THE EFFECT OF ECONOMIC CONDITIONS ON ELECTRICITY CONSUMPTION IN MALAYSIA

Nur Athirah Najwa Azhar [i], Noor 'Adilah Ibrahim[ii], Shahrina Ismail[iii]

[i]Student, Faculty Science and Technology, Universiti Sains Islam Malaysia.
athirahazhar98@gmail.com
[ii](Corresponding author) Lecturer, Faculty Science and Technology, Universiti Sains Islam Malaysia.
nooradilah@usim.edu.my
[iii]Lecturer, Faculty Science and Technology, Universiti Sains Islam Malaysia.
shahrinaismail@usim.edu.my

Abstract

This study attempts to explore the effect of the economic conditions, including population growth rate, inflation rate and unemployment rate, on the electricity consumption in Malaysia over the period from 1982 to 2018. Multiple Linear Regression is used to examine the significant determinants of electricity consumption. In addition, Pearson's correlation and autocorrelation function are used to investigate the correlation between all the variables and to identify the presence of random processes in the series, respectively. The result of the multiple regression model validates the significance of the variables population, inflation, and unemployment. It shows that all the variables have a significant negative relationship with electricity consumption. Whereas the Pearson correlation confirms that there is a correlation between variables population and unemployment with electricity consumption. In contrast, the result of autocorrelation function indicates the existence of random process in this study.

Keywords: *Electricity Consumption, Economic Condition, Correlation, Population, Malaysia*

INTRODUCTION

Electricity is one of the basic elements that play a big part in our daily life. Electricity consumption accounts for a substantial portion of final energy consumption in countries worldwide. Thus, it is very important to understand electricity consumption behaviour concerning improving economic growth and development. Based on the Department of Statistics Malaysia (2019), electricity consumption per capita in Malaysia in the year 2010 has increased from 3900 kilowatt-hours (kWh) per capita to 4750 kilowatt-hours (kWh) in the year 2019.

The demand for electricity in Malaysia has always risen from 1978 to 2018 since the demand growth from the sectors or industries also increases. Furthermore, the Department of Statistics Malaysia (2019) has stated that the Malaysian population in 2020 is 32.6 million and expected to increase up to 34 million in 2025. The population also become the reason that led to the high demand for electricity.

Overusing electricity can cause negative effects to the user, whether in the form of fuel or electric bills. The electricity consumption in Malaysia reached its highest in August 2018 with the usage of 12,785.769 kilowatt-hours (kWh), while the lowest consumption was in February 1989 with a consumption of 1,385.300 kWh (Malaysia Energy Information Hub, 2020). Latif et al., (2019) examine that the electricity consumption in Malaysia rises with an average of 2533 GWh per year. The total electricity consumption is 604 ktoe in 1978 and rise to 1715 ktoe in 1990. Then, it continues to rise to 5263 ktoe in 2000 and 12607 ktoe in 2017.

However, underlying concerns appear with the increasing electricity demand, making sure the continuous supply of energy is cost-efficient (Tan et al., 2013). Apart from that, they found that the electricity production in Malaysia is also expected to increase with a growth rate of 5.3% from 2005 to 2030 that has been compelled by the high growth of demand from different sectors and industries.

Economic conditions play a significant role in determining the amount of electricity consumed in all countries over the world. The current rise of interest in the issues involving energy consumption level and the limited studies on this related topic has motivated us to investigate the effect of economic growth on electricity consumption. There are several economic conditions that might have significant impacts towards electricity consumption such as population growth, inflation rate as well as unemployment rate.

According to the research conducted in Pakistan by Hameed & Khan (2016), the high population growth has caused the rate of domestic electricity consumption increased to a higher level. Their findings also showed a significant positive relationship between population growth and domestic electricity consumption in Pakistan. In addition, the research conducted by Abbas et al. (2015) and Ridzuan et al. (2019) indicated that the inflation is expected to influence the demand for electricity because of its effect on consumers' purchasing power. Thus, people tend to minimise their electrical consumption due to rising inflation by adopting numerous energy-efficient products.

