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Investigating The Co-Integration Among Electricity Production Function in Malaysia: Bound Testing Approach

Hussain Ali Bekhet
Graduate Business School, College of Graduate Studies
University Tenaga Nasional (UNITEN)
43000, Selangor-Malaysia
profhussain@uniten.edu.my, drbekhet1953@hotmail.com

Nor Hamisham Binti Harun
College of Business Management and Accounting,
Universiti Tenaga Nasional (UNITEN),
Muadzam Shah Campus,
Pahang-Malaysia
Hamisham@uniten.edu.my

ABSTRACT

The aim of the current paper is to investigate the long-run relationship among the factors of electricity production function in Malaysia. Time series data for production (Q), Gross Fixed Capital Formation (GFCF), labour (L), and energy (E) for the 1980-2012 period is used. To explore this relationship, production theory and time series model, ARDL, are applied. The results show that the individual variables are stationary in the first difference at the 5 percent significance level. The diagnostics test reveals that there is no serial correlation among the variables (between production and its production factors). Therefore, the result also shows co-integration among the electricity determinants, using the bound test approach, at 5 percent significance level. This result indicates the long-run relationship among production, capital, labour and energy in the electricity industry.

Keywords: Production Factors, Electricity Industry, Unit Root Test, Bound Test, Malaysia.

ABSTRAK

Kertas kerja ini dibuat adalah untuk mengkaji hubungan jangka masa panjang terhadap faktor-faktor yang mempengaruhi sektor elektrik dengan menggunakan teori fungsi pengeluaran. Kajian ini menggunakan data siri masa yang terdiri daripada pengeluaran (Q), pembentukan modal kasar (K), tenaga kerja (L) dan tenaga (E) bagi tahun 1980-2012. Untuk mengkaji hubungan ini, teori pengeluaran dan model siri masa, ARDL digunakan. Keputusan kajian menunjukkan bahawa setiap data pegun pada pembezaan pertama bagi paras keyakinan 5%. Ujian diagnostik juga menunjukkan bahawa tiada hubungan persamaan di kalangan pembolehubah yang dikaji (iaitu di antara pengeluaran dan faktor-faktor pengeluaran). Kajian yang menggunakan pendekatan 'bound test' menunjukkan bahawa wujudnya hubungan jangka masa panjang terhadap faktor-faktor pengeluaran di dalam sektor elektrik.

Kata kunci: Faktor-faktor Pengeluaran, Sektor Elektrik, Ujian Kepegunan, 'Bound Test', Malaysia.

INTRODUCTION

Many people think of production as highly structured, often mechanical process whereby raw materials are transformed into finished goods. Economists emphasize that production is also much more general concept, encompassing many activities not ordinarily thought as such. Frank (2008) defined it as any activity that creates present of future utility. Equation (1) shows that the relationship between inputs and outputs is formalized by a production function of the form,[1]

$$Q = f(k, l, m, \ldots \ldots) \quad [1]$$

[1] Refer to Microeconomic Theory : Basic Principles and Extensions (Walter Nicholson)

Where *q* represents the firm's output of a particular good during a period, *k* represents the machine usage during the period, *l* represents hours of labour input, m represents raw materials used, and the notation indicates the possibility of other variables affecting the production process.[2]

Production is the process through which inputs are combined and transformed into output. Economists often distinguish between production in both the short run and the long run. The short run is a period of time over which one or more inputs are fixed. The long run is a period of time over which all inputs are variable.[3] Most outputs can be produced by a number of different techniques. However, in order to analyze the most appropriate technology, the researchers used the concept of elasticity of substitution to determine the suitable factors that will be utilized in the production. Generally, firms will use labour and capital as their resources to produce goods and services. Sometimes, the producers cannot identify the appropriate resources that will used to maximize production.

Previous empirical studies show that substitution elasticities are generally a function of the percentage changes in factor price as well as relevant cross price elasticities. Morishima (1967) revealed that the elasticity allows only one input price to change but Mundlack (1968) showed and classified it as a two inputs, one price elasticities. McFadden (1963) explained that the elasticity is a shadow elasticity which holds cost constant (Thompson, 1997).

