Analyzing the Role of Oil, Electricity and Coal Consumption on Industrial Growth: Evidence from Thailand

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Abstract:
Oil, electricity and coal are most common and widely used fuels around the world and they do have some impact on the industrial growth of industries in various countries. The author has set up the whole study which has a core purpose of finding out the impact of oil, electricity and coal consumption on industrial growth in the presence of two control variables i.e. CO2 emission and access to electricity. As the first step, the author collected reliable data from authentic sources that was comprised of 29 years and was in context of Thailand. All this data was about specifically the variables that have been included in the study. To test and analyze this data, the author applied various tests and approaches for various purposes. The unit root tests were applied for the investigation of order of integration and stochastic properties of variables, cointegration tests were applied in order to investigate the cointegrated relationships between the variables and Granger causality test was applied so that the causal relationships between variables can be identified effectively. The results showed that oil and coal consumption along with CO2 emission have significant impact on industrial growth. In the last, the author has discussed some theoretical, practical and policy making benefits along with some limitations and boundaries of this study.

Keywords: Industrial growth, Energy consumption, Coal consumption, Oil consumption, Electricity consumption

1. Introduction

Industrial growth is an indicator of the economic growth in developing countries. Economic growth indicates economic welfare and macroeconomic purpose of the government of a country (Azam, Nawaz, Riaz, 2019; Yasar, 2017; Jermsittiparsert, Saengchai, Boonrattanakittibhumi, & Chankoson, 2019; Rungsrisawat, Jermsittiparsert, & Thanetpaksapong, 2019; Phrakhruopatnontakitti, Watthanabut, & Jermsittiparsert, 2020). Industrial output is governed by energy consumption, along with labor and capital inputs. Energy plays an important role in the production process, creating a relationship between energy, industrial growth and economy of a country (Qazi, Ahmed, & Mudassar, 2012). Thailand is one of the countries that has grown rapidly in aspects of industry and

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economy in the past two decades. Thailand has had outstanding economic record due to an open economy with low tariffs and very few import restrictions. The manufacturing sector of Thailand accounted for 30% of the GDP in 2017 and about 6.2 million people found jobs due to this sector (Jones & Pimdee, 2017). The GDP of Thailand has seen a constant increase in the past few years, depicted in the figure no.1 attached below. This increase in GDP is driven by factors like increased FDI, imports and exports, industrial development and increased tourism trends in Thailand. The global trends of energy consumption have increased the competitiveness between developing economies and a raise in energy usage and demand has been observed (Shahbaz, Zakaria, Shahzad, & Mahalik, 2018).

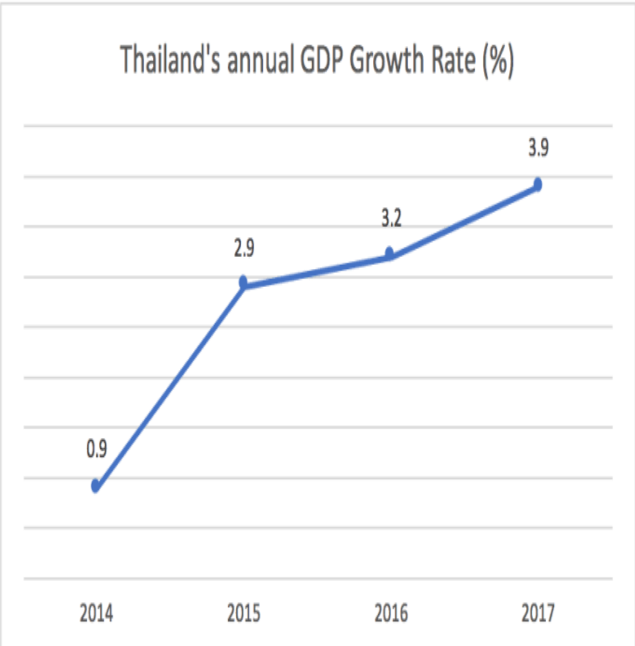

Figure no.1: Annual GDP of Thailand.

Energy is one of the most important aspect in the lives of people today because it is the driving force of economy. The IEA, International Energy Agency, predicted that between the years of 2001-2030, about 16 billion in US dollars are needed for investment into energy sector for fulfilling the energy requirements of the world (Teekasap, Toraninpanich, & Teekasap, 2018). Teekasap et al. (2018) divided industries into light and heavy industries and mapped the consumption of energy in these industries, shown in the figure no.2. Crude oil has been the major source of Thailand's energy consumption. However, Traivivatana, Wangjiraniran, Junlakarn, and Wansophark (2017) predicts that if there will be a spike in oil demands, import of refined oil has

