The Role of Electricity and Energy Consumption Influences Industrial Development between Regions in Indonesia

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ABSTRACT

Our research aims to determine the effect of electricity distribution and energy consumption on industrial development dynamics that occur between regions in Indonesia by adding investment and inflation as control variables. The analysis tools that we use are static (Fixed Effect) and dynamic (GMM) panel data model with a dataset of 34 provinces for the 2012-2019 period. The static model results state that the distribution of electricity and investment has a significant positive effect on the industry, and so does energy consumption, but not significantly. In contrast, inflation has a significant negative effect. There are differences in dynamic results, namely, electricity distribution and energy consumption have a negative and significant effect on industrial development. These results suggest different actions in industrial development concerning timeframes.

Keywords: Electricity Distribution, Energy Consumption, Industry, GMM, Indonesia
JEL Classifications: C33, O14, Q40

1. INTRODUCTION

The process of industrialisation and industrial development is a pathway of activities to improve people's welfare in the sense of a more advanced level of life or a higher standard of living. Industrial development is part of long-term economic development to achieve a balanced economic structure.

Industrialisation is the "most popular" in development efforts, especially from improving economic conditions. Industrialisation is considered a plan as well as a remedy for many countries. As a strategy, industrialisation is considered a "linear" process that must be passed through several interrelated and sequential stages in transforming economic structures in many countries. Meanwhile, industrialisation is seen as useful in overcoming underdevelopment problems, poverty, inequality, and unemployment. Where according to this view, it is assumed that the developed industry is labour-based based industry, prioritises local core competencies (local resources), has a high multiplier impact (output, income,

labour, and technology), and brings regional spillover to the surrounding area (Kuncoro, 2007).

The 9th SDG's objectives are to build long-lasting infrastructure, support inclusive and sustainable industrialisation, and foster innovation, while some of the goals of this goal are; (1) Encourage inclusive and sustainable industrialisation and, by 2030, significantly increase the industry's share of job creation and gross domestic product, in line with the national situation, and double the industry's share in less developed countries; (2) Increasing access of small scale industries and other small scale businesses, especially in developing countries to funding services, including affordable credit combined with value chains and markets.

Indonesia is one of the countries plotted as a new industrial country. This can be seen from the manufacturing industry sector's contribution from 2015 to 2019, an average of 21.27% with an average growth rate of the industrial sector of 4.27%. Meanwhile, the value of contributions and growth that occur fluctuates from

year to year. In 2015 the contribution value was 21.54% with a growth rate of 4.33%, the trend in the following year decreased the value of the contribution and the growth rate became 21.38% and 4.26%. Furthermore, until 2019, a continuing decline value contribution with a final value of 20.79%, for value growth increased in 2017 to 4.27%, again decreased until 2019 to 3.80%.

The role of industry in structural development in an economic indicator is the manufacturing sector's contribution to GDP, absorbed labour, and industrial commodities contribution to exports of goods and services has improved or vice versa (Arsyad, 2010). Furthermore, industries can be classified as capital-intensive and labour-intensive industries, and the trend of industrial development in Indonesia is more labour-intensive.

Development of the manufacturing industry is inseparable from the flow of capital provided by investors and the support of available infrastructure, especially energy infrastructure and supply or fuel oil consumption, especially diesel. It is known that factories operate more with the use of diesel fuel. Therefore, the research aims to determine the effect of energy infrastructure, fuel consumption, and investment on developing the manufacturing industry sector in Indonesia's provinces.

The study is structured as follows: the next section briefly reviews the research conducted on the subject. The following section describes the data and methodology, while section 4 presents and explains the empirical results and discussion. The final section presents conclusions and policy implications.

2. LITERATUR REVIEW

Haraguchi et al., (2019) analyses industrialisation drivers in developing countries. Different industrialisation patterns are likely to be influenced due to significant political, technological and organisational changes. The analysis results reveal that successful industrialisation is driven by factors, including the country's initial economic conditions, contributing factors and other characteristics, such as demography and geography. Other results suggest that other variables over which policymakers can control play an important role. These include, among other things, promotion of investment (whether publicly or privately funded) and education; trade management and capital disclosure; financial sector development and promotion of macroeconomic and institutional stability.