Meanwhile, Chen & Guat (2019) stated that Malaysia has recorded a 3.4% unemployment rate in the third quarter of 2018, showing an increasing rate of 0.1% from the second quarter. In addition, 524.4 thousand unemployment are recorded, which increased 1.6% compared to 2017. Inevitably, the unemployment also would give a significant impact towards electricity consumption has been studied by Ramli et al. (2018), Tatli & Barak (2019). Based on this past research, it has been proved that there are several factors that contribute to the electricity consumption. Thus, in this study, our main aim is to investigate the most significant factors that mainly influence the consumption of electricity in Malaysia.

METHODOLOGY

In this study, the data is collected annually from 1982 to 2018. The data for electricity consumption is obtained from the website Malaysia Energy Information Hub https://meih.st.gov.my/home and Malaysia Energy Statistics Handbook 2019. Next, all the data for the independent variables, including population growth, inflation rate and unemployment rate, are taken from the World Development Indicators.

Regression Analysis

To find the relationship between economic conditions and electricity consumption, we use Ordinary least squares (OLS) regression. It is a method where the sum of squared residuals is minimised and can be evaluated by finding the difference between the predicted and observed values to determine the best-fitted line. We propose the following model:

$$logY = \beta_0 + \beta_1 logX_1 + \beta_2 logX_2 + \beta_3 logX_3 + \varepsilon_t, \quad (1)$$

where Y= the annual electricity consumption in ktoe;

X_1 = the population growth rate;
X_2 = the inflation rate;
X_3 = the unemployment rate;
β_0 = intercept;
ε_t = error term;
β_i = estimated coefficient of respective variables where i = 1, 2, 3

Unit Root Test

Unit root test is a method or technique to check the stationarity of series of a data. The Augmented Dickey-Fuller (ADF) test is used to know the order of integration for each variable. This test provides an effective relationship between the variables in the long run. The unit root test is conducted to test whether there is a unit root in the series. If unit-roots exist, it indicates that the data are non-stationary which lead to spurious regression. The hypothesis for the ADF test is as follows:

$$H_o: \text{unit root present}$$
$$H_a: \text{no unit root}$$

If the ADF value is lower than the critical value, then the null hypothesis will be rejected. That means that the series is experiencing stationary and absence of unit root.

t-Test

It aims to determine whether two populations are statistically different from each other. The key data values are mean value, standard deviation, and the number of data needed to calculate the t-test. The test statistics for the t-test is given as:

$$t = \frac{\beta_j - \beta_j}{se(\hat{\beta}_j)} \quad (2)$$

where $\hat{\beta}_j$= estimated regression coefficient;
β_j = hypothesized value;
$se(\hat{\beta}_j)$ = coefficient standard error of $\hat{\beta}_j$.

with the following hypothesis:

H_o : β_i is not significantly different than 0

H_a : β_i is significantly different than 0.

We may reject the null hypothesis if the p-value is less the significance level, $\alpha = 0.05$.

F-test

F-test is applied in this research to examine if the suggested regression model gives a better fit to the data. If the p-value is lower than the significance level, $\alpha = 0.05$, there is enough evidence to validate that the model fits the data rather well. The test statistics for F-test is given as follows:

$$\text{F statistic} = \frac{(SSR_1 - SSR_2)/(q)}{SSR_2/(n-k-1)}, \quad (3)$$

where SSR_1 = sum of the squared residual of fitted model 1;
SSR_2 = sum of the squared residual of fitted model 2;
q = numerator degrees of freedom;
(n – k – 1) = denominator degrees of freedom.

Autocorrelation

The autocorrelation is applied in this study to examine if there is dependency between current values with its own previous values. The formula for the autocorrelation is as below:

$$r_k = \frac{\sum_{t=k+1}^{T}(y_t - \bar{y})(y_{t-k} - \bar{y})}{\sum_{t=1}^{T}(y_t - \bar{y})^2}, \quad (4)$$

where r_k= autocorrelation for lag k;

k = time lag;
T = number of observations in time series.