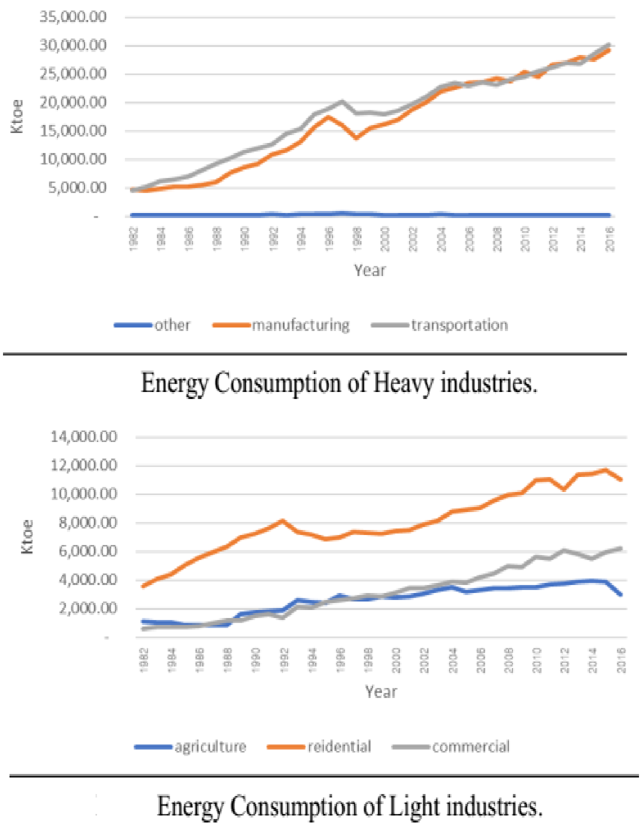

Figure No.2: Industrial energy consumption trends in Thailand

more likelihood. About 20% of the total energy demands of Thailand, according to Promdee, Monthienvichienchai, and Panbamrungkij (2018), are currently being fulfilled by coal consumption. Coal is the only source of energy that can replace the depletion caused by natural. Another major source of energy in Thailand is electric energy. Electricity is the key energy player in most of the countries, affecting both the aggregate supply and demand of energy. On the demand end, electric energy is essential product for the consumers for maximizing the utility. The demand of energy is a mirror reflection of the growth and civilization of a country (Long, Ngoc, & My, 2018).

The developing countries around the world are investing in the growth of industrial sectors. Chandio, Rauf, Jiang, Ozturk, and Ahmad (2019) discussed that energy consumption is a vital factor that shows the promotion of industry of a country. Developing countries like Thailand, that have a booming industry and economy growth is rapidly increasing day and night, have increasing energy demands and consumption. The increased demands of energy consumption have also led to a depletion in natural energy resources like natural gas, coal and petroleum. If the energy supply is cut short, the industries will not be able to flourish (Kagermann, 2015). This issue is prevalent not only in Thailand, but in all the developing industrial economies of the world. The current market demands that studies must be conducted to evaluate how energy depletion can be overcome and how the energy consumption is related to growth of industrial sector. The major aims and objectives of this research are mentioned below.

- Analyzing the role of oil consumption in driving the industrial growth of Thailand
- To study the role that the consumption of coal energy plays in the growth of Thailand's industrial growth.
- To determine the role of electric energy consumption for diving the industrial growth of Thailand.

The ASEAN countries are one of the major regions in the world that have shown major economic and industrial growth in the past few years. Thailand is the most influencing in terms of energy production. The scope of this study is to research the impact of energy consumption on industrial growth in Thailand. Many studies have been conducted in the past that study the link between energy consumption and growth of industry and economy (Azam, Khan, Zaman, & Ahmad, 2015; Nathan, Liew, & Wong, 2016; O'Rielly & Jeswiet, 2015; Sutthichaimethee & Kubaha, 2018). These researches provide an abundance of literary volume and the governments of developing countries have been aided by these studies for policy-making in terms of energy production and distribution of energy for industrial usage. This study contributes by demonstrating the role of coal, oil and electricity consumption on the industrial growth in Thailand. Remaining parts of this paper has a detailed critical and relational literature review to derive hypotheses followed by an exhaustive research methodology. Results, discussion, conclusion, implication, limitations and future research indications have also been given in the remaining part of this paper.

