European Journal of Economic and Financial Research
ISSN: 2501-9430
ISSN-L: 2501-9430
Available on-line at: http://www.oapub.org/soc

DOI: 10.46827/ejefr.v6i4.1372 Volume 6 │ Issue 4 │ 2022

DISAGGREGATED ENERGY CONSUMPTION AND INDUSTRIAL OUTPUT IN THE PHILIPPINE ECONOMY: EVIDENCE FROM THE PERIOD 1978 – 2006

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Abstract:
This paper examines the relationship between energy consumption and industrial output for 1978-2006. The study used Ordinary Least Square (OLS) to test the relationship of Energy Consumption by sources to Industrial Output. Results revealed that oil, coal, and geothermal are the sources of energy that significantly affect industrial output. Oil, coal, and geothermal positively affect industrial output at a 5 percent significant level.

JEL: N70; O10; O13; Q40

Keywords: energy consumption by sources (oil, coal, hydro, and geo), industrial output, Ordinary Least Square (OLS)

1. Introduction

Energy is frequently referred to as a development catalyst. According to Rogner and Popescu (2001), energy is necessary for long-term development and economic growth. The availability and efficient utilization of energy resources, labor, and capital inputs determine the level of industrial output. The importance of energy in the manufacturing process prompts researchers to investigate the relationship between energy consumption and economic growth.

The impact of energy consumption on economic growth has recently piqued the interest of economists and policymakers. According to Erbaykal (2008), the 1970s oil crisis demonstrated the importance of energy as a production factor.

Since then, energy has emerged as a production factor alongside labor and capital. Today, most people, including the industrial sector, use energy as a major input in production. Energy is critical to the operation of the industrial sector, particularly in

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energy-intensive industries like manufacturing and processing. Industrial sectors such as manufacturing and processing consume a large portion of the country's total energy consumption. The conversion of raw materials into industrial materials such as steel, aluminum, glass, or petroleum products necessitates significant energy (Production system technology, 1992). According to Todaro (1985), energy is the foundation of modern industrial economies. Third-world countries like the Philippines rely heavily on oil as a fuel source in their expanding industrial economies.

"*Energy is critical to nation-building*", Secretary Raphael P. Lotilla stated during the 17th National Statistics Month (NSM) opening ceremonies in October 2006. In terms of GDP contribution, the Philippines' three most important economic sectors are industry, services, and agriculture. In recent years, the services sector has shown consistent growth, whereas the agriculture sector, while still significant, has been declining. According to 1997 data, the agriculture sector contributed 20% of GDP, the industrial sector contributed 32%, and the services sector dominated the economy with 48% of GDP (http://www.nationsencyclopedia.com).

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The industrial sector accounted for 31.3 percent of the Philippines' GDP in 2010, and the country had an advanced development economy, with a GDP (PPP) of 188.719 billion in 2010. As a newly industrialized economy, it was ranked 32nd in the world. The Philippines' economy continues to rely heavily on agriculture, but it is increasingly dominated by the manufacturing and service sectors (http://economywatch.com).

For example, breaking into the source of oil is an important component of the country's energy consumption. The huge amount of money spent to import crude oil and how an increase in petroleum prices and LPG shortage affect the smooth operation of many businesses in the country demonstrate the importance of fossil energy (Kwakwa 2012). According to the Department of Energy (DOE), Philippine oil prices increased the country's oil import bill by 18% to $3.16 billion in the first three months of 2011, up from $2.67 billion in the same period last year. This increase comes despite a 9% drop in the volume of crude oil and finished petroleum products imported in the first quarter of 2011 to 30.22 million barrels, down from 33.267 million barrels the previous year. The 30.22 million barrels contain 18.45 percent crude oil (61 percent), and 11.773 percent finished petroleum product (39 percent).