Furthermore, another paper by Haraguchi et al. (2019) shows that human resources and institutions represent contextual factors that support industrial growth, along with macroeconomic policies related to investment and openness to foreign trade and capital. Also found, most of these factors drive the acceleration of industry and contribute to the continuous industrialisation process that characterises economic growth.

Research by Franck and Galor (2019) with research questions Is industrialisation conducive to economic development in the 21st century? Research shows that early industrialisation has an adverse effect on long-term prosperity, stemming from the negative impact of the adoption of labour-intensive, skillless technology in the early stages of industrialisation at the current human resource level and thus the incentive to adopt skills-intensive technology.

Opoku and Boachie (2020) states that the main concern about the environment is greenhouse gas emissions and their impact on climate change in recent years. Using the Pooled Mean Group estimation technique, it is found that the effect of industrialisation on the environment is generally insignificant. However, the effect of foreign direct investment on the environment was found to be very significant.

The empirical results from Kumari and Sharma (2018) on the causal relationship between gross domestic product, foreign direct investment and electricity consumption in India, show that electricity consumption plays a vital role in GDP and high GDP attracts more FDI to India. Next, results by Tiwari et al. (2020) provide evidence of a unidirectional causality that flows towards overall economic growth for electricity consumption at the state level. However, there is a unidirectional causal relationship at the sectoral level ranging from electricity consumption to economic growth in the agricultural sector and economic growth to electricity consumption in the industrial sector.

Ozturk and Acaravci (2011) examined the short and long-run causality between electricity consumption and economic growth in 11 Middle Eastern and North African (MENA) countries using the Autoregressive Distributed Lag (ARDL) testing approach of cointegration and error correction model vectors. Cointegration test results show no cointegration between electricity consumption and economic growth in three of the seven countries (Iran, Morocco and Syria). Thus, a causal relationship cannot be estimated for these countries. However, cointegration and causal relationships were found in four countries (Egypt, Israel, Oman and Saudi Arabia). The overall results show no relationship between electricity consumption and economic growth in most MENA countries. The same previous results were also obtained from Acaravci and Ozturk (2010) in 15 transition countries (Albania, Belarus, Bulgaria, Czech Republic, Estonia, Latvia, Lithuania, Macedonia, Moldova, Poland, Romania, Russian Federation, Serbia, Slovak Republic and Ukraine).

Apergis and Payne (2011) examined the relationship between electricity consumption and economic growth for 88 countries categorised into four panels based on World Bank income classifications (high, middle-upper, middle-lower and low income) the framework of a multivariate panel for the period 1990-2006. The results reveal (1) a two-way causality between electricity consumption and economic growth in both the short and long term for the panel of high- and middle-to-upper income countries; (2) unidirectional causality from electricity consumption to economic growth in the short run, but two-way causality in the long run for a panel of lower-middle-income countries; and (3) unidirectional causality from electricity consumption to economic growth for a panel of low-income countries.

Meidani and Zabihi (2014) paper discusses the causal relationship between Real GDP and energy consumption in various economic

sectors including (household and commercial, industrial, transportation and agricultural sectors) for Iran during 1967-2010 using a time series technique known as the Toda-Yamamoto method. Also, an error correction model is estimated so that the results of the two methods are compared. The results find a robust unidirectional causality from energy consumption in the industrial sector to real gross domestic product. Energy consumption in the industrial sector appears to be able to boost economic development.

Tang et al. (2016) examined the relationship between energy consumption and economic growth in Vietnam using the neoclassical Solow growth framework for 1971-2011. The concepts and methods of cointegration and Granger causality are used to build relationships between variables. The results confirm the cointegration between variables. In particular, energy consumption, FDI and capital stock positively affect economic growth in Vietnam.

Gungor and Simon (2017) examined the relationship between energy consumption, financial development (FD), economic growth, industrialisation and urbanisation in South Africa for the period 1970-2014. The results confirm that there is a long-run equilibrium relationship between these variables. Moreover, urbanisation, FD, and industrialisation are positively correlated with energy consumption in the long run. The results also indicate a long-term two-way causality between industrialisation and energy utilisation, FD and energy consumption, FD and industrialisation.

Next, Tran et al. (2020) examine the effects of energy consumption, economic growth, and the trade balance in East Asian countries. They are using panel data analysis during the period 1996-2015. The results show that energy consumption has a negative impact on the trade balance, while economic growth can have a negative impact on the trade balance but is not significant. Furthermore, the same results from Shahbaz et al. (2017) that the results of asymmetric causality show that only negative shocks to energy consumption impact India's economic growth during the period 1960Q1-2015Q4.