2. Literature Review

2.1 Industrial Growth and Oil Consumption

Oil is a dominant source of energy that plays a huge role in the economic growth and stability of industrial sector of a country. Oil or petroleum is regarded as the most used fossil fuel for energy production and consumption globally contributing to 32% of demand fulfilling of energy. A survey (Alam & Paramati, 2015) showed that the global consumption of oil grows at about 1.3% annually and this increased usage will contribute to depletion, CO_2 emissions and degradation of the environment. Rehman, Deyuan, Hussain, and Chandio (2018) showed through their research that energy consumption from oil in households has a negative impact on economy while in industries has a positive impact. As compared to coal, oil is better alternative of source of energy in terms of pollution, thus consumption of oil on industrial scale is more suitable (Bloch, Rafiq, & Salim, 2015). Thailand is an industry-oriented country with high levels of involvement in automotive industries and the consumption of energy is linked to industrial development in literature(W. Li et al., 2019; Sutthichaimethee & Kubaha, 2018). Literature (Nath, 2018) has stated at different places that oil and gasoline products are primary fuel for the industries. Many industries are basing on such machinery which can only be operated through gasoline products. Under such circumstances, impact of oil consumption can be seen on industrial growth. Past studies (W. Li et al., 2019; Nath, 2018) have depicted that automobile industry, molding industry and mining industry uses such kind of equipment which needs enough amount of oil and only through these operations their growth can be ensured. Petroleum industry itself contributing a lot in economic growth of any country especially the ASEAN region and oil is a direct input in such industry. It is also making this more evident that oil consumption can increase economic growth of any country especially such growth which originates from industry. Countries like Thailand which are famous for their tourism, have many companies for logistics and travelling and again oil consumption is a direct raw material of such companies. Tourists travel through local Taxi services or newly emerged mobile applications such as Uber and Cream (Wang, Le, Nguyen, & Ngoc-Nguyen, 2019). All these travelling services are also major users of oil products and ultimately their contribution is also significant in economic growth. Arab and Gulf countries are using Oil for all their fuel needs as they are not moving towards renewable energy sources. The reason behind such excessive usage of oil is its abundance in Middle-East and almost all sectors are using it for power generation. Under-developed and developing countries which don't have the luxury of enough dams and streams to generate electricity from water (Almutairi, Thoma, & Durand-Morat, 2018; Pradesha et al., 2019), they are still using oil for power generation. However, contribution of oil's consumption in their economic growth is under question due to a large portion of oil in import bill. Such kind of heavy import bill puts a lot of burden on country's balance of payment. Despite of this negative impact, most of the studies in literature are definitely in accordance with the positive impact of oil consumption on industrial growth. An empirical study has been conducted in Iran by using ARDL method (Chen & Fang, 2018) and results have shown that oil consumption has impact on growth in short-run but not in long-run. Its evidence can also be seen in other studies where use of oil is considered as threat for environment and thus its long-run implications are coming under question. The discussed literature has helped to form the following hypothesis.

H1: The consumption of oil on industrial scale affects the growth of industry of a country positively.

2.2 Industrial growth and electricity consumption

The invention of electric power is the reason that the second industrial revolution occurred in the history of mankind and the introduction of electricity to human society occurred. Electricity is the source of sustainable energy that provides grounds for economic and social developments in any country. Increase of electric consumption allows the progress of the industrial economy. Reduction in the overall energy consumption in a country is needed for the management of its economy and reducing the costs of energy production, however, in case of industrial usage of electric power, the case is totally different because the more the industrial usage and consumption of electric energy occurs, the more the industrial output will be gained (Zhang, Zhou, Yang, & Shao, 2017). Electricity is an energy form that is in demand in households as well as by the industries. The industrial sector in Thailand is the largest electricity consumer in the country, consuming about 48% of the total electricity generated, followed by equal distribution of 24% each in households and

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business sector between the years of 2009-2016. The electricity generation in Thailand is highly dependent on natural gas; 60% of electricity is generated through natural gas sources and 9% through renewable hydropower (Simpson & Smits, 2019). Although a significant portion of electricity consumption also goes to residential or domestic users, still industrial use of electricity is far greater than the domestic use. Countries which are highly involved in production of plastic furniture are even applied taxation on such industries on the basis of units of electricity consumed in a month (Gopinathan, Kumaran, Rahaman, & bt Ismail, 2018; Traivivatana & Wangjiraniran, 2019). These taxation procedures are applied by agreeing on a formula that consumption of a certain level of electricity means a certain level of production. Non-manufacturing sector like service sector which includes health care, education, banking and telecom sectors that are not directly related with intensive production but still they are big consumers of electricity. It reflects that electricity consumption and its contribution in economic growth is not just restricted to manufacturing sector but also implying on service sector too (Kurniawan & Managi, 2018; Wang et al., 2019). As many developed countries are trying to make cities carbon free, trend to adopt renewable sources such as solar and wind energy is grossly increasing. However, these sources also come in category of electricity and they have emerging role in industrial development and ultimately in economic growth. Another argument which has been raised by the literature often is about tradeoff between gas and electricity. With the shortage of gas in many countries of the world, most of their appliances are converting in electricity. Example of instant heaters can be taken in this regard as many companies are not making such heaters which are working on electricity instead of gas so a certain increase in electricity consumption can be seen in this regard (Nath, 2018; Sutthichaimethee & Kubaha, 2018).The discussed literature has helped to form the following hypothesis.

