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How to Fuel Better? Assessing the Impact of Energy Use on Industrialization in Developing Countries

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Abstract
Industrialization is the engine of economic growth. Most of the developing countries shifted from agriculture towards industrialization with the motivation of pursuing higher economic growth since the last few decades. Past studies have shown that there is clear evidence of a strong correlation between energy consumption and economic growth. Hence, this paper aims to contributes on the topic of energy consumption and how it impacts the level of economic growth through industrialization. Our findings show that the association between use of energy at manufacturing sector, which have been proxied using amount of refined energy and petroleum allocated to manufacturing sector, and the development of manufacturing sector, which have been proxied using level of GDP on manufacturing sector, is not a mere correlation. Estimations using lagged independent variable proves that an increase on use of energy at manufacturing sector has a positive and, to some extent, significant impact on the expansion of manufacturing sector. Furthermore, this study also finds that the effect of use of energy on manufacturing sector on the expansion of manufacturing sector seems to be weaker and even becomes insignificant on the Non-ASEAN Plus countries. One factor that might explain such phenomena is the difference on the commitment from each country to allocate energy for the development of their manufacturing sector. The energy allocation refers to the share of energy which flows to the manufacturing sector instead to other non-manufacturing sector, such as agriculture, services, or even consumption. Higher share of energy which flows to the manufacturing sector indicates a commitment by the government and/or the society to mobilize resource and energy to better leverage the development of the manufacturing sector which ultimately lead to the economic growth. Another factor that might contribute to higher share of energy use is wage as lower wage in ASEAN Plus countries enables the firm and industry to hire more labor; hence expanding their scale of production. The bigger production scale implies they might have a higher economies-of-scale which translated into a more efficient energy use.

JEL Classification: O40; O14; Q4

Keywords
Economic Growth — Industrialization — Energy Consumption

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1. Introduction

Industrialization is the engine of economic growth. Most of the developing countries shifted from agriculture towards industrialization with the motivation of pursuing higher economic growth since the last few decades. This shift requires a massive amount of energy use, mainly fossils. As some countries are blessed with rich natural resources, they enjoyed substantial amount of economic benefit during the era of commodity boom and sufficient amount of energy to support the industrialization process. However, the efficacy of energy use to bolster economic growth is rather varies across countries. This phenomenon raises a question of what factors could make one country use energy better than the others.

All human activities require energy use; in fact, all human impacts on the environment can be seen as the consequences of energy use which has a various number of impacts. Around 80% of global energy consumption in 2018 came from fossil energy (British Petroleum, 2019). Energy use is sometimes seen as a proxy for the environmental impact of human activity in general. The factors that reduce the total amount of energy needed to produce economic value, therefore, also act to reduce the environmental impact of economic growth in precisely the same way as they reduce energy consumption. Energy extraction and processing always involve some forms of environmental disturbance, including both geomorphological and ecological disruption, in addition to pollution. Pollution creations, such as noise from transport, and land-use impacts, such as the construction of roads, etc., are inevitable in the process of energy use. More often than not, energy use is discussed around the spectrum of its negative implication only. There is a growing concern of increasing energy consumption from fossil energy as it has at least two problems. First, fossil energy is non-renewable energy which will be depleted

sooner or later and when it does, people will be difficult to do their activities. Second, the use of fossil energy creates pollution. To transform fossil fuels into energy requires a combustion process that also produces pollutants other than energy.

However, not all impacts of energy use are equally harmful to the environment and human health. Hannesson (2009) concludes that most of the world's primary energy comes from fossil fuels; it is going to be very difficult to reconcile reductions in carbon dioxide emissions with continued economic growth, especially in poor and medium rich countries. As there is a significant inherent opportunity cost from energy usage to the environment, energy consumption should be allocated to a more productive sector such as the industrial sector. Shifting energy usage to the productive sector will make energy use more efficient by reducing the amount of energy use for each unit of GDP.