The parametric cost function approach allows the researcher to investigate scale economies. Akkemik (2008) studied the cost function in the Turkish electricity generation sector by estimating elasticities using long-run and short-run translog cost function. He aimed to estimate the scale economies and the extent of over capitalization in the electricity generation sector.

Stern (1997) revealed that energy is also an essential factor of production. All production involves the transformation or movement of matter in some way and all such transformations require energy (Stern, 2004). As we know, using the production theory, capital and labour are easier to measure but this measurement is still very imperfect compared to that energy (Stern, 1999). Thus, the energy plays an important role in the industries, including the electricity sector. Furthermore, The Ninth Plan strengthens the initiatives for energy efficiency and renewable energy that focused on better utilisation of energy resources (Ninth Malaysian Plan, 2006). Therefore, the primary aim of this paper is to establish, from observations in the electricity sector in Malaysia for the 1980-2012 period, the long-run relationship between production and its production factors (capital, labour and energy) in the Malaysian electricity industry. The importance of this study is verified and confirmed the result using the theory of production function (including energy) to test the long-run equilibrium relationship, a case study in the electricity industry in Malaysia. Also, the result could be used to identify the importance of energy in the industry, especially in the electricity sector.

The rest of the paper is organized as follows. Section 2 reviews the electricity sector, focusing on the background and the growth rate of the electricity sector in Malaysia. Section 3 reviews the previous literature related to the current study. Section 4 defines the data, variables and methodology used in this study. Section 5 presents the result and analysis. In Section 6, we discuss the policy implications of the results. Finally, section 7 summarizes some conclusions and suggests recommendations and further studies.

OVERVIEW OF ELECTRICITY SECTOR

The electricity sector is one of the most important sectors in any agency as it provides electricity service to all sectors. For instance, the electrical and electronics (E&E) industry is the leading sector in Malaysia's manufacturing sector, contributing significantly to the country's manufacturing output, exports and employment are 26.94%, 48.7% and 32.5%, respectively (MIDA, 2013).

For many years, it can be seen that the development of the electricity sector recorded earlier in Malaysia in terms of power generation can be traced from a small mining town in Rawang, Selangor. The history of electricity started when two enterprising individuals, Loke Yew and Thamboosamy Pillai installed an electric generator in 1894 to operate their mines. In 1895, the railway stations in Kuala Lumpur received its first electricity supply. Then in year 1900, the Sempam Hydroelectric Power Station in Raub, built by the Raub Australian Gold Mining Company became the first power station in Malaysia.

In the mid-twenties of the 20th century, the Central Electricity Board (CEB) was established and came into operation on 1 September 1949. Then, on 22 June 1965, Central Electricity Board (CEB) of the Federation of Malaya was renamed as the National Electricity Board (NEB) of the States of

[2] Refer to Microeconomic Theory : Basic Principles and Extensions (Walter Nicholson)
[3] Refer to Microeconomics (Bernheim & Whinston)

Malaya. One of the plans, called the National Grid, was the primary electricity providing transmission network linking the electricity generation, transmission, distribution and consumption in Malaysia.

By 1980, the Board was supplying the whole Peninsular with electricity services. By 1984, the installed electricity capacity had more than doubled to 1379.2 MW exceeding peak demand by a healthy margin. Then, on 1 September 1990, the Prime Minister Dato' Seri Dr. Mahathir Mohamad officially proclaimed TNB (Tenaga Nasional Berhad) a private company wholly owned by the government.

Electricity is produced in power stations which are normally situated away from urban and industrial areas where the power is required by the consumers. Electricity generated in the power stations is transmitted by high voltage electricity supply lines from power stations to electrical substations and then distributed at lower voltages from the substations to the consumers (http://www.st.gov.my).

In Malaysia, the high voltage supply lines in the Peninsula are owned and operated by Tenaga Nasional Berhad (TNB) while those in Sabah and Sarawak are run by Sabah Electricity Sdn. Bhd. (SESB) and Sarawak Electricity Supply Corporation (SESCO) respectively (http://www.st.gov.my). Tenaga Nasional Berhad (TNB) is the largest electricity utility in Malaysia with almost RM73 billion in assets (TNB, Annual Report, 2011).