Sample Autocorrelation or well known as ACF is defined as how the observations are related in a time series, and it measured the variable current observation, y_t and the past observation, y_{t-p}. In comparison, Sample Partial Autocorrelation or denoted by PACF is used to measure the degree of association between y_t and y_{t-p} when the Y-effects are removed. The behaviour of the ACF and PACF of different models need to be observed as a way to identify the presence of random processes. Thus, the behaviour for the ACF and PACF is illustrated in Table 1.

Model	ACF	PACF
AR(p)	Dies down	Cut off after certain lag p
MA(q)	Cut off after certain lag q	Dies down
ARMA(p,q)	Dies down	Dies down

Table 1: Behaviour of ACF and PACF of different models

The model for the series can be identified after observing the behaviour of the ACF and PACF. The model can be whether autoregressive (AR) model, moving average (MA) model, autoregressive and moving average (ARMA) model or autoregressive integrated moving average (ARIMA) model.

The equation formula for AR model with order p is as follows:

$$Y_t = c + \sum_{j=1}^{p} \emptyset_j Y_{t-j} + \varepsilon_t, \quad (5)$$

where $\emptyset_j$ = vector of model coefficients;
Y_{t-j} = past series values (lags).

Autoregressive models work on a combination of past values of the variables, making the statistical technique famous and common for analysing the economics and other processes that change over time such as in predicting the security prices.

Meanwhile, the MA model is a model that uses the past forecast errors in a regression rather than uses past forecasts to predict the future value. A moving average process of order q can be written as:

$$Y_t = c + \varepsilon_t + \sum_{j=1}^{p} \theta_j \varepsilon_{t-j}, \quad (6)$$

where θ_j = vector of model coefficients;

ε_{t-j} = the past forecast errors value.

Last but not least, the ARMA model are the combination of both MA(q) and AR(p). The formula for the ARMA model is shown as follows:

$$Y_t = c + \varepsilon_t + \sum_{j=1}^{p} \emptyset_j Y_{t-j} + \sum_{j=1}^{p} \theta_j \, \varepsilon_{t-j} , \tag{7}$$

where $\emptyset_j$ = autoregressive model parameter;
Y_{t-j} = past series values;
θ_j = moving average model parameter;
ε_{t-j} = past forecast errors value.

Pearson's Correlation

We used Pearson's correlation to investigate the correlation between economic conditions and electricity consumption where it measures the strength of the association between two variables. Positive correlation shows that both variables are in the direction of increase or decrease together. In contrast, the negative correlation tells that when a variable decreases, the other will increase and vice versa. The correlation coefficient formula is shown in the equation below:

$$r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 (y_i - \bar{y})^2}} , \tag{8}$$

where r = correlation coefficient;
x_i = values of x;
$\bar{x}$ = mean of values of x;
y_i = values of y;
$\bar{y}$ = mean of values of y.

Multicollinearity

Multicollinearity can be defined as the state of high intercorrelations among the independent variables in the multiple regression model. Besides, multicollinearity causes the coefficients estimates to be very sensitive to small changes in the model. It also reduces the precision of the estimate coefficients. To test the existence of the multicollinearity in our regression model, we use the variance inflation factor (VIF). Basically, the VIF value of 1 shows no correlation between the independent variables while the values of VIF that exceed 10 indicates that multicollinearity exists in the variables. The formula for variance inflation factor (VIF) is given as below:

$$\text{VIF} = \frac{1}{1-R^2} , \tag{9}$$

where R^2 = goodness of fit.

RESULTS AND DISCUSSION

Descriptive Statistics

The summary of the descriptive statistics is shown in Table 2.

