Electricity Consumption and GDP Growth in Hong Kong

Wai Lok Chan[1], Wai Hung Fan, Lam Li
City University of Hong Kong, Hong Kong, China
[1] Corresponding author: Wai Lok Chan, email:
wlchan229-c@my.cityu.edu.hk

Abstract

Electricity is a necessity that firms and households use every day, while GDP (Gross Domestic Product) is a measure of the standard of living of an economy. For last decades in Hong Kong, it was generally observed that the electricity consumption and GDP growth grow hand in hand. Therefore, in this article, we investigate the relationship between electricity consumption and GDP growth in Hong Kong using econometric models with time-series data for the period of 1970 to 2012. We also investigate whether a long-run relationship exists between electricity consumption and GDP growth.

Keywords: cointegration test, econometric model, unit root test

1. Introduction

This paper is to study the relationships between electricity consumption (per capita) and the GDP (per capita) growth in Hong Kong using econometric models estimated with annual data. It also compares the electricity consumption (per capita) in different sectors such as the domestic, industrial, and commercial sectors of Hong Kong.

Basically, two variables are considered in our econometric model. They are real GDP (per capita) and electricity consumption (per capita). Hence, the model is designed as follows:

$$\text{EC} = \alpha + \beta\,\text{GDP} + \varepsilon\ , \qquad (1)$$

where EC is electricity consumption (per capita), GDP is real GDP (per capita), and ε is an error term. This specification follows the absolute income hypothesis of Keynes (1936).

We first take natural log of the two variables [electricity consumption (per capita) and Real GDP (per capita)] in (1), which then becomes the model for long-run relationship between electricity consumption (per capita) and real GDP (per capita), as follows:

$$LnEC_t = \gamma_0 + \gamma_1 LnGDP_t + \delta_t, \qquad (2)$$

Next, we take first difference of the two variables [electricity consumption (per capita) and Real GDP (per capita)], and obtain the following expression for short-run relationship between electricity consumption (per capita) growth rate and real GDP (per capita) growth rate:

$$\text{DLnEC}_t = \beta_0 + \beta_1\,\text{DLnGDP}_t + \varepsilon_t, \qquad (3)$$

where $DLnEC_t$ and $DLnGDP_t$ are electricity consumption (per capita) growth rate and real GDP (per capita) growth rate, respectively. ε and δ are error terms.

To further study how real GDP affects the electricity consumption in different sectors, we design the following models to study the short-run relationship between the electricity consumption (per capita) growth rate in different sectors (that is, *commercial*, industrial, and domestic sectors), and real GDP (per capita) growth rate:

$$DLnECC_t = \theta_0 + \theta_1 \, DLnGDP_t + \varepsilon_{1t}, \tag{4}$$

$$DLnECI_t = \lambda_0 + \lambda_1 \, DLnGDP_t + \varepsilon_{2t}, \tag{5}$$

$$DLnECD_t = \mu_0 + \mu_1 \, DLnGDP_t + \varepsilon_{3t}, \tag{6}$$

where $DLnECC_t$, $DLnECI_t$ and $DLnECD_t$ are the electricity consumption (per capita) growth rate in commercial sector, industrial sector and domestic sector respectively, $DLnGDP_t$ is the real GDP (per capita) growth rate, and ε is an error term.

It is noteworthy that the relationships specified in (1) and (2) represent a long-run relationship between electricity consumption (per capita) and real GDP (per capita), while (3), (4), (5) and (6) stand for short-run relationships. We will explain more later as we proceed.

The data for GDP, electricity consumption in *Terajoules* and Hong Kong's Year-end population were collected from the websites of the Census and Statistics Department of the Government of the Hong Kong Special Administrative Region (HKSAR), where data for electricity consumption date back to the earliest available year of 1970. Hence, our estimation period covers the period of 1970-2012. All data in this report are transferred to the basis of per capita. Real GDP (per capita) were collected from the websites of the Census and Statistics Department directly while total electricity consumption (per capita) and electricity consumption (per capita) in different sectors are calculated by dividing data of electricity consumption by Hong Kong's Year-end population. And our data for Gross Domestic Product are expressed in chained (2010) Hong Kong dollars. In addition, we also collected data for electricity consumption in commercial, industrial and domestic sectors. The reason we investigate the electricity consumption in these sectors is that in 2011, it was observed that commercial and domestic users took up the largest share (93 percent) of total local electricity consumption, while the consumption of the manufacturing industry declined sharply.