By using the energy and economic growth nexus framework, shifting energy use to the industrial sector may also increase the rate of industrialization in a country as energy could be seen as a crucial factor in the industrial productive activity. Even though there is no clear consensus of how the energy consumption and economic growth are related, past studies have shown that there is clear evidence of a strong correlation between energy consumption and economic growth. Hence, this paper aims to contribute on the issue. Our study intends to shed some lights on the topic of energy consumption and how it impacts the level of economic growth through industrialization. Using developing countries as our sample, we also try to deepen our analysis by analyzing the role of manufacturing sector within the constellation of energy consumption and how it is related to the growth of the economy.

2. Literature Review

Energy consumption can be seen as a production factor as higher economic growth requires higher energy consumption (Ucan et al., 2014; Halicioglu, 2008). However, the causality between those factors differs across context. Apergis and Payne (2012) stated four hypotheses that could explain the relationship between energy consumption and economic growth, namely growth, conservation, interdependent, and neutrality hypotheses. First, the growth hypothesis denotes that energy consumption complements labor and capital as a production function. This hypothesis will be the main focus of this study. Several works of literature proved this hypothesis by finding a uni-direction Granger Causality from energy consumption to economic growth. The consequence of this relationship is that any attempt to reduce energy consumption will impede economic growth. Asafu-Adjaye (2000) investigates the relationship between income (Gross Domestic Product, GDP), energy use per capita and prices (proxied by consumer price index, CPI) in India, Indonesia, Thailand, and Philippines. He found a uni-directional Granger Causality from energy consumption to GDP in India and Indonesia, while a bi-directional Granger Causality in Thailand and Philippines.

Second, the conservation hypothesis stated that energy consumption is a function of economic growth. The empirical support for this hypothesis is based on the presence of a uni-direction Granger Causality from economic growth to energy consumption. On this hypothesis, one could conclude that energy conservation policies would not affect GDP. Thus, the energy conservation policy should be undertaken. Zhang and Cheng (2009) investigate the relationship between economic growth, energy consumption and carbon emissions in China during 1960–2007. They found a uni-directional Granger Causality from real GDP growth to energy consumption. Govindaraju and Tang (2013) also investigate the relationship in China with India as an additional country. The result is, however, slightly different from Zhang and Cheng, whereas they found a bi-directional relationship in China and a uni-directional Granger Causality from economic growth to energy consumption in India.

Third, the interdependent hypothesis postulates the interdependent relationship between energy consumption and economic growth. This hypothesis is supported by the presence of bi-direction Granger Causality between energy consumption and economic growth. Al-mulali (2011) examines the relationship between oil consumption (as a proxy for energy consumption) and economic growth in the Middle East and North Africa (MENA countries). He found a bi-directional Granger Causality with a panel data model between variables. The results support the view of energy consumption and economic performance has a strong relationship with each other.

Fourth, the neutrality hypothesis used the assumption that energy consumption has a weak correlation in economic growth. The empirical support for this hypothesis is supported by the absence of Granger Causality between energy consumption and economic growth. Developing economies are trying to industrialize their economy by following the success of Japan, China, and South Korea. Industrialization provides many benefits such as higher and more stable economic growth, efficient use of land, and more (Chandra, 1992). However, one thing to keep in mind is that the industrial sector consumed more energy than other sectors (U.S. Energy Information Administration, 2016). Thus, it may decrease the overall energy intensity in a country during the transition of energy consumption from other sectors to the industrial sector.

3. Data and Methodology

3.1 Methodology

Overall, the method used in this study will help us to understand the association between use of energy and the development of manufacturing sector from 20 middle income countries in 2005 until 2015. The magnitude of association between those variables implies a clue about how well middle-income countries leverage their use of energy for the development of manufacturing sector. It is also interesting to see how different groups of countries have different magnitude of the elasticity between use of energy and the development of manufacturing sector.

To unpack the correlation between the use of energy by the manufacturing sector and the development of the manufacturing sector itself, this study employs Panel Data Ordinary Least Regression (OLS) with fixed effect at country and year level. This method allows us to draw the correlation as well as controlling for region and time heterogeneity.