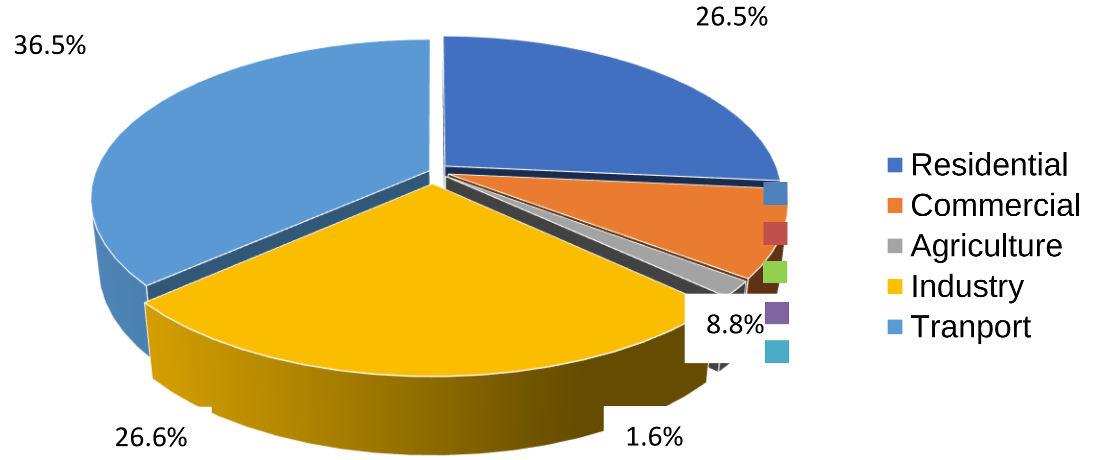
Meanwhile, the country's export earnings increased by nearly 83 percent in the first quarter, to $437.1 million from $239.2 million the previous year. Export volume increased by 47 percent to 4.245 million barrels, up from 2.896 million barrels the previous year. Thus, total net export earnings from crude and petroleum oil were $2.725 billion in the first quarter of this year, up from $2.43 billion in the same period last year (http://business.inquirer.net).

In the Philippines, geothermal energy accounts for approximately 27 percent of total electricity production generated by power plants. Geothermal plants are abundant on the islands of Luzon, Negros, Mindanao, and Leyte. Electricity generated by geothermal plants is less expensive than electricity generated by natural gas and coal. It is even less expensive than hydroelectric power (http://www.philippines.hvu.nl). As of 2010, the Philippines was the world's second-largest geothermal energy developer (http://www.renewablepowernews.com). The Philippines' reliance on imported fossil fuels for power generation makes the country vulnerable to price shocks in international markets. Although significant indigenous geothermal resources are being fully developed, imported fossil fuels will continue to dominate the energy mix until this occurs. Despite the fact that current electricity generation is sufficient to meet demand, export capacity is limited, and the country's expansion of generating capacity is primarily focused on coal power. The country's hydroelectric generation plants are suffering as reservoir levels fall. Power plant instability is becoming a problem in several grids, most notably the Luzon grid, which recorded a 236 MW generation deficit on March 3rd, 2010 (http://www.reegle.info).

The Philippines partially derives approximately 3,367 MWh from its hydropower plant resources through five mini-hydropower contracts. Eleven hydropower plants with a combined capacity of 300 MW are being built. Because of the abundance of water resources, hydropower is an important part of the energy sector. However, the large initial investments, lengthy construction periods, and associated environmental concerns have tainted some of its appeals. The DOE estimates that the potential for small hydro is around 1,300 MW (http://cigrasp.pik-potsdam.de).

According to the Department of Energy, the Philippines' industrial sector is one of the largest energy users, second only to the transportation sector (see Figure 1), consuming approximately 26.6 percent of total energy consumption in 2008. (DOE). As of 2012, it accounted for 31.5 percent of the country's GDP (http://indexmundi.com). According to the same figure, residential accounts for approximately 26.5 percent of total energy consumption, commercial accounts for 8.8 percent, agriculture accounts for 1.6 percent, and transportation accounts for 36.5 percent of total energy consumption.

Figure 1: Total final energy consumption by sector in 2008



Source: Department of Energy.

2. Objectives of the Study

The main objective of this study is to determine the relationship between disaggregated energy consumption and industrial output in the Philippines. Specifically, this study aims;

1) To present the trends of energy consumption and industrial output in the Philippines from the period 1978 to 2006; and
2) To provide empirical evidence of the relationship between energy consumption and industrial output.