H2: The demand and consumption of electricity by the industry of a country has positive growth effects on its industrial growth.

2.3 Industrial growth and coal consumption

The primary source of energy all over the world are fossil fuels and the major fossil fuels that are used for energy generation are coal and oil. ASEAN region is dominated by coal consumption for their energy needs. Thailand is one of the most exhaustive country in terms of usage of coal energy. Coal is a cheap source of energy, as long as it is available locally, due to its heat generation capacity and the industries in Thailand demand coal consumption more than other sources of energy. Energy in industries is mainly needed for manufacturing and coal serves as the best reserve for that due to the production of heat and light on a large scale. Bloch, Rafiq, and Salim (2012) examined the relation between consumption of coal and the growth of industry and economy by using a vector model and co-integration to analyze the difference between supply and demand of coal energy. Labor, capital and coal consumption were used as supply variables and coal prices, CO_2 emission and coal consumption were used as demand variables. Results shows that consumption of coal has a linear causality with both supply and demand. Another study (R. Li & Leung, 2012) examined the relationship between the coal consumption in industry and the GDP in China. The results link coal consumption to economic growth and especially such growth which derive from industry. Although coal consumption is quite rare in modern day agriculture, yet its consumption was there few years back. In contrast with industrial side of the economy, coal consumption in agricultural sector was region specific as it varies with the agricultural practices opt in a certain region (W. Li et al., 2019; Pradesha et al., 2019; Thorbecke, 2019). Large locomotives which are primarily responsible to carry freight are still using coal as engine fuel. Such locomotives are providing logistic services to many industries and still competing with modern logistic tools and their contribution in industrial growth is significant. Many contemporary thoughts have recently emerged in support of non-usage of coal due to pollution challenges but many industries are still using it due to its lesser cost and more productivity, A dream of carbon free economy and green infrastructure are posing big challenges for coal and its consumption. Literature (Chen & Fang, 2018; Kurniawan & Managi, 2018) has argued at some places that utilizing coal is one of the biggest pollution challenges in modern world which has undermined its use in industries in developed countries. The discussed literature has helped to form the following hypothesis.

H3: The coal consumption at the industrial level maps growth of industry of a country.

3. Methodology

3.1 Data

The author has collected data from World Bank and Global Economy databases which are considered to be very authentic and accurate. This is significant as the reliability and authenticity of data has major impact on the quality of results produced after testing and investigation of data. The gathered data is time series data and is specifically in the context of Thailand and is consisting of the time period of 29 years. To be very specific and precise, the author has collected data in accordance with the already chosen variables which include oil consumption, electricity consumption, coal consumption and industrial growth in a particular region. It is a crystal clear fact that data collection has its own important in any research process as it is the base of the research and all the tests and approaches are applied on this data. As a result, the inferences are generated based on all these tests and its quality is completely dependent on the quality of data.

3.2 Model Specification

The purpose to conduct this research is to find out the impact of various aspects of consumption including oil, electricity and coal consumption on the industrial growth of a country. This impact is supposed to be measured in the presence of two selected control variables i.e. access to electricity and CO2 emissions. All the above-mentioned variables fall in one of the categories of variables each i.e. independent, dependent and control. These variables are measured in various respective measurement units and are represented by using particular notations. The author has discussed these aspects for each variable one by one. The first independent variable, oil consumption (OIL) will be measured in terms of thousands of barrels per day. The second independent variable, electricity consumption (ELEC) will be measured in terms of billion kilowatt hours. The last independent variable, coal consumption (COAL) will be measured in terms of thousand short tons. Moreover, the only dependent variable of the study, industrial growth (INDUS) will be measured in terms of contribution of industry in GDP growth. Apart from the above discussed variables, the first control variable, access to electricity (ATE) will be measured in terms of the percentage of population having the access of electricity while the other control variable, CO2 emission (CO2E) will be measured in terms of thousands of tons of CO2 emitted. After the definition of all the respective measurement units for each of the variable involved in the study, the next step that author is to encounter is the generation of a regression equation or model. This model can be generated based on the notations and measurement units used for all the variables. In

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this particular study, the author has produced the following regression equation:

$$INDUS_t = \alpha + \beta_1 OIL_t + \beta_2 ELEC_t + \beta_3 COAL_t + \beta_4 ATE_t + \beta_5 CO2E_t + \varepsilon_t$$

In this equation, INDUS= industrial growth, OIL= oil consumption, ELEC= electricity consumption, COAL= coal consumption, ATE= access to electricity, CO2E= carbon dioxide emission and ε_t= error term.