Mathematically, the model can be written as follows:

$$\ln\_sizeman_{ct} = \alpha + \beta \ln\_enerman_{ct} + \gamma C_{ct} + R_c + T_t + \varepsilon_{ct} \quad (1)$$

$\ln\_sizeman_{ct}$: log value of GDP on manufacturing sector (million USD) at country c and year t
$\ln\_enerman_{ct}$: log value of amount of refined energy and petroleum allocated to manufacturing sector (million USD) at country c and year t
C_{ct} : Set of control variable which consist of trade openness, energy intensity, and GDP per capita at country c and year t
R_c : country-level specific characteristics at country c
T_t : year-level specific characteristics at year t
ε_{ct} : error term

Further, to better identify the causal effect of the use of energy at manufacturing sector on the development of manufacturing sector, this study introduces the $\ln\_enerman$ value *from previous periods* (lag value) to replace the contemporaneous value of $ln\_enerman$ on year t. To maintain reasonable size of observation, this study only uses lagged value of log value of amount of refined energy and petroleum allocated to manufacturing sector at $t-1$, $t-2$, $t-3$, and $t-4$. Hence, the additional equations in this study are:

$$\ln\_sizeman_{ct} = \alpha + \beta \ln\_enerman_{ct-1} + \gamma C_{ct} + R_c + T_t + \varepsilon_{ct} \quad (2)$$

$$\ln\_sizeman_{ct} = \alpha + \beta \ln\_enerman_{ct-2} + \gamma C_{ct} + R_c + T_t + \varepsilon_{ct} \quad (3)$$

$$\ln\_sizeman_{ct} = \alpha + \beta \ln\_enerman_{ct-3} + \gamma C_{ct} + R_c + T_t + \varepsilon_{ct} \quad (4)$$

$$\ln\_sizeman_{ct} = \alpha + \beta \ln\_enerman_{ct-4} + \gamma C_{ct} + R_c + T_t + \varepsilon_{ct} \quad (5)$$

Lagged independent variable in equation (2), (3), (4), and (5) will be helpful for this study on reducing the risk of endogeneity as well as inferring a more solid uni-directional impact from use of energy at manufacturing sector to the development of manufacturing sector.

3.2 Data

3.2.1 Unit of Analysis

This study picks 20 countries which were classified as middle income countries in 2005 based on World Bank's Atlas method (see Appendix: Table A1). To make sure that this study does not miss major phenomena on manufacturing sector development in developing countries, we select some major countries with strong industrialization - e.g. China, India, Vietnam - as well as other countries from different region which faced different context and setting – e.g. Russia, South Africa, Kazakhstan, Morocco, etc.

For period of observation, this study chooses annual data ranging from 2005 until 2015. The reason behind the decision to pick 2005-2015 as the period of observation is because the amount of refined energy and petroleum allocated to manufacturing sector data, which come from OECD's Input-Output Table and stands as the main independent variable in this study, only available from 2005 until 2015. The combination of 20 countries and yearly data from 2005 until 2015 gives this study 220 panel observations in total at the full sample framework.

3.2.2 Data Source

Main Dependent Variable

• GDP on manufacturing sector

This study uses GDP on manufacturing sector (in million USD) to proxy the development of manufacturing sector in 20 countries from 2005 until 2015. The data is taken from World Bank's World Development Indicator.

Main Independent Variable

• Amount of refined energy and petroleum allocated to manufacturing sector

This study uses amount of refined energy and petroleum allocated to manufacturing sector (in million USD) to proxy the use of energy at manufacturing sector in 20 countries from 2005 until 2015. The data is taken from OECD's Input-Output Table.

Control Variables

• Trade openness

This variable uses share of export and import on total GDP (in percent) to proxy openness to international economy and trade in 20 countries from 2005 until 2015. The data is taken from World Bank's World Development Indicator.

• Energy intensity

This variable uses energy intensity level of primary energy (MJ per PPP of GDP 2011 Price) to proxy for the efficiency of energy processing in 20 countries from 2005 until 2015. The data is taken from World Bank's World Development Indicator.

• GDP per capita

This variable uses GDP per capita (in USD) to proxy for state of economic development in 20 countries from 2005 until 2015. The data is taken from World Bank's World Development Indicator.

4. Results and Analysis

Figure 4.1 presents the scatterplot of the GDP on manufacturing sector and energy volume allocated on manufacturing sector for the full sample of twenty countries with two data points at 2009 and 2015.