3. Methodology

3.1 Conceptual Framework

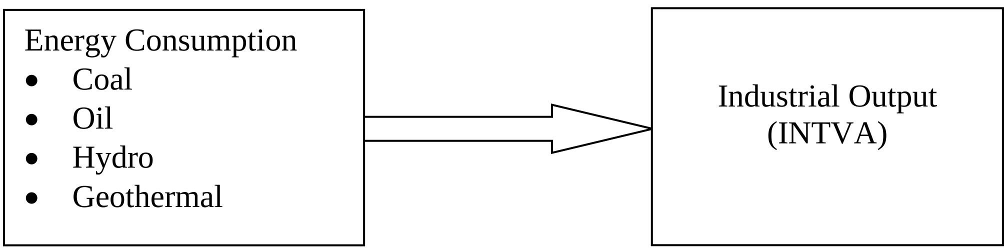


Figure 3: Possible relationships between energy consumption and industrial output

GDP growth in a country is typically used as an indicator of economic development because it includes the output of all different sectors of the economy. Agriculture, residential, services, commercial, transportation, and industrial sectors contribute to the country's GDP. The industrial sector is one of the largest contributors to the country's GDP, accounting for approximately 31.5 percent of the total GDP in 2012 (http://indexmundi.com). According to Qazi et al. (2012), one of the primary reasons for the industrial sector's downturn is a lack of energy, particularly in large-scale manufacturing.

Energy is a major production input, particularly in the industrial sector; Jeremy Rifkin confirmed that machines and inanimate forms of energy were used to boost production from the beginning of the Industrial Revolution. On the other hand, industrial production measures changes in output for the economy's industrial sector, including manufacturing, mining, and utilities. Industrial output is a key indicator for economic forecasting. It is frequently used to gauge inflationary pressures because high industrial production levels can cause price fluctuations. Figure 3 depicts the potential relationship between industrial output and energy consumption (oil, coal, hydro, and geothermal).

3.2 Data Sources

This study used annual secondary data that covers the period 1978 to 2006. The data source for industry value added (in constant 2000 USD) was obtained from the World Bank indicator. The data for disaggregated energy consumption were obtained from the Philippine Statistical Yearbook (PSY) of the National Statistical Coordination Board (NSCB).

3.3 Economic Model

The economic model uses the following form:

$$Y = (X_1, X_2, X_3, X_4,) \qquad (1)$$

Where;
Y = Industrial Value Added (INTVA);
X_1 = coal;
X_2 = oil;
X_3 = hydro;
X_4 = geothermal.

The Ordinary Least Square (OLS) method is used to estimate the values of the parameters. Ordinary Least Square is a method that determines the estimate by minimizing the sum of the squared residuals (the difference between the predicted and the observed values). Estimates are best linear unbiased estimators (BLUE) if the following assumptions are satisfied.

a) $E(\varepsilon) = 0$

This implies that the mean of the error terms is zero.

b) $Var(\varepsilon) = \sigma^2$

This is the property of homoscedasticity, i.e., that the errors have a common variance.

c) Cov (ε_i,ε_j) = 0 where i ≠ j.

This is the property of no autocorrelation, i.e., no errors are serially correlated.

Regression analysis will convert the economic model (1) into the empirical model, explaining the influence and relationship between explanatory variables and dependent variables. The statistical techniques will determine the effect of the explanatory variables on the dependent variable, holding other variables constant (Hill *et al*., 1999).

The OLS estimator is consistent when the regressors are exogenous; there is no multicollinearity, and optimal in the class of the best linear unbiased estimators (BLUE) when the errors are homoscedastic uncorrelated. Under these conditions, the method of OLS provides minimum-variance mean-unbiased estimation when the errors have finite variance. Under the additional assumption that the errors be normally distributed, OLS is the maximum likelihood estimator (www.en.wikipedia.org).

Problems such as multicollinearity, heteroscedasticity, and autocorrelation exist when assumptions are violated. Adding more and more variables to the model would lead to a problem of multicollinearity because one variable might be related to other variables. In this case, there is no guarantee that the data will be "*rich in information*", nor will it be possible to isolate the economic relationship or parameters of interest (Hall, Griffiths, and Judge, 1997). When we have time-series data, the observations follow a natural ordering through time. There is always a possibility that successive errors will be correlated. This correlation between errors is called autocorrelation, which violates the third assumption. Autocorrelation could be detected either by the residual plot or by Durbin-Watson (DW) exact statistic. The DW statistics, D, are defined below.

$$D = \frac{\sum_{t=2}^{t=T}(\hat{e_t} - \hat{e_{t-1}})}{\sum_{t=2}^{t=T} \hat{e_t}^2}$$

Lastly, the problem of heteroscedasticity is also an important point to consider, which violates the second assumption. It usually occurs when we have cross-section data. If such problems exist, a generalized least squares (GLS) procedure must be applied to transform the model to eliminate the cause.