Table 2: Descriptive Statistics

	Log Electricity Consumption	Log Population	Log Inflation	Log Unemployment
Mean	3.613768	0.322502	0.343988	0.575510
Median	3.721151	0.366351	0.425292	0.536558
Std. Dev.	0.383539	0.113336	0.313568	0.127328
Skewness	-0.443958	-0.556152	-1.160818	1.382963
Kurtosis	1.806864	2.006275	3.956712	4.085633

Sources: EViews Analysis Output

Based on Table 2, we can conclude that the log inflation and log unemployment are leptokurtic since the value of excess kurtosis is greater than the normal distribution. In contrast, the log electricity consumption and log population are platykurtic since the excess kurtosis is less than 3. Besides that, the log unemployment is positively skewed while the other variables are negatively skewed.

Unit Root Test

Table 3 shows the result of the unit root test. The table shows that the ADF value, which is -4.381058, is lower than all the critical values at 1%, 5%, and 10% significance levels. Thus, the null hypothesis is rejected, and this means that the series does not has a unit root and is experiencing stationary.

Table 3: Augmented Dickey-Fuller (ADF) test

		t-Statistics	Prob
Augmented Dickey-Fuller test statistics		-4.381058	0.0013
Test Critical values	1% level	-3.626784	
	5% level	-2.945842	
	10% level	-2.611531	

Sources: EViews Analysis Output

Multiple Linear Regression

Table 3: Result of the multiple regression

Variable	Coefficient	Std Error	t-Statistic	Prob	Rsquared
Log Population	-2.061023	0.302262	-6.818674	0.0000	0.829283
Log Inflation	-0.238815	0.104416	-2.287157	0.0287	
Log Unemployment	-1.370621	0.301198	-4.550564	0.0001	

Sources: EViews Analysis Output

Based on the regression result in Table 3, all the variables are significant at 5% significance level since the p-value is less than the significance level, $\alpha = 0.05$. Besides, the results also show a negative relationship between electricity consumption and all the independent variables. This means that as the population, inflation and unemployment rate increase, electricity consumption will decrease. Meanwhile, the R-squared shows that the data fit the regression model rather well . The value of R-squared of 0.829283 indicates that 82.9283% of the data fit the regression model. Figure 4.1 shows the graph of the multiple regression.

t-Test

Based on Table 3, we can reject the null hypothesis since the p-value of t-statistics for all variables is less than a 5% significance level. Therefore, we can conclude that all the variables are significant.

F-test

The p-value of F-statistics is less than the significance level, whereas we can reject the null hypothesis. Thus, it can be said that all population, inflation, and unemployment variables can jointly influence electricity consumption.

Autocorrelation

Based on Figure 1, it can be observed that the ACF dies down fairly quickly while the PACF cut off at lag 1. This indicates that the series are experiencing the autoregressive process with order 1 or denoted by AR(1) process.

Figure 1: ACF and PACF of the series

Date: 12/18/20 Time: 11:28
Sample: 1 37
Included observations: 37

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.517	0.517	10.708	0.001
		2	0.314	0.064	14.780	0.001
		3	0.122	-0.086	15.415	0.001
		4	0.010	-0.054	15.419	0.004
		5	-0.059	-0.042	15.575	0.008
		6	-0.067	-0.001	15.785	0.015
		7	0.061	0.164	15.966	0.025
		8	0.026	-0.073	15.999	0.042
		9	0.061	0.030	16.191	0.063
		10	0.041	-0.007	16.282	0.092
		11	0.002	-0.041	16.282	0.131
		12	-0.008	0.021	16.286	0.178
		13	-0.022	0.003	16.316	0.233
		14	-0.046	-0.064	16.448	0.287
		15	-0.133	-0.113	17.612	0.284
		16	-0.245	-0.195	21.746	0.152
		17	-0.126	0.147	22.890	0.153
		18	-0.017	0.127	22.911	0.194
		19	-0.088	-0.210	23.527	0.215
		20	-0.077	-0.054	24.031	0.241
		21	-0.124	-0.104	25.411	0.230
		22	-0.134	-0.026	27.145	0.206
		23	-0.233	-0.075	32.764	0.085
		24	-0.207	-0.060	37.518	0.039
		25	-0.218	-0.131	43.234	0.013
		26	-0.183	-0.021	47.637	0.006
		27	-0.039	0.091	47.853	0.008
		28	-0.001	0.030	47.853	0.011
		29	0.102	0.103	49.731	0.010
		30	0.111	0.001	52.259	0.007