According the log value of GDP on manufacturing sector, China's economy has an extremely large size of manufacturing sector. On the other hand, Tunisia is recorded as a country with the smallest value of GDP on manufacturing sector. From the Figure 4.1 we can see that the position of their manufacturing sector size is surprisingly followed by the volume of energy allocated on the manufacturing sector. This full sample correlation shows that energy volumes on manufacturing sector has positive linkage with the size of manufacturing sector. The positive relationship is also presented by the point transitions from the data in 2009 to 2015. Most of countries has moved to the right due to the higher energy volume allocated on manufacturing sector (except in Tunisia), however, the increase is also followed by a higher size of manufacturing sector. So, the position

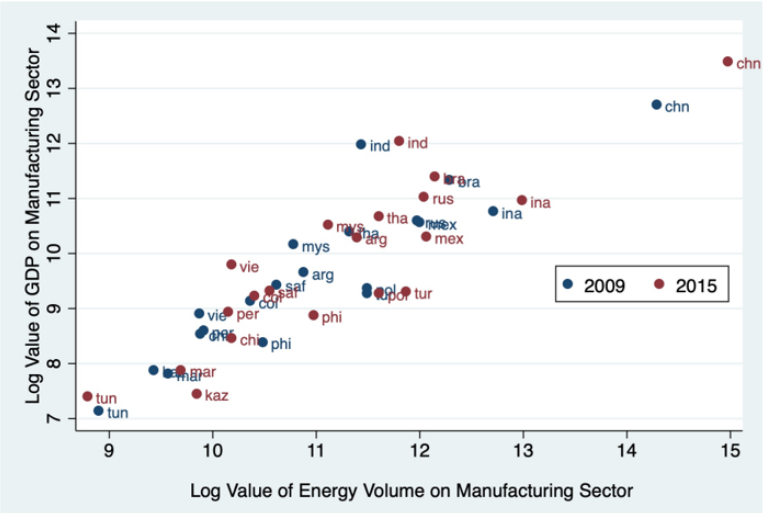

Figure 4.1. Scatterplot GDP on Manufacturing Sector and the Volume of Energy Allocated to Manufacturing Sector
Source: Author's calculation

moves not only to the right but also to the top. It indicates a persistent positive linkage through different time. However, the evidence needs to be re-examined using the regression estimation below.

In general, the estimation finds that the use of energy on manufacturing sector positively correlates with the development of the manufacturing sector. Table 4.1 shows the elasticities of size of the manufacturing sector due to an increase of the use of energy on manufacturing sector.

Overall, the elasticities are positive and significant at least at 95% confidence interval, even though their power tend to decrease from t to t-4. At the contemporaneous period, this study finds that one percent increase on use of energy on manufacturing sector correlates with approximately 0.4 percent increase on the size of manufacturing sector. From the results based on t-1 until t-4, this study further finds that one percent increase on use of energy on manufacturing sector in previous years expand the size of manufacturing sector by 0.36, 0.24, 0.17, and 0.13 percent, respectively. The complete and more detailed regression result of this estimation is available in Appendix: Table A2.

Further, this study also checks the heterogeneity that might happened across different regional settings. To be able to do so, this study disaggregates the 20 countries into two different groups: ASEAN members (Indonesia, Malaysia, Thailand, Philippines, and Vietnam) plus China and India (ASEAN Plus, hereafter) and the rest of them which neither the member of ASEAN nor China nor India (Non-ASEAN Plus, hereafter). We also take out China and India from ASEAN Plus to construct group of countries which exclusively come from ASEAN (ASEAN, hereafter). The motivation behind this disaggregation is that most of the countries which are the member of ASEAN Plus have been regarded as the world's industrial powerhouses and hold strategic position in global value chain - e.g. Thailand, Vietnam, China, India. This study wants to check whether those member of ASEAN Plus have different pattern of elasticity with other Non-ASEAN Plus or ASEAN countries.