3.4 Empirical Estimation

Equation (1) is the basis for the model of the study. The empirical model is expressed as follows:

$$INTVA_i = \beta_0 + \beta_1 Coal + \beta_2 Oil + \beta_3 Hydro + \beta_4 Geo + \varepsilon, \qquad (2)$$

Where;

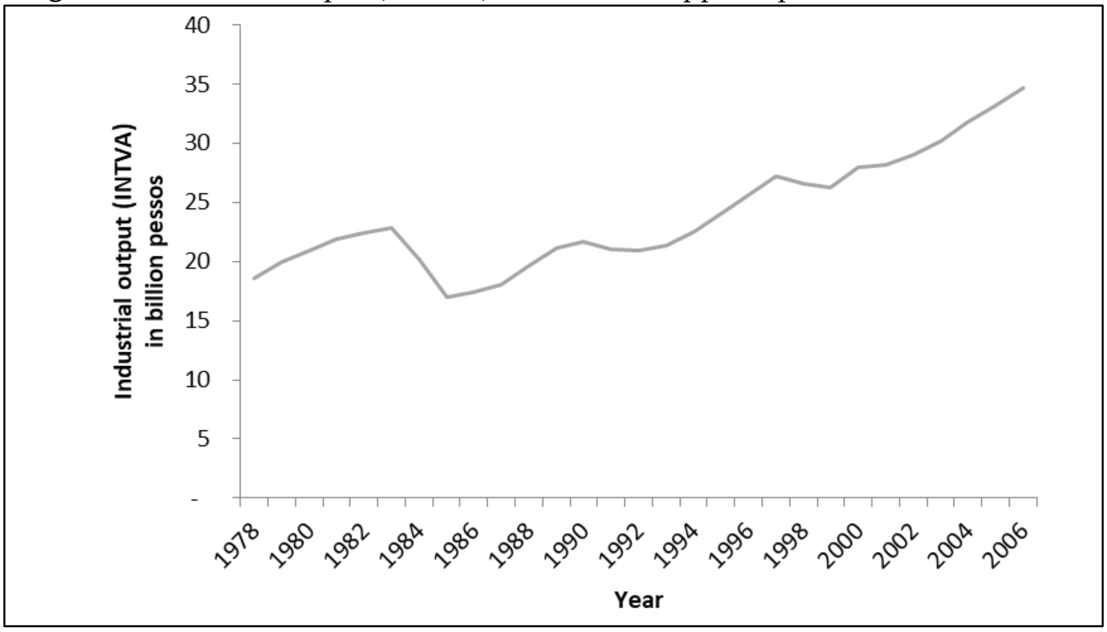
$INTVA_i$ = Industrial Value Added in constant 2000 USD;
Coal = coal in million barrels of Fuel-oil equivalent;
Oil = oil in a million barrels of Fuel-oil equivalent;
Hydro = hydro in a million barrels of Fuel-oil equivalent;
Geo = geothermal in a million barrels of Fuel-oil equivalent;
ε_i = error term.

4. Results and Discussion

This section presents a discussion of the results and findings of the study. This includes the presentation of the graphical plots and trends of the variables and the discussion of regression analysis estimates.

4.1 Graphical Presentation of the Variables

Figure 4: Industrial output (INTVA) in billion Philippines pesos from 1978 to 2006