Ministry of Energy, Green Technology and Water (KeTTHA) is the federal ministry in charge of electricity portfolio for Peninsular Malaysia and Sabah (www.awer.org.my). This institution is focused in policy development and assisted by Energy Commission to regulate the electricity industry as well as end users (www.awer.org.my). Therefore, the 10th Malaysian Plan has developed the policy which aims to encompass energy security and economic efficiency as well as environmental and social considerations.

Though, the growth rate of sales revenue (in RM Million) for TNB and energy use has increased by 11% and 6%, respectively, for the 1980-2012 period (See Figure 1 and Figure 4). These growth rates indicating that the electricity as an important input in various production sectors and showing how important the final product is for consumers with a presumably low price elasticity of demand (Akkemik, 2009). This means that the electricity industry is of vital importance to the economy, together with energy.

Additionally, the growth rate of the labours (in working hours) for TNB is 1% for the 1980-2012 period (See Figure 2). As we know, the TNB is largest electricity utility and this company are listed on the main board of Bursa Malaysia. Annual Report TNB (2011) reported that the TNB employed more than 31,000 people Group-wide to serve an estimated 8.08 million customers in Peninsular Malaysia, Sabah and Labuan. Furthermore, the growth rate of Gross Fixed Capital Formation (GFCF) is 5%, for the 1980-2012 period (See Figure 3). These results indicate that, over the years, the capital is seen as one of the most important factors used in the electricity sector. Gross fixed capital formation (formerly a gross domestic fixed investment) includes land improvements (fences, ditches, drains); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings (http://www.tradingeconomics.com).

Then, the analysis will become interesting to establish the relationship among these variables (production, capital, labour and energy) as an evidence for the production function theory in the electricity industry in Malaysia. In that case, the researchers could extend this study to become more effective to provide the results for decision makers and researchers.

LITERATURE REVIEW

The current paper proposed to analyze the relationship between capital and labour in the production of the electricity sector in Malaysia for the 1980-2012 period. Many studies have examined the factors of production in the industrial sector. For example, Al-Mutairi & Burney (2002) examined the crude oil industry in Kuwait. They analyzed the factor substitution between capital and labour using elasticity of substitution. They found that the two inputs (i.e capital and labour) are substituted. The result also indicated the existence of diseconomies of scale in the production of crude oil.

Antony (2009) discussed the elasticity of substitution between capital and labour using the production function for two types of country; developed country and developing country. The result shows that the developed country enjoyed a higher elasticity of substitution while the developing country was unable to do so due to the choice of technology. This has important implications for a variety of economic issues.

Other empirical studies have also analyzed the elasticity of substitution using the production function and cost function. Juselius (2008), proposed an indirect method for making empirical inference on the elasticity of substitution between capital and labour. A negative long-run relationship between real manufacturing wages and the capital-labour share was established. The evidence was further strengthened by a positive relationship between the real interest rate and real wages. Akkemik (2009) estimated cost functions and investigated the degree of scale economies, overinvestment, and technological progress in the Turkish electricity generation sector for the 1984-2006 period using long-run and short-run translog cost functions. Estimations were done in six groups of firms, public and private. Overall, it was found that the regulation of the market under the newly established regulating agency after 2002 was effective and there were potential gains from such regulation. Jones (2008) discussed the elasticity of substitution between production factors related to the change in the ratio of the factors used in a production process to a given change in the factor price ratio. An aggregate concept such as elasticity relates a change in overall factor endowments to the resulting change in factor prices. The aggregate elasticity of substitution was shown to be an average of production elasticity and demand elasticity.

One of the production theories used to estimate the elasticity of substitution is constant elasticity of substitution (CES) production. Nakamura (2009) considered an increase in the range of capital use as a form mechanization. A CES production function is dynamically derived from Leontief production functions through the endogenous complementary relationship between capital accumulation and mechanization. This implies that a CES production function can be resolved into technological change that does not involve changes in total factor productivity (Nakamura, 2009). Caloghirou et al. (1997) examined the factor substitution in Greek manufacturing during the 1980s. They used pooled data in static and dynamics translog expenditure share models. The inputs are capital, labour, electricity and no-electricity energy (liquid, solid, gas). The results indicate substitutability among factors in the short run. Meanwhile, in the long run, electricity and capital complements are labour and non-electrical energy.