Table 4.2 shows the elasticities of development on manufacturing sector due to an increase on use of energy on manufacturing sector in ASEAN Plus, Non-ASEAN Plus, and ASEAN. In general, the regression presents that countries which are the member of ASEAN Plus have the strongest association between use of energy on manufacturing sector with the development of manufacturing sector. At period t, elasticity of ASEAN Plus member lies around 0.4 percent, meanwhile the Non-ASEAN Plus member has the elasticity less than 0.2 percent. Further, as we move from t-1 to t-4, the association between use of energy on manufacturing sector with the development of manufacturing sector becomes weaker and less significant, both for ASEAN Plus member and Non-ASEAN Plus member. However, the elasticities of ASEAN Plus member are still higher than Non-ASEAN Plus member in t-1, t-2, t-3, as well as t-4. ASEAN Plus member have point estimates of elasticity around 0.2-0.3 percent in t-1, t-2, t-3, until t-4. On the other hand, point estimate of elasticity of Non-ASEAN Plus stays slightly below 0.2 percent in t-1 and then start decreasing, insignificant, and approaching to zero from t-2 until t-4. Another interesting finding from Table 4.2 is the elasticity of ASEAN Plus drops when we take out China and India from the list to form ASEAN group of countries. This finding implies a significant role from China and India on pushing the higher elasticity in the ASEAN Plus group. The complete and more detail regression result of this estimation is available in Appendix: Table A3.

In general, the results of this study focus on the elasticity between use of energy on manufacturing sector and the development of manufacturing sector. Our findings show that the association between use of energy at manufacturing sector, which have been proxied using amount of refined energy and petroleum allocated to manufacturing sector, and the development of manufacturing sector, which have been proxied using level of GDP on manufacturing sector, is not a mere correlation. Estimations using lagged independent variable in equation (2), (3), (4), (5) prove that an increase on use of energy at manufacturing sector has a positive and, to some extent, significant impact on the expansion of manufacturing sector.

The findings in this study are similar with some previous studies. This study confirms previous study from Asafu-

Table 4.1. Regression Result using Equation (1), (2), (3), (4), and (5) – Full Sample

Elasticity	Log of Size of Manufacturing Sector			
Log of Use of Energy (t)	0.817***	0.454***	0.782***	0.399***
	(0.03)	(0.06)	(0.03)	(0.05)
Log of Use of Energy (t-1)	0.815***	0.433***	0.780***	0.364***
	(0.03)	(0.07)	(0.03)	(0.06)
Log of Use of Energy (t-2)	0.811***	0.290***	0.778***	0.242***
	(0.03)	(0.07)	(0.03)	(0.06)
Log of Use of Energy (t-3)	0.814***	0.212***	0.782***	0.166***
	(0.03)	(0.08)	(0.03)	(0.06)
Log of Use of Energy (t-4)	0.825***	0.203**	0.794***	0.134**
	(0.03)	(0.08)	(0.04)	(0.05)
Control	No	No	Yes	Yes
Country FE	No	Yes	No	Yes
Year FE	No	Yes	No	Yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Author's calculation

Table 4.2. Regression Result using Equation (1), (2), (3), (4), and (5) – Regional Disaggregation

Elasticity	Log of Size of Manufacturing Sector		
	ASEAN Plus	Non-ASEAN Plus	ASEAN
Log of Use of Energy (t)	0.385***	0.179***	0.298***
	(0.08)	(0.07)	(0.11)
Log of Use of Energy (t-1)	0.306***	0.169**	0.0919
	(0.10)	(0.07)	(0.14)
Log of Use of Energy (t-2)	0.253**	0.0565	0.0633
	(0.12)	(0.06)	(0.15)
Log of Use of Energy (t-3)	0.226*	0.0197	0.108
	(0.12)	(0.06)	(0.15)
Log of Use of Energy (t-4)	0.271*	0.00485	0.285*
	(0.13)	(0.06)	(0.16)
Control	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Author's calculation

Adjaye (2000) which proved a uni-directional effect from energy consumption to economic growth in the context of developing countries by showing the similar pattern in manufacturing sector.

However, as being depicted in Table 4.2, this study also finds that the effect of use of energy on manufacturing sector on the expansion of manufacturing sector seems to be weaker on the Non-ASEAN Plus countries. This differs from the elasticity on ASEAN Plus countries which appears to be stronger and more significant. One factor that might explain such phenomena is the difference on the commitment from each country to allocate energy for the development of their manufacturing sector. The energy allocation in this discussion refers to the share of energy which flows to the manufacturing sector instead to other non-manufacturing sector, which could be agriculture, services, or even consumption. Higher share of energy which flows to the manufacturing sector indicates a commitment to mobilize resource and energy to better leverage the development of the manufacturing sector. Figure 4.2 shows share of refined energy and petroleum which flows to the manufacturing sector.