2. Augmented Dickey-Fuller unit root tests

Respective plots of electricity consumption (per capita), real GDP (per capita), electricity consumption (per capita) growth rate, real GDP (per capita) growth rate, and electricity consumption (per capita) growth rates in different sectors show that all variables contain time trends. The use of trending explained or explanatory variables may result in a spurious regression problem. To ensure such a phenomenon does not occur in our study, we conduct the Augmented Dickey-Fuller (ADF) unit root tests. It was designed by Dickey and Fuller (1979) to investigate the stationarity property of time series variables.

The results of our ADF unit root tests are shown in Table 1:

Table 1 ADF unit root tests for all variables used in model estimation

Time Series	5% critical value	$\tau - statistic$ of the unit root tests (with linear trend and intercept)	Stationary or not?
LnEC	-3.523	-0.162	No
LnGDP	-3.520	-1.385	No
LnECC	-3.520	1.602	No
LnECI	-3.523	-1.413	No
LnECD	-3.520	1.602	No
DLnEC	-3.523	-4.576	Yes
DLnGDP	-3.523	-5.613	Yes
DLnECC	-3.523	-5.690	Yes
DLnECI	-3.523	-4.249	Yes
DLnECD	-3.529	-2.840	No
DDLnECD	-3.530	-8.975	Yes

Table 1 indicates that the variables in levels, that is, LnEC, LnGDP, LnECC, LnECI, and LnECD contain unit root, suggesting they are not stationary.

Since ADF unit root tests τ -statistics for per capita electricity consumption growth rate DLnEC, real per capita GDP growth rate DLnGDP, and per capita electricity consumption growth rates in commercial and industrial sectors DLnECC and DLnECI are smaller than their respective test critical value at the 5% significance level, they provides evidence that the series are stationary.

On the other hand, the ADF unit root test τ -statistic for per capita electricity consumption growth rate in domestic sector DLnECD is greater than its test critical value at the 5% significance level, it does not provide evidence that the series is stationary. But the second-differenced series DDLnECD is stationary as indicated in Table 1.

3. Co-integration Test

Next, it is the co-integration test. Co-integration test is designed to find out whether a long-run relationship, like the one specified in (2), exists between two or more non-stationary series. If such a long-run relationship exists, the linear combination of these non-stationary series will become stationary. Apart from the long-run relationship, these non-stationary series are also said to be co-integrated.

To test the existence of the long-run relationship between LnEC and LnGDP, the following steps are performed. First, the regression of LnEC on LnGDP is run, just like the equation we specified in (2). In the second step, we save the sample residuals, denoted as $\hat{\delta}_t$, and check if it is stationary. Figure 1 below shows the plot of $\hat{\delta}_t$.

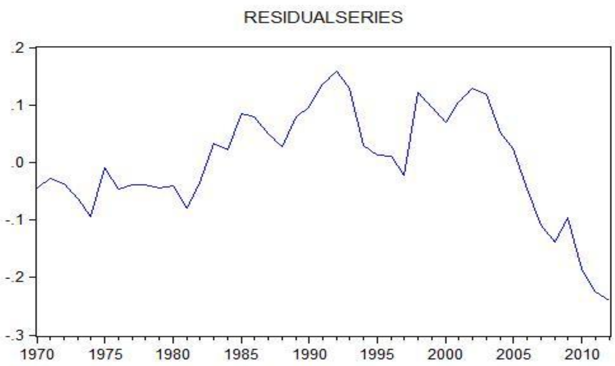

Figure 1: Residual series for $\hat{\delta}_t$

Since the plot in Figure 1 indicates that the residual series does not fluctuate around a constant mean obviously, it is unlikely to be stationary. In the meantime, an ADF unit root test is carried out to further test whether this residual series is stationary. Table 2 contains the test result.

Table 2: ADF unit root test for the sample residuals $\hat{\delta}_t$

Time series	5% critical value	$\tau - statistic$ of the unit root test (with linear trend and intercept)	Stationary or not?
$\hat{\delta}_t$	-3.521	-0.613	No

Table 2 above gives the ADF unit root test for the residuals $\hat{\delta}_t$. The τ – statistic value is -0.61, which is larger than the 5% critical value of -3.52, suggesting there is no evidence that the residual is stationary. As the residual of model (2) is not stationary, it does not provide evidence that a long run relationship exists between real GDP (per capita) and electricity consumption (per capita) in Hong Kong.