Thompson (2006) reviewed the applied theory of energy cross price partial elasticities of substitution and presented it in a transparent fashion. The methodology used was log linear, translog production and cost functions due to their economic properties and convenient estimating forms, but the theory applies other functioning forms. However, we can also relate ways and means of analyzing the interactions between energy and capital or labour. Gunn (1997) reviewed the diverse commentaries in New Zealand's ongoing electricity sector reform process, within the context of government's energy policy objective. Therefore, the purpose of this study is to highlight the interactions between the concepts of energy and economic efficiency. Furthermore, Welsch & Ochen (2005) revealed the determinants of production-related energy used in West Germany in the 1976-1994 period. The approach was to estimate a system of share equations of energy, capital, low skilled labour, high skilled labour and materials in the West German production sector, taking account of biased technological change and increasing trade orientation.

The majority of empirical studies used the elasticity of substitution in the production function to estimate the relationship between capital and labour. Other studies have focused on the sector level, for example manufacturing. Other studies have also analyzed the elasticity of substitution in the macroeconomic issues. Our study will analyze the production factors in electricity sector focusing on Tenaga Nasional Berhad (TNB), Malaysia. However, the current study focuses on the production theory to analyze the presence of the long-run relationship between production and its production factors (capital, labour, energy). This result will help policy makers get better information for policy formulation.

DATA AND METHODOLOGY

Data Sources

In the current study, annual data for the (1980-2012) period is used. The analysis is based on time series data for the electricity sector production (Q), capital (K), labour (L) and energy (E). For the production, sales revenue (in Malaysian currency, RM Million) is used and extracted from Annual Report TNB, Malaysia. While employed the Gross Fixed Capital Formation (GFCF) is a proxy for capital, taken from Department of Statistics Malaysia (DOSM, 2010). The GFCF was calculated at constant price (2000 as a base year). For labour, we used number of workers in hours hired by TNB including all subsidiaries under TNB. Instead of that, the energy data applied as a total energy in an industrial were extracted from National Energy Balance (2010). This data is measured in kilo tonnes of oil equivalent (ktoe). We also used the technology (T) as the variable, which indicates that when time is increased, the new technology will be introduced. We used Tenaga Nasional Berhad (TNB) in Malaysia to present the electricity sector. This is because TNB is the biggest power producer in Malaysia, providing approximately 60% of total electricity production.

Methodology

Many researchers assume that firms have a type of production function. This idea was first introduced by mathematician Charles Cobb and economist (US Senator) Paul Douglas (Bernheim & Whinston, 2008). The firm's production function describes the output (Q) as a function of capital (K), labour (L), energy (E) and technology (T) as follows:

$Q = f(K, L, E, T)$, where, Q, K, L, E and T represent the output, capital, labour, E energy and technology respectively.

Cobb-Douglas linear production function is a useful starting place for this study because of its economics and estimating properties depend on the estimated parameters (Thompson, 2006). The production theory is used which was presented by Ghali and El-Sakka (2004), Soytas and Sari (2007) and Yuan et al. (2009). This function can be presented as in Equation [2].

$$Q = A(t)K^{\propto}L^{\beta}E^{\gamma} \quad [2]$$

A (*t*) has a positive derivative, $\frac{dA}{dt} > 0$ indicating that with a higher technology *t* the same inputs produce more output (Thompson, 2006). The estimated coefficients α, β and γ are represents the elasticities of capital, labour and energy, respectively.