In general, Figure 4.2 shows that ASEAN Plus countries (red line) mostly have higher share of refined energy and petroleum which flows to the manufacturing sector compare to the Non-ASEAN Plus countries (grey line). This higher share of energy to manufacturing sector implies a better commitment from ASEAN Plus countries to mobilize their resource for the development and expansion of their manufacturing sector, which eventually lead to a stronger and more significant elasticity between use of energy at manufacturing sector and the development of manufacturing sector.

Furthermore, Figure 4.3 shows that ASEAN Plus Countries, on average, has a lower level of wage compared to the Non-ASEAN Plus counterpart. This might play a role in explaining the higher consumption share of energy by the manufacturing sector as lower wage enables the firm and industry to hire more labor; hence expanding their scale of production. The bigger production scale implies they might have a higher economies-of-scale which translated into a more efficient energy use.

5. Concluding Remark

To be able to reach the maximum feasible level of welfare is the ultimate goal of every society in this world. Furthermore, the most widely means used to achieve such goals

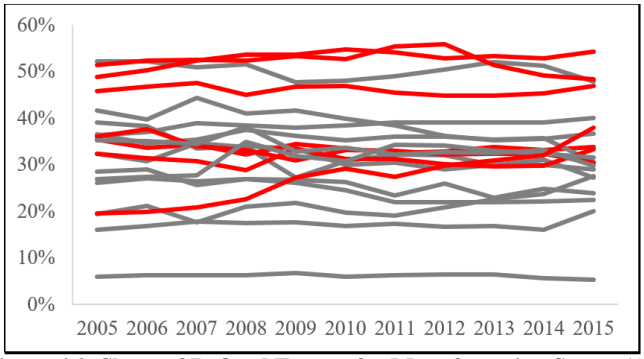

Figure 4.2. Share of Refined Energy for Manufacturing Sector (%)
Source: Author's calculation

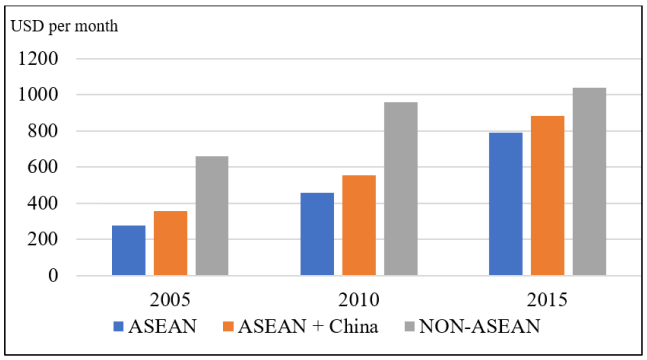

Figure 4.3. Average Wage in Manufacturing Sector
Source: ILO

within a nation is through an industrialization process. Traditional consensus believes that the industrialization process has been achieved by growing and improving the productivity and the contribution of the manufacturing sector in the economy.

However, while there is still an ongoing discussion of how the energy consumption and economic growth are related, past studies have shown clear evidence on the strong correlation between energy consumption and economic growth. Hence, this paper aims to contribute on the issue. Our study intends to shed some lights on the topic of energy consumption and how it impacts the level of economic growth through industrialization. Using developing countries as our sample, we also try to deepen our analysis by analyzing the role of manufacturing sector within the constellation of energy consumption and how it is related to the growth of the economy.

This study found that the use of energy on manufacturing sector positively correlates with the development of the manufacturing sector. We found that the elasticities of size of the manufacturing sector due to an increase of the use of energy on manufacturing sector are positive, even though their power tend to decrease from t to t-4. At the contemporaneous period, this study finds that one percent increase on use of energy on manufacturing sector correlates with 0.4 percent increase on the size of manufacturing sector. From the results based on t-1 until t-4, this study further finds that one percent increase on use of energy on manufacturing sector in previous years expand the size of manufacturing sector by 0.36, 0.24, 0.17, and 0.13 percent, respectively.