4. Short run analysis

Having failed to find the long-run relationship between electricity consumption and real GDP in Hong Kong, we now proceed to the short-run analysis. We run the growth rate of electricity consumption (per capita) on the growth rate of real GDP (per capita) as specified in (3), that is,

$$\text{DLnEC}_t = \beta_0 + \beta_1 \text{ DLnGDP}_t + \varepsilon_t, \qquad (3)$$

The estimated regression for (3) with standard errors in parentheses is

$$DL\hat{n}EC_t = \underset{(0.008)}{0.021} + \underset{(0.153)}{0.467} \text{ DLnGDP}$$

$R^2 = 0.186$, $Se= 0.040$, DW= 1.326,

where R^2 is the coefficient of determination, *Se* is the standard error of the regression, and DW is the Durbin-Watson statistic for testing the first-order serial correlation.

Next, we also run the regression of electricity consumption (per capita) in commercial sector on real GDP (per capita) growth and electricity consumption (per capita) in industrial sector on real GDP (per capita) growth specified in (4) and (5) respectively:

$$DLnECC_t = \theta_0 + \theta_1 \, DLnGDP_t + \varepsilon_{1t}, \qquad (4)$$

The estimated regression for (4) with standard errors in parentheses is

$$DL\hat{n}ECC_t = \underset{(0.150)}{0.039} + \underset{(0.008)}{0.323} \, DLnGDP$$

.

$R^2 = 0.104$, Se= 0.039 , DW= 1.316

$$DL\hat{n}ECI_t = \lambda_0 + \lambda_1 \, DLnGDP_t + \varepsilon_{2t}, \qquad (5)$$

The estimated regression for (5) with standard errors in parentheses is

$$DL\hat{n}ECI_t = \underset{(0.011)}{-0.044} + \underset{(0.195)}{1.020} \, DLnGDP$$

$R^2 = 0.404$, Se= 0.050, DW= 0.982

We now turn to the relationship between electricity consumption (per capita) growth rate in domestic sector and GDP (per capita) growth rate. From ADF test results, it is found that the series of electricity consumption (per capita) growth rate in domestic sector DLnECD is not stationary.

To ensure the variables used the regression models are stationarity series which will make the t-tests valid, we differentiate the series again and arrive at the second differenced per capita electricity consumption in domestic sector DDLnECD. The ADF unit root test for the second differenced per capita electricity consumption in domestic sector is smaller than its test critical value at the 5% significance level, it provides evidence that the series is stationary (see Table 1).

For studying the short-run relationship between the second differenced per capita electricity consumption in domestic sector and real GDP (per capita) growth rate, model (6) is modified as follows:

$$DDLnECD_t = \rho_0 + \rho_1 \, DLnGDP_t + \varepsilon_{3t}, \qquad (6)$$

where $DDLnECD_t$ is the second differenced per capita electricity consumption in domestic sector, $DLnGDP_t$ is the real per capita GDP growth rate, and ε_{3t} is an error term. The estimated equation with standard errors in parentheses is:

$$DDL\hat{n}ECD_t = \underset{(0.013)}{0.010} - \underset{(0.233)}{0.293} \, DLnGDP$$

$R^2 = 0.039$, Se= 0.060, DW= 3.112

Note that the slope coefficient is negative which is not consistent with our expectation.

We now summarize our interpretations of our results given above.

For every 1 percent change in real per capita GDP, on the average leads to 0.467 percent change in per capita electricity consumption in Hong Kong. Every 1 percent change in real capita GDP growth would on the average lead to 0.323 percent change in commercial electricity consumption. For every 1 percent change in real per capita

GDP growth, on the average, it leads to 1.020 percent change in per capita electricity consumption in industrial sector.

However, the result of regression of DDLnECD on DLnGDP has the wrong sign problem, suggesting the real GDP growth is not helpful in explaining the per capita consumption in domestic sector. Other explanatory variables such as prices can be considered as an alternative.

5. Conclusions

From the results above, it is concluded that in Hong Kong, real per capita GDP growth and per capita electricity consumption growth show a positive and significant relationship, implying higher real GDP growth in general would result in higher electricity consumption growth.

When breaking down Hong Kong's electricity consumption into different sectors, it is concluded that higher real per capita GDP growth could bring higher electricity consumption growth in commercial sector and industrial sector, respectively.

However, at this stage, we cannot find any relationship between per capita electricity consumption growth rate in domestic sector and real per capita GDP growth rate, suggesting other explanatory variables such as electricity price may be useful than per capita GDP to explain the electricity consumption in domestic sector. This is for future study

Overall, no long run relationship exists between real capita GDP and per capita electricity consumption.

References

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