For the purpose of this study, all the data was expressed in logarithms indicating that each of the estimated coefficients represents the elasticity. Also, transforming Equation [2] into log linear form as in Equation [3]. The E-views Microsoft package (Version 8) is used for the current paper.

$$InQ = InA(t) + \propto InK + \beta InL + \gamma InE + \varepsilon \quad [3]$$

Unit Root Test

As a result of the importance of stationary properties, Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are applied to find the existence of unit roots and robustness for each variables. The purpose of these tests is to make sure that the individual variables used in this study are stationary and to determine whether they are integrated or not. The result could be spurious regression, if the test is non-stationary series. The null and the alternatives hypothesis for the existence of unit root for variable X_{ti} (K, L and E) are;

H_0: $\delta = 0$ (X_{ti} is non-stationary or contains a unit root)
H_1: $\delta < 0$ (X_{ti} is stationary or non-unit root)

Then, if the value of ADF or PP tests statistic is less than critical value, the null hypothesis will be rejected. In other words, if the estimated value for δ is significantly less than zero, the series is stationary. Otherwise, the time series have a unit root process. Some studies confirmed that, the economic variables are likely to be stationary in the first difference, *I(1),* for most economic variables (Tang, 2009).

Bound testing approach

The current paper presents the Autoregressive Distributed Lag (ARDL) model for bound test approach that proposed by Pesaran et al. (20011) to examine the long-run relationship among the variables. This model is appropriate and popular to use because of several reasons compared to the Engle and Granger (1987) and the Johansen and Juselius (1990) [Pesaran *et al*., 2001]. First, this procedure is useful to test long-run relationship when the dataset is small. Second, there is no restriction imposed on the order of integration among variables in levels irrespective of whether the underlying regressors are *I(0)* or *I(1)*.

Third, this procedure is relevant when the explanatory variables are endogenous, and is sufficient to simultaneously correct for residual serial correlation (Law, 2008).

Therefore, to analyze the long-run relationship, the ARDL model or unrestricted error correction model (UECM) as in Equation (4) is used.

$$\Delta InQ_t = c + \beta_1 InQ_{t-1} + \beta_2 \, In \, K_{t-1} + \beta_3 \, In \, L_{t-1} + \beta_4 \, In \, E_{t-1} + \sum_{i=1}^{p} \propto_{1i} \Delta \, In \, Q_{t-i} + \sum_{i=0}^{p} \propto_{2i} \Delta \, In \, K_{t-i} + \sum_{i=0}^{p} \propto_{3i} \Delta \, In \, L_{t-i} + \sum_{i=0}^{p} \propto_{4i} \Delta \, In \, E_{t-i} + \varepsilon_t \quad [4]$$

Where, Δ is the first difference operator and ε_t is an error term. From the estimation of UECM, the long-run elasticities are the coefficient of the one lagged explanotary variable (Law, 2008) in Equation [4]. Therefore, the coefficients of all explanotary variables in Equation [4] are restricted to find the long-run relationship using Wald test (F-statistics). The null and alternative hypotheses are as follows:

$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$ (no long-run relationship)
$H_1: \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq 0$ (a long-run relationship exists)

The computed Wald test value compared to critical values in table Case III of Narayan (2005). According to Pesaran *et al*. (2001), the lower bound critical values assume that the explanatory variables, x_{ti} are integrated order zero, I(0), while the upper bound critical values assume that the x_t are integrated of order one, *I(1)*. If F-statistics is greater than the upper bound critical values, *I(1)*, there is a long-run relationship between the production of the electricity sector and its production factors. Meanwhile, if F-statistics is smaller than lower bound critical values, *I(0)*, we failed to reject H_0, which means that no long-run relationship among variables.

RESULT ANALYSIS

Stationarity Test

As we have already stated, the estimation of unit root test for stationarity requires an examination of the ADF and PP tests on all variables used. If all of the series is non-stationary in levels, *I(0)*, they should be stationary in first difference I(1) or second difference I(2).

Therefore, Table 1 reveals the results of the unit root tests for the four variables in the logarithms form, which are lnQ, lnK, InL and lnK. Also it shows that all the variables are stationary at first difference. This implies that we have to reject the null hypothesis, because the test values for both tests (ADF & PP) are less than the critical value at 1% level of significance.

Bound Testing

The results of the OLS estimation for Equation [4] show that the goodness-of-fit of the specification, R^2 and adjusted R^2, are 80% and 62%, respectively. Using Hendry's general-to-specific method, the model is confirmed by diagnostics test, the Breusch-Godfrey serial correlation Lagrance multiplier test. This test reveals that the residuals are serial uncorrelated among the variables (See Table 2).