Table 1: Empirical evidence from past studies

Authors	Country/ Group	Period	Variables	Methodology	Results
(Wolde-Rufael, 2006)	17 African countries	1971-2001	Electricity consumption and economic growth	Cointegration test, Granger causality test	Long run relationship between economic growth and electricity consumption, causal relationships
(Kouakou, 2011)	Cote d'Ivoire	1971-2008	Electricity consumption and economic growth	Cointegration test, Granger causality test, error correction model	Long run cointegration and causality between Electricity consumption and economic growth
(Altinay & Karagol, 2005)	Turkey	1951-2000	GDP growth, electricity consumption	Granger causality test, VAR model	Unidirectional causality from GDP growth to electricity consumption
(Dutta & Ahmed, 2004)	Pakistan	1973-1995	Trade liberalization and industrial growth	Cointegration and error correction modeling	Significant long term relationship between Trade liberalization and industrial growth
(Ghosh, 2002)	India	1951-1997	Electricity consumption and economic growth	Phillips Perron test, Granger causality test	No long run relationship between both variables, unidirectional causality between them

3.3 Estimation Procedure

After the collection of data and generation of a regression equation, the author then applies various tests and techniques on the data for various purposes and to gain results in different contexts. In this study the author has adopted ADF and LLC unit root tests, ARDL bounds

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cointegration test and Granger causality test. The objectives and characteristics of all these tests have been discussed and described by the author in this section.

3.3.1 Unit Root Test

The most basic step in the data analysis of any research is usually the identification of integration order and stationarity properties of the collected data. The order of integration is necessary to be checked because the data can only pass to the next step if the order of integration of dependent variables is zero while the order of integration for independent variable is either zero or one. This mixed order of integration variables can move to the further process of research. For this motive, the unit root tests are generally used (Im, Pesaran, & Shin, 2003). The author has selected augmented Dickey Fuller ADF and Levin Lin Chu LLC unit root tests for serving the above mentioned purpose. The unit root tests are inferred on the foundation of null hypothesis and its alternate hypothesis, both of which indicate different situations. The null hypothesis, in this context, shows that unit root is present in the data and it is non stationary in nature (Pesaran, Shin, & Smith, 2001). In the same fashion, the alternate hypothesis indicates that there is no unit root and the data has become stationary. In this way, the results are inferred from unit root tests. The general equations used for this purpose are given as:

$$\Delta X_t = \alpha + \alpha X_{t-1} + \beta T + cD_t$$

$$\Delta X_t = \beta + \beta X_{t-1} + ct + bDT_t + \sum_{j=1}^{k} dj\,\Delta X_{t-j} + \varepsilon_t$$

$$\Delta X_t = \gamma + \gamma X_{t-1} + ctb + dDT_t + \sum_{j=1}^{k} dj\,\Delta X_{t-j} + \varepsilon_t$$

$$\Delta X_t = \Omega + \Omega X_{t-1} + ct + dD_t + dDT_t + \sum_{j=1}^{k} dj\,\Delta X_{t-j} + \varepsilon_t$$

In this equation, t represents the time period.

3.3.2 Bounds Cointegration Test

Once the orders of integration of various variables involved in the study have been identified and investigated the cointegration tests are applied to that data. An important aspect that must be considered here is that one can apply bounds cointegration test only when the variables having mixed order of integration are obtained (Engle & Granger, 1987). Other cointegration tests do not show such behavior as they require a specific type of order of integration for cointegration test to be applied. Past studies have clearly shown that if the sample size of the data is small, bounds cointegration test give more accurate and authentic results (Enders, 2008). In this regard, mostly tests that are used include Wald test and F test. The basic equation that can be used for bounds cointegration test has been given by the author here:

$$\Delta lnINDUS_t = \beta_0 + \sum_{i=0}^{p} \beta_i \Delta lnINDUS_{t-i} + \sum_{k=0}^{q} \beta_k \Delta lnOIL_{t-k} + \sum_{l=0}^{r} \beta_l \Delta lnELEC_{t-l} + \sum_{m=0}^{s} \beta_m \Delta lnCOAL_{t-m} + \lambda_{INDUS} lnINDUS_{t-1} + \lambda_{OIL} lnOIL_{t-1} + \lambda_{ELEC} lnELEC_{t-1} + \lambda_{COAL} lnCOAL_{t-1} + v_t$$