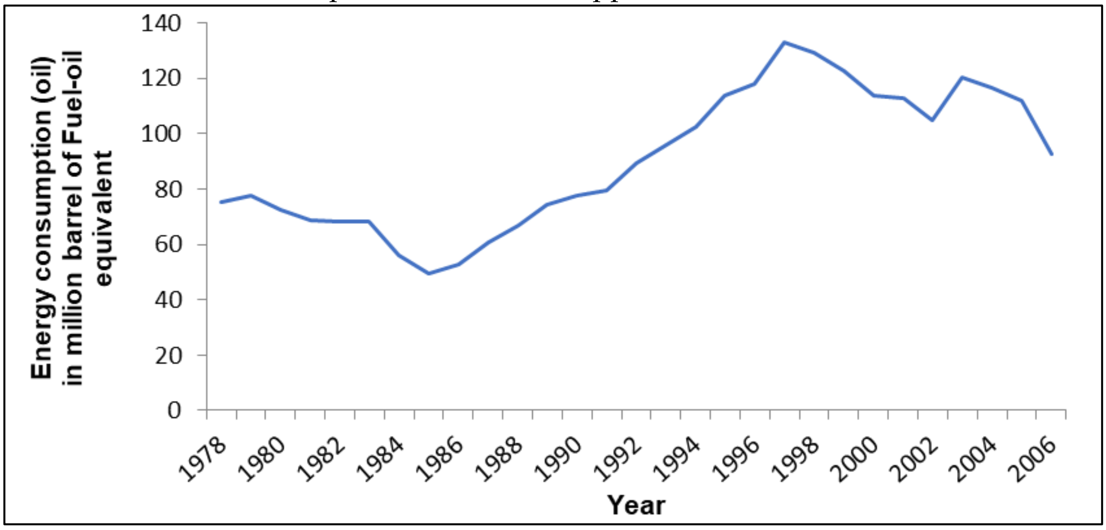


Source: World Bank.

During 1978-2009, the industrial output in the Philippines followed an increasing trend (see Figure 4). In 1983, however, there was a rapid downfall in industrial production until 1985. During that period, the decline in industrial output was attributed to the energy shortage. In the following year, the industry output returned to its trend and continued to increase until 2006. The energy shortage impacts industrial growth, especially a coal shortage, the highest contributor to the Philippine Energy Mix. The shutting down of the reserve units of coal-fired power plants like the Saul Power Station was due to the several power generating plants that were put into preventive maintenance that resulted simultaneously in a huge energy shortage. In the following years, the industrial sector could redeem its growth due to efficient energy sources, uplifting the maintenance of existing power plants, and ensuring the adequate supply of coal feedstock (Pangonilo, 2010).

Figure 5 presents the oil energy consumption in a million barrels of Fuel-oil equivalent of the Philippines from 1978 to 2006. During this period, oil consumption exhibits fluctuating behavior.

Figure 5: Energy consumption (Oil) in a million barrels of Fuel-oil equivalent of the Philippines from 1978 to 2006



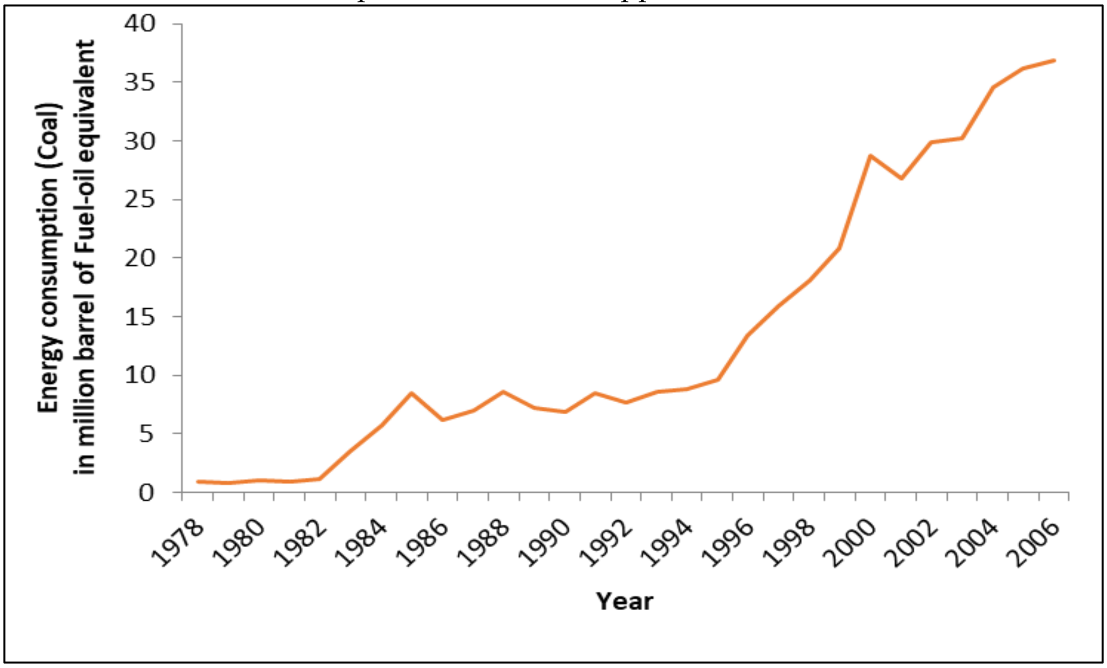
Source: PSY (Philippines Statistical Yearbook).