Meanwhile, the Table 3 shows the result of the bounds test for co-integration analysis. Using the critical values from Narayan (2005), the null hypothesis of no long-run relationship among production and its production factors in the electricity sector, is rejected at the 5 percent significant level. The computed F-statistics of this model (7.905843) are greater than the upper bound critical value from Narayan (2005). This result indicates the steady-state long-run relationship among production, capital, labour and energy in the electricity sector.

POLICY IMPLICATIONS

This study tests the relationship among the variables of production theory in the Malaysian electricity sector. The ARDL model is used to find out the relationship between production (output) and its determinants. The results showed that there is a co-integration, long-run relationship, between the production and its determinants including energy. This result is consistent with earlier findings (Juselius, 2008) but his study focused on the relationship between capital and labour only. The result also relevant to the TNB Company because TNB has powered national development efforts for more than 60 years by providing reliable and efficient electricity services (TNB, Annual Report, 2011). Therefore, TNB is the largest electricity utility company in Malaysia with estimated RM73 billion worth in assets (http://www.tnb.com.my).

Over the years, TNB has diversified from its core business into the manufacture of transformers, high voltage switchgears and cables; the provision of professional consultancy services; and architectural, civil, electrical engineering works and services, repair and maintenance. The company also engages in research and development, property development and management services. The TNB also takes the opportunities making inroads into emerging markets in the region as well as in the Middle East (TNB, Annual Report TNB, 2011). The major aim of this paper is to give an initiative about the electricity production. Then, we have to explore other methods to make the production theory applicable to all companies in Malaysia. Consequently, the effectiveness of production in terms of various inputs can be planned.

CONCLUSION AND RECOMMENDATION

This paper examines the production theory in the electricity sector for the (1980-2012) period. The electricity production (sales revenue in RM Millions), capital (GFCF in RM Millions), labour (working hours) and energy use (ktoe) variables were transformed into logarithms form and were used for testing and estimating the long-run relationship using UECM. The results reveal that there is a long and dynamic relationship between the production, capital, labour and energy variables. For further study, it is recommended to extend the terms of methodology by using the long-run and short-run relationship. Also a survey on other factors (such a low skilled labour, and high skilled labour) should also be done. Furthermore, we can explore another method to analyze the electricity production and its factors. The broadened analysis will help other researchers and policy maker to sketch appropriate policy, particularly in the electricity sector.

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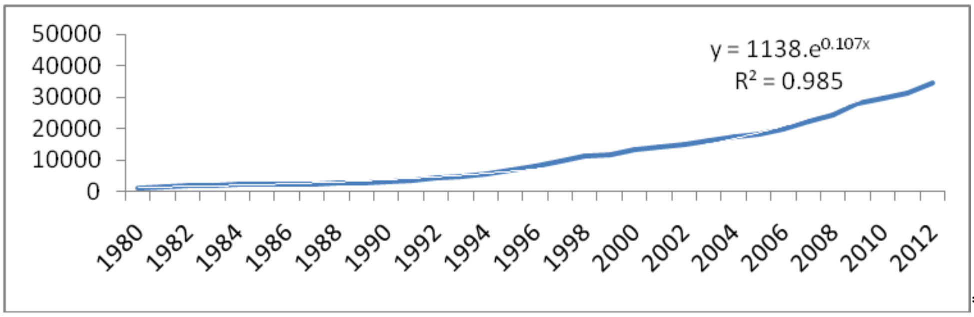
FIGURE 1**:** Electricity Production for 1980 – 2012 (RM Million)



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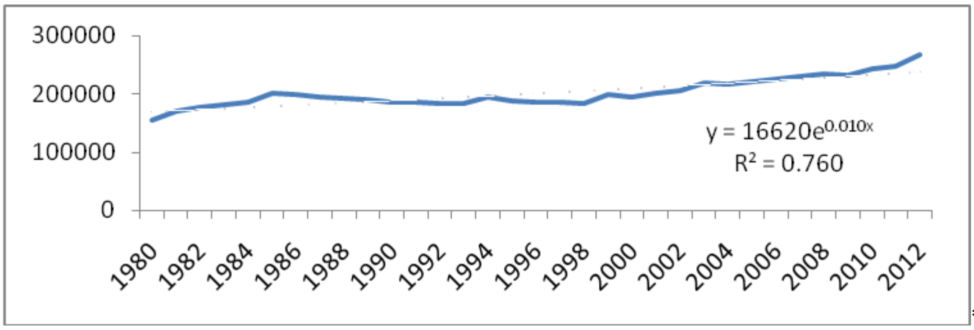
Source: TNB (1980-2012), Annual Report TNB (Performance Highlights), Malaysia