Asafu-Adjaye et al. (2016) examine the relationship between economic growth and fossil and non-fossil fuels consumption. Except for developing importers, evidence of a two-way causality between fossil fuel consumption and real GDP in all subsamples were observed. Fossil fuel conservation efforts can directly disrupt economic growth.

Inflation, as an important economic indicator, can have a significant influence on GDP growth. However, during periods of negative (falling) inflation, economic structure development can create volatility and uncertainty, impacting industrial growth and potential (Dinç et al., 2019). Next, Roncaglia de Carvalho et al. (2018) show an inverse and low correlation between inflation persistence and economic development, which implies that the model can only partially explain inflation differences across different economic development levels.

3. METHODOLOGY

3.1. Dataset
This research method is the quantitative method with static panel regression (fixed effect or random effect) and dynamic (First difference or SysGMM). This research uses analysis units of 34 provinces with the period 2012-2019. Data sources come from many surveys by the Central Statistics Agency (BPS) including socio-economic, GRDP, investment, and inflation surveys. Besides, oil and gas data is obtained from the Ministry of Energy and Mineral Resources.

For the model formula to be used, several variables must be defined as follows: (1) Industry (Ind), calculated from the share of the industrial sector to GRDP; (2) Electricity distribution (Elec), this variable is the ratio of electricity distribution to total population which reflects the availability of electricity capacity (Kwh), the source of data from economic surveys and regional welfare statistics by the Central Statistics Agency; (3) Energy consumption (BBM) of this variable is represented by the realization of the quota of diesel oil and data sourced from the Ministry of Energy and Mineral Resources; (4) Investment (INV), the variable used is the annual investment data in units of billions of rupiah; (5) Inflation (INF), is the annual inflation data obtained from BPS.

3.2. Model Panel Data
The Pooled Data panel is a combination of cross-section and series data (Greene, 2012). If we have T is time (t = 1,2,…, T) and N the number of individuals (i = 1,2,…, N), then using panel data we will have a total unit of observation N×T. If the number of time units is the same for each individual, then the data is called a balanced panel. On the other hand, the number of time units is different for each individual, called an unbalanced panel (Verbeek, 2017). In this study, a balanced panel was used.

In this study, the general equation used is as follows:

$$\ln\text{Ind}_{it} = \alpha + \beta_1 \text{Elec}_{it} + \beta_2 \ln\text{BBM}_{it} + \beta_3 \text{INV}_{it} + \beta_4 \text{INF}_{it} + \varepsilon_{it} \quad (1)$$

As is generally known, in panel data regression, there are three model approaches: Pooled Least Square (PLS), Fixed Effect Model (FEM), and Random Effect Model (REM). In this study, the model used is based on the results of the selection from the Hausman test.

A dummy variable is added to change the intercept in the fixed-effect method, but the other coefficients remain the same for each observed province. To consider each unit's individuality cross-section can be done by making different interceptions in each province. The equation model used is the least square dummy variable (LSDV), in which the dummy variable is added as much as the number of cross-sections is reduced by one to avoid dummy variable traps. So, the application in eq (1) becomes as follows:

$$\ln\text{Ind}_{it} = \alpha + \beta_1 \text{Elec}_{it} + \beta_2 \ln\text{BBM}_{it} + \beta_3 \text{INV}_{it}$$
$$+ \beta_4 \text{INF}_{it} + \sum_{i=1}^{33} D_i^c \alpha_i + \varepsilon_{it} \quad (2)$$

Furthermore, for the random effect method, the specific effect of each individual is α_i treated as part of the error component which is random and uncorrelated with the observed explanatory variable (X_{it}). Thus, the random effect model equation can be written as follows:

$$Y_{it} = \alpha_i + \beta_j X_{it} + E_{it} \qquad (3)$$

$$E_{it} = (\mu_{it} + v_t + w_{it}) \qquad (4)$$

where: μ_i = component cross section error; v_i = component time series error; w_{it} = component combination error.