From 1978 to 1985, a decreasing trend in oil consumption in the country is observed, having an annual growth rate of -14.3 percent. One of the reasons cited for the decreasing oil consumption is the persistent increases in oil prices in the international market. In the succeeding years, however, oil consumption exhibited an increasing trend. From 1986 to 1997, oil consumption increased by 19.6 percent annually, increasing up to 132.92 million barrels of Fuel-oil equivalent in 1997. However, the volatility of oil prices in the world market from 1998 to 2006 brought oil consumption down to 92.5 million barrels of Fuel-oil equivalent.

As reported by the Department of Energy (DOE) Philippines ' oil prices increased the country's oil import bill. During the last years, the Philippines developed new offshore deepwater oil deposits. The country began to increase the production of oil; due to this, there was an increase in the consumption of oil in the country, according to Oil and Gas Journal (OGJ).

As presented in Figure 6, coal consumption in the Philippines exhibits an increasing behavior. Coal is the new gold, once ignored as coal-fueled power plants are not welcome due to their negative contribution to society. The majority of humanity is against plants. The increasing coal consumption in the country has been attributed to the development of our coal power plant using our coal production.

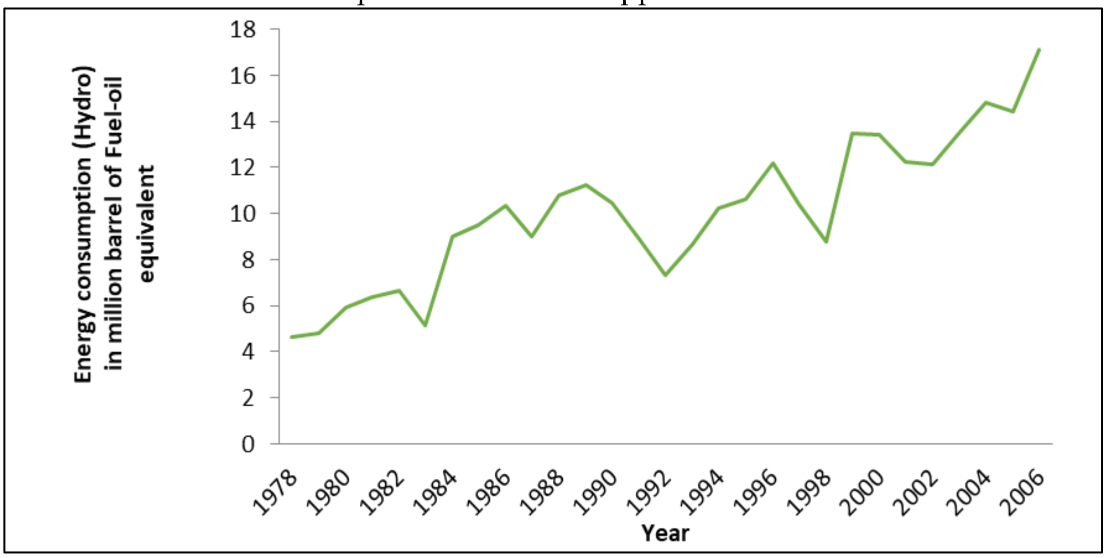
Figure 6: Energy consumption (Coal) in a million barrels of Fuel-oil equivalent of the Philippines from 1978-2006



Source: PSY (Philippines Statistical Yearbook)

The Philippines is estimated to have a total coal resource potential of 2.53 billion metric tons. Due to this, new coal-fired power plants were installed to supply the high energy demand. Hence, coal consumption revealed an increasing behavior from the year 1982 to 2006. The higher volatility of oil prices pushed industries to switch to coal as an alternative source of energy (http://malayan.com.ph).

Figure 7: Energy consumption (Hydro) in a million barrels of Fuel-oil equivalent of the Philippines from 1978-2006