In the above equation $v_t$represents the error while Δ shows the first difference level. The first test that can be used here is Wald test that can only be applied if the coefficient of short run variable is more than one while in this case all the coefficients of short run variables are equal to zero therefore Wald test may not be successfully applied here. Therefore, we will move towards the F test which is based on the value of F-statistic. This value can be compared with various values having order of integration of zero or one (Enders, 2008). The values of different variables have been divided into lower and upper bound values. This division is actually based on the fact that significance levels of 90, 95 and 99 percent are crucial in this regard. The F-statistic value is them compared with these estimated values. An important and significant point must be made clear here that null and alternate hypothesis are involved in this scenario. The null hypothesis shows no cointegration while the alternate hypothesis shows the presence of cointegration among the variables. Now, when the F-statistic value is compared with the lower and upper bounds estimated values the results can be inferred. If the value of F-statistic is greater than the upper bound value than the null hypothesis is rejected and the presence of cointegration is confirmed. On the contrary, if the F-statistic value is lower than the lower bound value, then the null hypothesis is accepted and the absence of cointegration is confirmed. Apart from these cases, there is another situation that the F-statistic value may be in between the upper and lower bounds values (Dickey & Fuller, 1981). In this situation, the estimation of rejection becomes difficult whether it is accepted or rejected. After the investigation of cointegration among variables, the elasticity of coefficients is estimated both in short run and long run. This estimation in short run and long run is conducted in accordance with the following equation,

$$
\begin{aligned}
lnINDUS_t = \alpha_1 &+ \sum_{i=1}^{p} \varphi 1_i lnINDUS_{t-i} \\
&+ \sum_{k=1}^{q} \omega 1_k lnOIL_{t-k} \\
&+ \sum_{l=1}^{r} \partial 1_l lnELEC_{t-l} \\
&+ \sum_{m=1}^{s} \emptyset_m lnCOAL_{t-m} + \mu_t
\end{aligned}
$$

3.3.3 Granger Causality Test

When the absence or presence of cointegration has been confirmed by the use of bounds cointegration test, the next step is to find out the presence of the causal relationship between the variables along with the direction of these relationships. There are two situations in this regard i.e. if the cointegration is not confirmed among the variables, then differenced variable can be adopted to find out the causality among variable (Dumitrescu & Hurlin, 2012). While, on the other hand if the cointegration is confirmed by bounds test, then Dumitrescu and Hurlin Granger causality test can be employed for the same purpose. The null and alternate hypotheses are also involved in this situation with the null hypothesis showing the absence of causal relationships and alternate hypothesis showing the presence of causal relationships. This causality can be checked by using a model having the error correction term of one period lag (ECTt-1) according to the following equation,

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$$ln\Delta INDUS_t = \gamma_0 + \sum_{i=1}^{p} \gamma 1_i \Delta lnINDUS_{t-i} + \sum_{k=1}^{q} \gamma 1_k \Delta lnOIL_{t-k} + \sum_{l=1}^{r} \gamma 1_l \Delta lnELEC_{t-l} + \sum_{m=1}^{s} \gamma 1_m \Delta lnCOAL_{t-m} + \psi ECT_{t-1} + \mu_t$$

In the above equation, ECTt-1 represents the error that must be negative.

4. Empirical Analysis

4.1 Results of Unit Root Test

The importance of order of integration cannot be denied in case of time series study due to which the author used ADF and LLC unit roots test in order to identify the order of integration of the variables. The results of these tests that have been presented in the table 2 also give the idea about stochastic properties of the variables. Basically the main factor upon which the decision of unit root test is based is the null and alternate hypothesis of unit root. The first hypothesis that is null refers to the situation where the unit root is present while the data involved is non stationary. Alternatively, the other hypothesis that is alternate hypothesis refers to the situation in which the unit root is absent however the data is stationary. When ADF test was applied, the results shown that most of the variables in level section of the table have accepted the null hypothesis of unit root presence and non-stationary data but when they were first differenced, all the variables rejected the null hypothesis indicating the absence of unit root and presence of stationary data. The same was the case in LLC that in the level series, most of the variables accepted the null hypothesis while in the first difference series; most of the variables rejected it. The modification of non stationary data to stationary data from level to first difference is actually based on the concept of first differentiation that is the basic factor for the data to become stationary. The overall results can be concluded in such a way that the data is in non-stationary condition in the level series while when it is first differenced it immediately becomes stationary.

Table 2: Unit Root Analysis

Constructs	ADF Test		LLC Test	
	Level	1st difference	Level	1st difference
INDUS	5.6246*	4.6532***	-1.8472	-3.3684***
OIL	2.5795	9.7555**	-2.4286	-2.4827***
ELEC	7.6536	12.7536**	-3.4628	-4.4289***
COAL	3.4667*	7.6436***	-7.8262*	-2.5734***
ATE	8.4467	8.3562***	-3.5382	-7.5427***
CO2E	1.6477	6.6736***	-4.4286	-9.5382**

4.2 Results of Bounds Cointegration Test

As it is clear that bounds cointegration test are used for the confirmation and investigation of any cointegrating and long run relationship between the variables, the results of this test applied by author have been presented in table 3. As F test test was used based on the nature of the collected data, therefore the F-statistic value has been compared with the upper and lower bound estimated values. The AIC criterion has been used by the author in order to estimate the lag length to be used in the test. As discussed in the earlier section of the study that in case of F test, three cases may be occurred i.e. F-statistic value greater