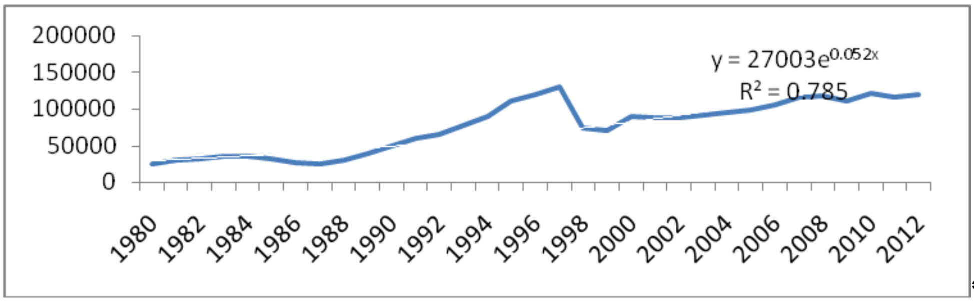
FIGURE 2: Labour for TNB (1980 – 2012)



*

Source: TNB (1980-2012), Annual Report TNB (Performance Highlights), Malaysia

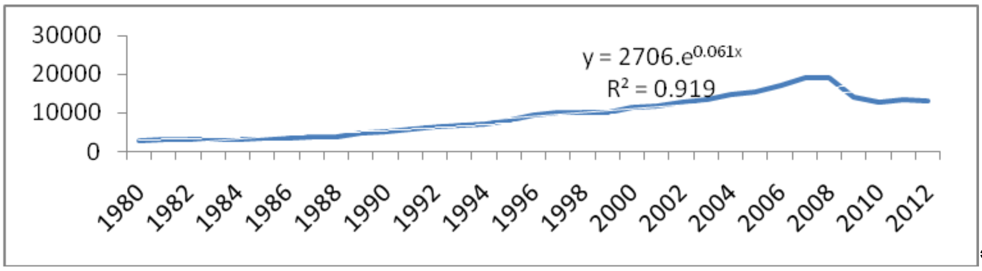
FIGURE 3: GFCF of Electricity Industry for 1980-2012 (RM)



*

Note 1: Data 2011 & 2012 estimating using mean.
Source: DOSM (2010).

FIGURE 4: Total Energy Use in Electricity Industry for 1980-2012 (ktoe).



*

Note 2: Data 2011 & 2012 estimating using mean.
Source: National Energy Balance, Malaysia (2010)

TABLE 1: Unit Root test for stationarity.

	At First Difference			
	ADF		PP	
	Intercept	Intercept and trend	Intercept	Intercept and trend
lnQ	*-5.663	*-5.377	*-5.499	*-5.263
lnK	*-4.079	**-4.032	*-4.017	**-3.965
lnL	*-5.638	*-5.591	*-5.634	*-5.622
InE	*-3.885	***-3.501	*-3.912	**-4.002

Notes: (1) *it means that the value test less (<) than critical value at 1%; (2) **it means that the value test less (<) than critical value at 5%; (3) ***it means that the value test less (<) than critical value at 10%.

Source: Output of the Eviews package, Version 8.0.

TABLE 2: Serial Correlation Test.

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.361	Prob. F(3,12)	0.302
Obs*R-squared	7.617	Prob. Chi-Square(3)	0.055

TABLE 3: F-Statistics for testing the existence of long-run co-integration.

Model	F-statistics	
Model : Q = *f*(K,L,E)	7.906**	
Narayan (2005) Critical Value	Lower bound	Upper Bound
1%	5.333	7.063
5%	3.710	5.018
10%	3.008	4.150

Note: **denote significant at 5% levels. Critical values are obtained from Narayan (2005)