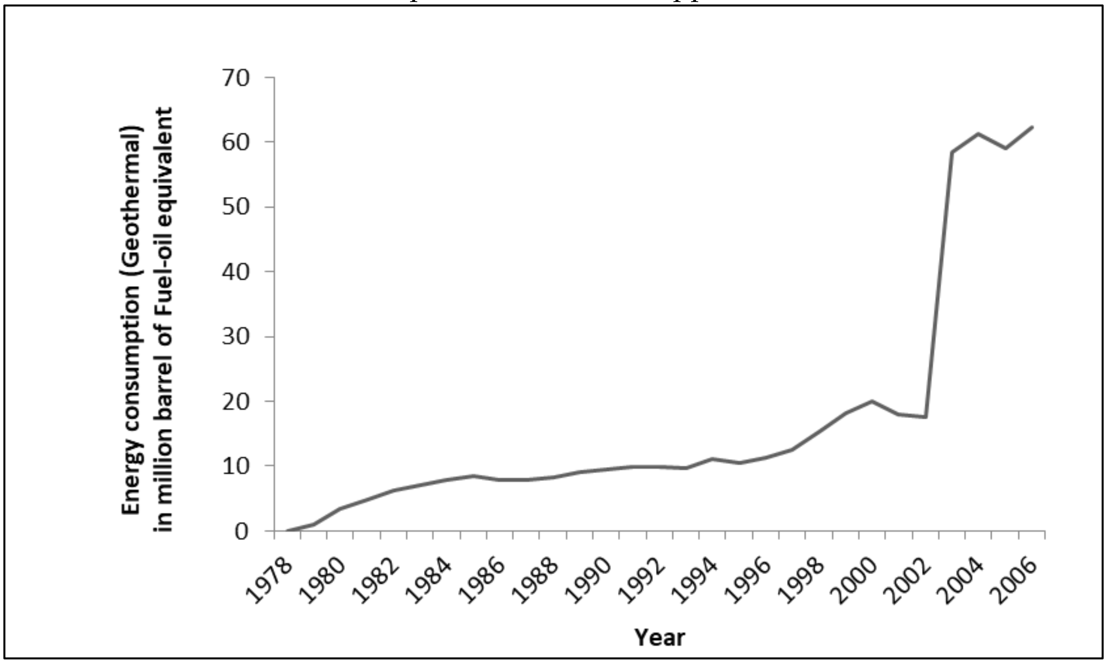
Source: PSY (Philippines Statistical Yearbook)

Figure 7 shows the behavior of the hydro energy consumption in a million barrels of Fuel-oil equivalent in the Philippines. As shown, hydro energy consumption presents a relatively erratic trend. The lowest consumption of hydro energy was in 1983, 1991, and 1998, with 5.12, 8.87, and 8.77 in a million barrels of Fuel-oil equivalent, respectively.

The Philippines has many hydroelectric power plants dispersedly located in various areas, such as the San Roque dam, which has a capacity of 85 MW. However, the sudden changes in the environment affect the water supply, which is the major input in the operation of all hydroelectric power plants all over the country, and significantly affects its production and consumption of it (http://www.squidoo.com).

Figure 8 presents the trend of the Philippines' geothermal energy consumption in a million barrels of Fuel-oil equivalent. An increasing Philippine energy consumption (Geothermal) behavior from 1978 to 2002 is observed. In 2003, geothermal energy consumption dramatically increased to 58.5 in a million barrels of Fuel-oil equivalent.

Figure 8: Energy consumption (Geothermal) in a million barrels of Fuel-oil equivalent of the Philippines from 1978-2006



Source: PSY (Philippines Statistical Yearbook)

In the World Geothermal Congress in the year 2000 announced that the Philippines was the largest consumer of electricity derived from geothermal sources and highlighted the potential role of geothermal energy in providing energy needs for developing countries. The Philippines is the second-largest supplier of geothermal energy, next to the United States. According to the Institute of Green Resources and Environment, the Philippines' geothermal energy provides 16 percent of the country's electricity. In 2005, geothermal energy accounted for 17.5 percent of the country's electricity production. Moreover, in 2006, the total installed capacity of geothermal power plants in the Philippines was around 12.5 percent based on DOE data; its actual contribution to the total electricity generated is about 18.42 percent.

4.2 Relationship of Energy Consumption by Sources to Industrial Output

A regression analysis using the Ordinary Least Square (OLS) method requires satisfying the underlying assumptions to obtain BLUE parameter estimates. These assumptions are:

a) $E(\varepsilon) = 0$

This implies that the mean of the error terms is zero.

b) $Var(\varepsilon) = \sigma^2$

This is the property of homoscedasticity, i.e., that the errors have a common variance.

c) $Cov(\varepsilon_i, \varepsilon_j) = 0$ where $i \neq j$.

This is the property of no autocorrelation, i.e., no errors are serially correlated.

In the study, it was found that there were no autocorrelation and heteroscedasticity in the model; hence the assumptions of Ordinary Least Square were not violated. Thus, Ordinary Least Square estimates are efficient and robust.