Next, the application of eq (3) to estimate the industrial model in eq (1) is as follows:

$$\ln Ind_{it} = \alpha + \beta_1 Elec_{it} + \beta_2 \ln BBM_{it} + \beta_3 INV_{it} + \beta_4 INF_{it} + E_{it} \qquad (5)$$

The appropriate method for estimating the random-effects model is Generalized Least Squares (GLS) with homoscedastic assumptions and no cross-sectional correlation.

3.3. Model Dynamic Panel Data

Dynamic panel data regression describes the relationship between economic variables which is dynamic. In line with cross-section and time-series models in panel data, dynamic relationships are characterized by including the lag of the dependent variable as regressors in the regression (Greene, 2012).

The general form of the dynamic panel data regression model proposed by Baltagi (2005) is as follows:

$$Y_{it} = \delta Y_{i,t-1} + X_{it}^T \beta + u_{it} \qquad (6)$$

With u_{it} it is assumed that the one-way error component is as follows:

$$u_{it} = \varepsilon_{it} + \mu_{it} \qquad (7)$$

Next, merging eq (6) and (7) then the dynamic panel equation is obtained as follows:

$$Y_{it} = \delta Y_{i,t-1} + X_{it}^T \beta + \varepsilon_{it} + \mu_{it} \qquad (8)$$

Thus, the dynamic panel data regression model used in this study becomes:

$$\ln Ind_{it} = \delta Ind_{i,t-1} + \beta_1 Elec_{it} + \beta_2 \ln BBM_{it} + \beta_3 INV_{it} + \beta_4 INF_{it} + u_{it} + \varepsilon_{it} \qquad (9)$$

The dynamic panel model uses the Generalized Method of Moments (GMM) approach. GMM has two models in the estimation, namely First-Differences GMM and System GMM. First-differences approach was developed by Arellano and Bond (1991) with the Generalized Method of Moments (GMM) method were lag of dependent variable starting from t-2, or called FD-GMM is used. This approach will produce a consistent estimator of α when N→∞ with T is relatively small.

The Sys-GMM method is useful for estimating the system of First-Differences equations and at the level, where the instruments used at that level are the first-differences lag of the series (Blundell and Bond, 1998). Sys-GMM estimator combines the first differentiation equation group with the level value as the instrument plus the level equation group with the first difference as an instrument. The validity of these additional instruments can be determined using the Sargan test for over-identifying instruments.

In research used a validity test that applies to GMM. As suggested by Arellano and Bond (1991); Arellano and Bover (1995); Blundell and Bond (1998), there are two test specifications. Firstly, the Sargan test of over-identifying restrictions that tests the instruments' overall validity and hypothesis null is that all instruments as a group are exogenous. The second test examines the hypothesis null that error term ε_{it} of the differenced equation is not serially correlated particularly in the second-order (AR2).

4. RESULTS AND DISCUSSION

This study's first model selection is to pay attention to the Hausman Test results, which is useful for choosing a static model between fixed-effects and random-effects. Based on Table 1, the Hausman test probability value is 0.000, which means that H_0 is rejected and states that the best model to use is the fixed-effect.

Furthermore, for the dynamic model, the Sargan test results' prob value on the FD-GMM and Sys-GMM models is greater than 0.05 and H is accepted, which means that the over-identifying restriction conditions in the use of the model are valid. The p-value of AR (2) greater than 0.05 shows no density of serial correlation problems in the second-order. The model is feasible to use, and it can be

Table 1: Summary of static and dynamic panel data results

Variable	Fixed effect	Random effect	FD-GMM	Sys-GMM
Constanta	9.24 (63.35)	9.115 (41.38)	1.538 (16.99)	1.072 (21.10)
$\ln Ind_{it-1}$	-	-	0.848 (84.05)***	0.898 (170.66)***
Elec	0.0003 (4.75)***	0.0003 (5.66)***	0.000021 (1.57)	−0.000026 (−4.13)***
BBM	0.012 (1.08)	0.019 (1.658)*	−0.0005 (−0.59)	−0.0011 (−1.81)*
INV	0.0067 (6.56)***	0.0075 (7.45)***	0.0004 (2.48)**	0.0002 (1.83)*
INF	−0.01 (−3.31)***	−0.0099 (−3.18)***	−0.0026 (−5.93)***	−0.0009 (−2.68)**
Hausman test	54.58 (0.000)		-	-
Sargan test (P-value)	-	-	28.87 (0.094)	29.40 (0.293)
AR (2) (P-value)	-	-	−1.655 (0.098)	−1.589 (0.112)
Adj. R^2	0.9932	0.2551	-	-
F-stat	1077.59 (0.000)	24.21 (0.000)	-	-
Obs.	272	272	238	238

Figures in the parentheses are t-statistics. ***, ** and * denote significance at 1%, 5% and 10% levels, respectively

concluded that the error term in the model has no serial, and it can be said that the estimator used is efficient.