In general, the results of this study focus on the elasticity between use of energy on manufacturing sector and the development of manufacturing sector. Our findings show that the association between use of energy at manufacturing sector, which have been proxied using amount of refined energy and petroleum allocated to manufacturing sector, and the development of manufacturing sector, which have been proxied using level of GDP on manufacturing sector, is not a mere correlation. Estimations using lagged independent variable prove that an increase on use of energy at manufacturing sector have positive and, to some extent, significant impact on the expansion of manufacturing sector.

Furthermore, this study also finds that the effect of use of energy on manufacturing sector on the expansion of manufacturing sector seems to be weaker and even becomes insignificant on the Non-ASEAN Plus countries. This differs from the elasticity on ASEAN Plus countries which appears to be stronger and more significant. One factor that might explain such phenomena is the difference on the commitment from each country to allocate energy for the development of their manufacturing sector. The energy allocation in this discussion refers to the share of energy which flows to the manufacturing sector instead to other non-manufacturing sector, which could be agriculture, services, or even consumption. Higher share of energy which flows to the manufacturing sector indicates a commitment to mobilize resource and energy to better leverage the development of the manufacturing sector. Another factor that might play a role is wage. On average, ASEAN Plus countries has lower wage compared to its Non-ASEAN Plus counterparts. Higher consumption share of energy by the manufacturing sector might be explained by wage level as lower wage enables the firm and industry to hire more labor; hence expanding their scale of production. The bigger production

scale implies they might have a higher economies-of-scale which translated into a more efficient energy use. Since this study focuses on specific part of energy use and industrialization process and inherently has several limitations, we encourage further study to shed more lights on this topic.

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Appendix

Table A1. List of Countries

Brazil	Vietnam	Argentina	Kazakhstan
India	Mexico	China	Morocco
Indonesia	Chile	Colombia	Peru
Malaysia	Philippines	Tunisia	Russia
Thailand	South Africa	Poland	Turkey

Table A2. Full Regression Result using Equation (1), (2), (3), (4), and (5) – Full Sample

VARIABLES	Log of Size of Manufacturing Sector																			
Log of Use of Energy (t)	0.817***					0.454***					0.782***					0.399***				
	(0.0264)					(0.0554)					(0.0259)					(0.0485)				
Log of Use of Energy (t-1)		0.815***					0.433***					0.780***					0.364***			
		(0.0281)					(0.0680)					(0.0281)					(0.0563)			
Log of Use of Energy (t-2)			0.811***					0.290***					0.778***					0.242***		
			(0.0305)					(0.0736)					(0.0309)					(0.0565)		
Log of Use of Energy (t-3)				0.814***					0.212***					0.782***					0.166***	
				(0.0327)					(0.0764)					(0.0334)					(0.0551)	
Log of Use of Energy (t-4)					0.825***					0.203**					0.794***					0.134**
					(0.0348)					(0.0779)					(0.0358)					(0.0542)
Trade Openess											-0.00161***	-0.00146***	-0.00141**	-0.00136**	-0.00134**	0.000992	0.000572	0.000269	6.25e-06	-0.000394
											(0.000455)	(0.000502)	(0.000557)	(0.000606)	(0.000650)	(0.000886)	(0.000929)	(0.00101)	(0.00104)	(0.00105)
GDP per Capita											3.58e-05***	3.17e-05***	2.94e-05***	2.76e-05**	2.54e-05**	5.37e-05***	6.34e-05***	7.52e-05***	8.14e-05***	7.93e-05***
											(9.18e-06)	(9.88e-06)	(1.07e-05)	(1.15e-05)	(1.21e-05)	(7.04e-06)	(7.27e-06)	(7.57e-06)	(7.38e-06)	(7.36e-06)
Energy Intensity											0.0206	0.0261	0.0262	0.0262	0.0242	-0.0809***	-0.0774***	-0.0869***	-0.0769***	-0.0688**
											(0.0176)	(0.0193)	(0.0214)	(0.0232)	(0.0251)	(0.0257)	(0.0265)	(0.0275)	(0.0268)	(0.0280)
Constant	3.086***	3.157***	3.258***	3.293***	3.252***	6.379***	6.748***	8.268***	9.158***	9.159***	3.212***	3.260***	3.353***	3.382***	3.352***	6.842***	7.206***	8.391***	9.074***	9.313***
	(0.262)	(0.279)	(0.301)	(0.321)	(0.340)	(0.519)	(0.632)	(0.684)	(0.709)	(0.721)	(0.265)	(0.291)	(0.320)	(0.345)	(0.367)	(0.492)	(0.569)	(0.570)	(0.561)	(0.540)
Country FE	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Observations	220	200	180	160	140	220	200	180	160	140	220	200	180	160	140	220	200	180	160	140
R-squared	0.814	0.809	0.799	0.797	0.803	0.991	0.992	0.993	0.994	0.995	0.843	0.833	0.821	0.817	0.821	0.994	0.995	0.996	0.997	0.998