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than upper bound, smaller than lower bound and in between the upper and lower bound. The first case will result in rejection of null hypothesis; the second case will result in the acceptance of null hypothesis while the last or third case will result in the ambiguity about the results. It can be observed in the table that the value of F-statistic is higher as compared to the upper bound estimated values which suggests that the null hypothesis has been rejected by this test. It would not have been rejected if the value of F-statistic is lower than the lower bound value or would have been ambiguous if it was lying in between the both upper and lower bound values. So it can be concluded that cointegrated relationships as well as long run relationships exist between the variables. As the presence of long run relationship has been confirmed, the next step is to find out the magnitude of the impacts that independent and control variables have on the dependent variables, for which ARDL long run and short run tests have been employed by the author.

Table 3: Cointegration Test

O.P.L. length (A.I.C)	F-Stat. (Bound Test)	V.C	L.B.C.V.	U.B.C.V.
(4,0,0,0,0)	7.72351**	2%	3.423	7.45
		4%	4.487	5.86
		9%	6.824	3.65

4.3 Results of ARDL Short Run and Long Run

The results of ARDL test to find out the elasticity of coefficients of both long run and short run have been presented in the table 4 and 5 respectively. The table 4 contains the short run results which shows that in short run the coefficient of oil consumption is significant as well as positive indicating that with one percent increase in oil consumption, the industrial growth will increase by 23.2 percent. In the same fashion, the elasticity of coefficient of electricity consumption is also significant and positive suggesting that with its one percent increase, industrial growth will increase by 38.6 percent. Apart from these variables, the elasticity of a control variable, access to electricity has also been found significant in this study. It means that with one percent increase in access to electricity, the industrial growth will increase by 15.7% effectively. These results show that oil consumption, electricity consumption and access to electricity have short run significant impact on industrial growth.

Table 4: ARDL Short Run Results

Variable	Coefficient	S. E	t-Stat.
OIL	0.2326	0.537	4.372***
ELEC	0.3862	0.862	3.592***
COAL	0.4827	0.864	2.492
ATE	0.1578	0.492	6.374**
CO2E	0.8642	0.728	5.747
ECTt-1	-0.4972	0.478	-2.289
R2	0.2397	F-Stat	112.492***
Adj. R2	0.3782	D.W.	2.49
Diagnostic Test	X2SC	X2W	X2AR
Indonesia	1.24 (1.743)	23.73 (1.735)	0.64 (0.745)

After short run results, the long run results have also been evaluated in this section. The long run results show that the coefficient of oil consumption and coal consumption are significant, elastic and positive and their relative increase on industrial growth will be 25.4 and 14.8 percent respectively. In addition, the impact of control variables, CO2 emission has also been found as significantly negative and elastic and with one percent increase in CO2 emission, industrial growth will decrease by 16.6%. These results clearly depict that oil consumption, coal consumption and carbon dioxide emission have long run impacts on industrial growth in a particular country.

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Table 5: ARDL Long Run Results

Variable	Coefficient	S. E	t-Stat.
INDUS	1.8547	0.858	3.754***
INDUS (-1)	-0.7579	1.586	2.885
INDUS (-2)	0.643	0.584	1.639***
OIL	0.254	0.753	3.465***
ELEC	0.9647	0.854	2.748
COAL	0.1487	0.647	4.643*
ATE	1.6897	1.753	1.635
CO2E	0.1665	0.853	3.375**
C	0.8657	0.864	2.375***
R2	0.8557	F-Stat	117.537***
Adj. R2	0.5659	D.W.	1.32
Diagnostic Test	X2SC	X2W	X2AR
Indonesia	4.933 (1.846)	2.387 (1.043)	1.43 (0.873)

4.4 Results of Granger Causality Test

After finding out all the cointegration, long run and short run relationships between the variables, the last step taken by the author in this research was to apply Granger causality test on the collected data. The results of this test have been evident in the table 6 given below. This table clearly indicates the presence of causal relationships either unidirectional or bidirectional between various variables. It can be seen in the table that causality runs from oil consumption to industrial growth and from electricity to industrial growth. However, after the correction of error, the causality that has been found runs from oil consumption and coal consumption to industrial growth of a country.