The results of the fixed-effect static model estimation (Table 1). State that the distribution of electricity (Elec) is positively and significantly related to industrial development. If there is an increase in one unit's electricity distribution ratio, it can increase the industry by 0.0003%. Furthermore, energy consumption (BBM) is positive at 0.012, which means that an increase in energy consumption per unit will increase industrial value but not significantly. The investment coefficient is positive and significant to the industrial value, which is 0.0067. Finally, inflation has a negative and significant impact on industrial value, where if there is an increase in inflation by one unit, the industrial value will decrease by 1%.

The FD-GMM results state that electricity distribution has a negative and insignificant relationship with the dynamic model industry. The energy consumption (BBM) coefficient is positive and does not significantly affect the industry's value. Furthermore, the investment coefficient has a positive and significant relationship with the industry, and finally, inflation has a negative and significant relationship with the industry.

Meanwhile, the Sys-GMM model results state that electricity distribution has a significant negative effect on the industrial value; this is different from the previous model results. Furthermore, energy consumption (BBM) has a negative and significant industrial value. The investment coefficient has a positive and significant value, which means it can increase the industrial value that occurs. Finally, inflation has a negative and significant value to the industry.

Based on the static model, the distribution of electricity supports industrial value development, which is in line with Kumari and Sharma (2018); Tiwari et al. (2020) where existing electricity is related to economic growth based on GDP. On the other hand, electricity distribution in a sustainable term is negatively related to industrial development, and this result is not in line with Amaluddin (2020); Apergis and Payne (2011) which states that there is a relationship between electricity and an increase in GDP. The distribution of electricity used in this study characterizes the availability of electricity for each region. In real terms, there are still areas that still depend on neighbouring power plants, even if this continues, so automatically, this area will always depend, and the costs will increase. For other reasons, the electricity-producing regions also continue to develop and meet their needs.

For this reason, the government should pay attention to the supporting energy infrastructure in the form of an even distribution of electricity between regions and later it will achieve an electrification ratio of 100%. This is also in line with the results Hidayat et al. (2020) state that energy infrastructure development, especially electricity, can reduce inequality between regions.

Next, the static model's energy consumption positively affects the industry, and it is just not significant. However, when viewed in a relationship, this result is in line with Asafu-Adjaye et al. (2016);

Gungor and Simon (2017); Meidani and Zabihi (2014); Tang et al. (2016) which states that there is a relationship between energy consumption in improving the economy. The inverse proportion occurs in the dynamic model, and there is a negative and significant relationship, which is also in line with Shahbaz et al. (2017); Tran et al. (2020). In this study, energy consumption is the consumption of diesel fuel, which is the primary fuel for industrialization. Consumption in a continuous-time raises the concern that this fuel is becoming scarce, resulting in this commodity's price increase. Industrial operating costs will automatically increase and will hamper industrial growth. It is only natural for policymakers to seek and continue to innovate in renewable energy to be used in sustainable industries. Meanwhile, in the short term, the government is serious about monitoring subsidized diesel fuel distribution to make it useful and efficient.

Furthermore, the dynamic estimation results, lag-industry, are positive and significant, which states that the industrial value that occurred in the previous period can affect the current industry value. Other variables in the model are considered constant or cateris paribus. In fact, the development of industries that already have supporting infrastructure will encourage industrialization development, and policymakers should continue to pay attention to these supporting facilities, and do not forget to make regulations beneficial to domestic industries.

5. CONCLUSION

Based on the results and discussion above, it can be concluded that statically the distribution of electricity and investment can significantly increase industrial development, and inflation significantly reduces industrial value. On the other hand, the dynamic model states that electricity distribution and energy consumption (diesel) are negatively and significantly related to industrialization, while investment and inflation are the same. These differences provide an overview for policymakers to issue policies that are right on target based on the period, both short, medium and long term.

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