Sources: EViews Analysis Output

By using E-Views, we obtain the estimated coefficient of AR(1), i.e $\theta = 0.518111$. By using this estimated coefficient, we may find the final residuals. Then, to know whether the series is white noise, we generate the autocorrelation function or ACF of the final residuals. Based on Figure 2, we can conclude that the final residuals are white noise since all values are lying within the confidence band.

Figure 2: ACF and PACF of final residuals

Sample: 1 37
Included observations: 37

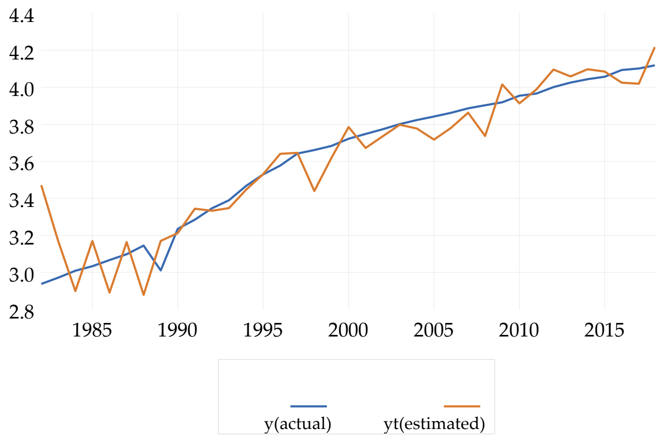
Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.028	-0.028	0.0322	0.858
		2	0.089	0.088	0.3602	0.835
		3	-0.020	-0.015	0.3770	0.945
		4	-0.026	-0.035	0.4070	0.982
		5	-0.058	-0.057	0.5581	0.990
		6	-0.116	-0.115	1.1797	0.978
		7	0.141	0.147	2.1337	0.952
		8	-0.040	-0.016	2.2135	0.974
		9	0.057	0.025	2.3826	0.984
		10	0.033	0.035	2.4397	0.992
		11	-0.028	-0.045	2.4828	0.996
		12	0.001	-0.001	2.4828	0.998
		13	-0.004	0.035	2.4838	0.999
		14	0.025	0.005	2.5223	1.000
		15	-0.027	-0.008	2.5685	1.000
		16	-0.241	-0.268	6.5734	0.981

Sources: EViews Analysis Output

Fitted Plot

Finally, the actual data is fitted with the estimated data as shown in Figure 3. Based on the plot, we can conclude that the suggested regression model fitted the actual data rather well. However, the fitted plot is rather rough which might due to lack of data. In overall, we can conclude that the model is quite significant to predict the future value of the electricity consumption.

Figure 3: The fitted plot of the estimated value



Sources: EViews Analysis Output

Pearson Correlation

Based on the result in Table 4, the population and unemployment have a strong correlation with electricity consumption since the coefficient value, which is -0.849685 and -0.684467, lie between ± 0.50 and ± 1. However, inflation is found to have a weak correlation with electricity consumption since the value is too low, which is -0.001799. Meanwhile, the value of 0.520957 indicates a quite strong correlation between variables unemployment and population.

Table 4: Pearson's Correlation Result

Correlation	**Log Electricity Consumption**	**Log Population**	**Log Inflation**	**Log Unemployment**
Log Electricity Consumption	1.0000000			
Log Population	-0.849685 0.0000	1.0000000		
Log Inflation	-0.001799 0.9916	0.018474 0.9136	1.0000000	
Log Unemployment	-0.684467 0.0000	0.520957 0.0009	-0.449865 0.0052	1.0000000

Sources: EViews Analysis Output

Multicollinearity

Based on the Table 5, all the variables population, inflation and unemployment have VIF values less than 10 and greater than 1. Since the VIF is lower, thus we can conclude that there is a low multicollinearity between population, inflation and unemployment.