Table 6: Granger Causality Test Results

Variables	F-statistic	Joint Long Run and Short Run F-statistics for long run							
	Δln INDUS	Δln OIL	Δln ELEC	Δln COAL	ECTt-1 [T-stat]	Δln INDUS. ECTt-1	Δln OIL. ECTt-1	Δln ELEC. ECTt-1	Δln COAL. ECTt-1
Δln INDUS	-	4.4885* (0.8477)	2.5189* (0.1585)	3.8875 (0.7538)	0.8538* [1.7487]	-	3.8438* (0.7438)	1.8368 (0.8438)	3.8548* (0.8643)
Δln OIL	3.6845 (0.6845)	-	4.8547 (0.8654)	4.7537 (0.8539)	0.0743** [2.8743]	2.8548* (0.8540)	-	3.4258 (0.4787)	2.4786 (0.5847)
Δln ELEC	2.4747 (0.5748)	2.9745 (0.4815)	-	2.6386 (0.8753)	0.854 [1.8549]	1.3657 (0.8496)	2.8548 (0.5387)	-	3.4577 (0.5874)
Δln COAL	0.8745 (0.8418)	3.1875 (0.8745)	2.3767* (0.0467)	-	0.8486*** [3.8543]	4.8475* (0.9643)	1.7539 (0.8649)	2.8437* (0.4875)	-

5. Discussion and Conclusions

5.1 Discussion

This study was conducted in order to find out the impact of oil, electricity and coal consumption on the industrial growth in a country. In this context, three major hypotheses were designed by the author. The first hypothesis stated that the oil consumption has significant impact on industrial growth. This hypothesis was accepted according to the results obtained from the tests applied. The same acceptance behavior has already been

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witnessed in the past studies (Wolde-Rufael, 2006). The next hypothesis was that electricity consumption has significant impact on industrial growth and this hypothesis has, however been rejected in this study. This rejection can be affirmed according to the past studies too (Kouakou, 2011). The next hypothesis was that the coal consumption has significant impact on industrial growth. This hypothesis has also been accepted in accordance with the results of this study. The past studies have also shown the similar types of result (Ghosh, 2002). Apart from these hypotheses, the impact of two control variables was also studied by the author from whom the impact of CO2 emission has found to be significant in context of industrial growth. This result too is in concordance with the past studies (Altinay & Karagol, 2005). The acceptance and rejection status of all the hypotheses that have been involved in this study have been discussed in this section along with the evidences from the past studies that have been conducted in almost similar context. These evidences increase the reliability and authenticity of the results that have been obtained by the application of various tests in this study.

5.2 Conclusion

Oil, electricity and coal are the most important types of fuels that can be used or consumed in order to increase productivity and thus the industrial growth in any country. The aim behind this study was to investigate the influence of oil, electricity and coal consumption on industrial growth. To achieve this motive, the author first collected data from Thailand consisting of 29 years and then applied some tests for the identification and investigation of several aspects of the collected data. Not only these tests were used for the identification of order of integration of the variables along with their stochastic properties but they were also used for the investigation of long run and short run relationships between various variables. Causal relationships both unidirectional and bidirectional were also established through the Granger causality test. Most importantly, the main purpose of this study was also served by the application of these tests. The results have shown that oil consumption and coal consumption have significant and positive impacts on industrial growth. While CO2 emission has significant and negative impact on industrial growth. In the last, several benefits in theoretical, practical and policy making context have been discussed in the last of the study. In addition, the limitations and boundaries associated with this study have also been identified by the author along with some recommendations to improve them. They will be very helpful for the other researchers and authors.

5.3 Implications

In this section of the study, the author has mentioned and discussed various theoretical, practical and policy making implications that may be identified in this particular study. As this study revolves around the growth of industrial sector, most of the implications are in context of industry. Three mostly consumed things in industries include oil, electricity and coal and all of them have been studied in this research in detain and their impact on industrial growth has also been studied. Researchers, authors and other people too may get information and knowledge about the above mentioned concepts from this study and use it for various purposes. It will also guide the industries of a particular country to effectively increase the use of oil, electricity and coal so that the productivity may increase and ultimately has significant positive impact on industrial growth. It will also guide the government authorities to develop policies and regulations that will create ease for the industries to consume the above mentioned aspects and as a result the industrial growth will also increase resulting in the enhancement of the economic development of the country.

5.4 Limitations and Future Research Recommendations

In the last portion of the study, a very important and useful aspect of the research has been effectively discussed by the author. This aspect refers to some of the limitations and boundaries that have been identified by the author and some recommendations and suggestions for the resolving of these limitations are also given. The first limitation that has been discussed is related to the sample size of the research. The author has mentioned that the sample size of the study is very small as compared to others. Another important thing is that this study is focused only on Thailand and has been conducted in its particular context. After that, the author has discussed that a few fixed and specific variables have been adopted by him in the study. The last point related to the limitations is that the tests or techniques that have been employed by the researcher are also fixed. These limitations and loopholes must be fulfilled by other researchers in their own studies for which the author has also given some recommendations. According to him, the future researchers may increase the sample size, include some other country in their study, use other variables or sets of variables and finally use some other time series data related tests that have not been used in this study. In this way, they can improve and increase the quality of their studies.

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