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A3. Full Regression Result using Equation (1), (2), (3), (4), and (5) – Regional Disaggregation

VARIABLES	Log of Size of Manufacturing Sector														
	ASEAN Plus					Non-ASEAN Plus					ASEAN				
Log of Use of Energy (t)	0.385***					0.179***					0.298***				
	(0.0784)					(0.0681)					(0.107)				
Log of Use of Energy (t-1)		0.306***					0.169**					0.0919			
		(0.102)					(0.0695)					(0.136)			
Log of Use of Energy (t-2)			0.253**					0.0565					0.0633		
			(0.115)					(0.0607)					(0.146)		
Log of Use of Energy (t-3)				0.226*					0.0197					0.108	
				(0.123)					(0.0559)					(0.149)	
Log of Use of Energy (t-4)					0.271*					0.00485					0.285*
					(0.133)					(0.0571)					(0.159)
Trade Openess	0.00420***	0.00286**	0.00243*	0.00238	0.00157	0.00212	0.00211	0.00187	0.00197	0.00201	0.00239**	0.000773	0.000347	0.000864	0.00134
	(0.00105)	(0.00118)	(0.00135)	(0.00153)	(0.00147)	(0.00157)	(0.00151)	(0.00148)	(0.00145)	(0.00165)	(0.00111)	(0.00125)	(0.00146)	(0.00172)	(0.00163)
GDP per Capita	4.30e-05**	5.70e-05**	7.04e-05***	8.26e-05***	9.15e-05***	8.08e-05***	8.10e-05***	8.70e-05***	8.94e-05***	8.88e-05***	5.63e-05**	4.34e-05	6.57e-05*	9.82e-05**	0.000121***
	(1.86e-05)	(2.17e-05)	(2.52e-05)	(2.49e-05)	(2.55e-05)	(8.45e-06)	(7.94e-06)	(7.40e-06)	(6.87e-06)	(7.14e-06)	(2.51e-05)	(3.24e-05)	(3.81e-05)	(3.88e-05)	(3.99e-05)
Energy Intensity	-0.111***	-0.101**	-0.0764	-0.0357	0.0239	0.0311	-0.00705	-0.0429	-0.0516*	-0.0476	-0.0603	-0.0364	-0.0370	-0.0691	-0.0420
	(0.0379)	(0.0449)	(0.0540)	(0.0555)	(0.0596)	(0.0335)	(0.0321)	(0.0302)	(0.0270)	(0.0304)	(0.0527)	(0.0626)	(0.0739)	(0.0832)	(0.0980)
Constant	9.724***	10.82***	11.40***	11.47***	10.45***	8.216***	8.556***	9.803***	10.20***	10.29***	9.251***	11.52***	11.96***	11.61***	9.546***
	(1.181)	(1.486)	(1.677)	(1.803)	(1.978)	(0.600)	(0.638)	(0.567)	(0.531)	(0.518)	(1.103)	(1.427)	(1.560)	(1.671)	(1.843)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	77	70	63	56	49	143	130	117	104	91	55	50	45	40	35
R-squared	0.997	0.997	0.997	0.998	0.998	0.994	0.995	0.997	0.998	0.998	0.996	0.995	0.995	0.996	0.996

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

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