Table 1: Estimated coefficients of energy consumption and industrial output using Ordinary Least Square (OLS)

Variable Name	Estimated Coefficient	Standard Error	P-Value
Oil	0.606*	0.172	0.002
Coal	0.220*	0.813	0.012
Hydro	-0.254^{ns}	0.199	0.215
Geo	0.937*	0.351	0.013
Constant	16.381	1.999	0.000
R^2 = 0.9036; Ns Not significant; *significant at 5%			

The industrial value-added measures the industrial output as a dependent variable of energy consumption by sources, namely, oil, coal, hydro and geothermal. The estimated coefficients generated using the Ordinary Least Square are presented in Table 1. Results revealed that among the sources of energy, three of them can significantly affect the production of the industrial sector. Oil, coal, and geothermal energy are sources that significantly influence industrial output, as indicated in the p-value, which is less than the 5% alpha level.

The oil energy source posted a coefficient of 0.607, implying that a 1 unit increase in oil consumption (in a million barrels of Fuel-oil equivalent) causes industrial output to increase by 0.607 billion pesos. On the other hand, the coefficient concerning coal is 0.220.

A 1 unit increase in coal consumption (in a million barrels of Fuel-oil equivalent) causes the industrial output to increase by 0.220 in billion pesos. Further, the coefficient of geothermal is 0.937, implying that a 1 unit increase in the consumption of geothermal (in a million barrels of Fuel-oil equivalent) causes the industrial output to increase by 0.937 billion pesos. The model registered an R^2 of 0.9036, which indicates that the model explains 90.36 percent of the variation in industrial production. The remaining 9.64 percent is explained by the other factors not included in the study.

Moreover, based on the model, oil poses a positive coefficient sign which implies a positive relationship. This indicates that when the consumption of oil increases, industrial output also increases. Coal has a positive coefficient which implies a positive relationship suggesting that as consumption of coal increases, the industrial output also increases. Moreover, geothermal has a positive coefficient which implies a positive relationship. This means that as the consumption of geothermal increases, the industrial output also increases.

The result was empirically supported by Saksson (2009) and Adenikinji (2005), implying that increasing consumption of energy oil, coal, and geothermal will cause industrial output to increase. Sasson (2009) confirmed that today's prosperity in the industrial sector is through secure and stable access to energy.

5. Summary and Conclusions

This paper investigated the relationship between industrial output and energy consumption according to sources: oil, coal, hydro, and geo. It also examined the trend of the variable, including industrial value added (INTVA) and energy consumption by sources (oil, coal, hydro, and geo) in a million barrels of Fuel-oil equivalent that covers the period 1978 to 2006. The data for industrial value added was taken from the World Bank data indicators. On the other hand, data on energy consumption by sources (oil, coal, hydro, and geo) were obtained from the Philippines Statistical Yearbook (PSY) of the National Statistical Coordination Board (NSCB).

The result of the study revealed that among the sources of energy, oil, coal, and geothermal significantly affect the industrial output. It suggests that increasing oil, coal, and geothermal consumption in the Philippines can greatly boost the industrial sector's production output.

5.1 Recommendations

The Philippines has many potential energy resources but needs effort to fully utilize these sources because we are now experiencing an insufficient supply of energy as a source of electricity in the industrial sector. Hence, to give rise to better production of industrial output, the study formulates the following recommendations:

1) Secure sustainability in the supply of energy from oil, coal, and geothermal is one of the major production inputs in the industrial sector.

2) Policymakers should formulate comprehensive studies and implement favorable and clean industrial growth policies, especially in the government sector.
3) Curtailing policies on energy would be harmful to industrial growth. In line with this, the government should improve and expand other sources of energy, such as wind and solar, to respond to the rising energy demand of the industrial sector.

5.2 Areas for Further Research

The following areas are suggested for further research:

1) The analysis of this study was based only in the Philippines setting; it can be extended into a Panel Data Series such as countries in Southeast Asia to compare the relative contribution of energy as an engine to industrial growth.
2) The use of other energy sources, such as wind, solar, and gas, could be included as a variable in forecasting the relationship between energy consumption by sources and industrial output.
3) Other energy consumption studies relate the effect to other sectors such as Services, Agriculture, Residential, etc.
4) Studies determining other factors could significantly contribute to the development of the industrial sector.

Conflict of Interest Statement

The author declares no conflicts of interests.

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