, the test performed for low-, middle-, and high-income groups suggested that the EEKC hypothesis only stands for the high-income group and the low- and middle-income groups did not satisfy the hypothesis. This might be implying that although there exists a turning point where the energy consumption per capita begins to decline as the Asia-Pacific regions achieve economic development, such a transition in the energy consumption is only occurring in the developed countries. It could be that regions that are struggling with poverty have no room to implement an energy policy to reduce their energy consumption. It is probable that for such countries, economic development is their higher priority than converting their major energy source from fossil fuels to more efficient energy sources or to spread energy saving technologies.

However, our results also tell us that once the regions can move to the high-income group, in our study an income group having an average GDP per capita above 5000 USD, there is a chance that a region can develop along the EEKC path and achieve an economic development without putting an environmental pressure through increased energy use.

Although the panel regression estimation did not provide us with a realistic GDP per capita at the turning point of the EEKC for the whole Asia-Pacific region, the DOLS cointegration model provided us with a potentially achievable level of GDP per capita. According to the estimation of the DOLS model, once the GDP per capita of the Asia-Pacific region exceeds 17,336 USD, the regions start to develop along the EEKC path. One might argue that this estimated income per capita is still high compared to the current average GDP per capita of the Asia-Pacific region but our DOLS model also found that the GDP per capita at the turning point of the EEKC for the high-income group is 19,456 USD. This income value was less than the average GDP per capita among the high-income group during 1984-2014, and hence, it might be indicating that the developed countries in the Asia-Pacific region is already achieving an economic growth along the EEKC.

All in all, although this study suggests that the EEKC hypothesis stand for the Asia-Pacific region, it is likely that the transition in the energy consumption along the line with the EEKC is only taking place in the developed countries. As countries with an average GDP per capita below 3000 USD did not meet the EEKC hypothesis and rather had an upward trend in the energy consumption as their income grows, a rigid energy policy is required for these developing countries to reduce their energy consumption to decrease their amounts of fossil fuel-driven greenhouse gas emissions. However, I believe this is not an difficult task for the Asia-Pacific region because our study show that at least the developed countries within the Asia-Pacific region are already growing with decreasing energy consumption along the line of the EEKC and that there is a chance for these developing countries to learn and make use of energy policies that worked effectively in these developed countries to achieve such economic development.

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