Table 5: Variance Inflation Factor Result

Variables	Coefficient Variance	VIF
Log Population	0.091362	1.542117
Log Inflation	0.010903	1.408678
Log Unemployment	0.090720	1.932734

Sources: EViews Analysis Output

CONCLUSION

In this paper, we have investigated the effect of the economic conditions and electricity consumption in Malaysia from 1982 to 2018 using a time series data analysis. To explore the effect of economic condition and electricity consumption in Malaysia, we first applied the multiple linear regression model. Based on the obtained result, we can deduce that all the variables negatively affect the electricity consumption. The conclusion summarised in the result has provided evidence that there is an effect of economic conditions on electricity consumption. In addition, there is a random process in the series, which is autoregressive model with order 1.

Meanwhile, the multicollinearity test shows that there is low multicollinearity in the variables. In overall, we can conclude that the variables suggested in this study can be used to forecast the electricity consumption in Malaysia since all variables are found to be significant. However, there is also limitation in this study which lack of data. The data used in this study is rather short, which is 37 years starting from 1982 to 2018, which can lead to inefficient results. Therefore, for the future research, we recommended to increase the number of data used used to get a better result.

In addition, we recommend that the research be done in the future by using the quarterly or monthly data since it is highly likely that those data can change the causal relationship between variables. The researchers always chose the annual data in terms of the data selection due to the unavailability of the quarterly or monthly data. Hence, we should look up the data to be further examined to increase the study's efficiency.

REFERENCES

Abbas, N., Saeed, S., Manzoor, S., Arshad, M. U., & Bilal, U. 2015. The relationship between electricity consumption, employment rate, inflation and economic growth in five developing countries. *Journal of Economics, Management and Trade*, 164- 171.

Chen, K. W., & Guat, C. L. 2019, December. Unemployment insurance: A case study in Malaysia. In *AIP Conference Proceedings* (Vol. 2184, No. 1, p. 050038). AIP Publishing LLC.

Department of Statistics Malaysia Official Portal. 2020. Retrieved 16 October 2020, from https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat& cat=124&bul_id=L2NnM0h0bFc2SGFaRGZEeGxETCtuZz09&menu_id=U3VPMld oYUxzVzFaY mNkWXZteGduZz09.

Hameed, L., & Khan, A. A. 2016. Population growth and increase in domestic electricity consumption in Pakistan: A case study of Bahawalpur City. *The Explorer Islamabad: Journal of Social Sciences*, *2*(1), 27-33.

Latif, A. F., Ahmad, N. A., Abdullah, M. R., Ismail, A., & Ghani, A. A. A. 2019, June. A Review on Energy Performance in Malaysian Universities Through Building Information Modelling (BIM) Adaptation. In *IOP Conference Series: Earth and Environmental Science* (Vol. 291, No. 1, p. 012033). IOP Publishing.

Malaysia Energy Information Hub. Retrieved on 9 October 2020 from https://meih.st.gov.my/home.

Ramli, S. F., Firdaus, M., Uzair, H., Khairi, M., & Zharif, A. 2018. Prediction of The Unemployment Rate in Malaysia. *International Journal*, *1*(4), 38-44.

Ridzuan, A. R., Kamaluddin, M., Ismail, N. A., Razak, M. I. M., & Haron, N. F. 2020. Macroeconomic Indicators for Electrical Consumption Demand Model in Malaysia. *International Journal of Energy Economics and Policy*, *10*(1), 16-22.

Tan, C. S., Maragatham, K., & Leong, Y. P. 2013. Electricity energy outlook in Malaysia. In *IOP Conference Series: Earth and Environmental Science* (Vol. 16, No. 1, p. 012126). IOP Publishing.

Tatli, H., & Barak, D. 2019. The relatonship between female unemployment and energy consumption: the case of OECD countries. *International Journal of Economic & Administrative Studies*, 24, 215-232.