ENERGY POVERTY - IMPACT OF RENEWABLE ENERGY ON SOCIO-ENVIRONMENT

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ABSTRACT

This research develops multiple linear regression model and moderating regression analysis to determine the impact of income inequality on the relationship between renewable energy use and carbon emissions in Indonesia during the period of 1990 to 2017. This research uses productive population living in the cities, the use of fossil energy, and dummy (the rules regarding CO_2 emissions) variables as control variables. The empirical result shows that income inequality can be a moderating variable for renewable energy relation; the more unequal income is, the stronger the negative relationship between renewable energy use and CO_2 emissions. Besides, this research also reveals the importance of rules to support renewable energy use in Indonesia which in turn is able to reduce carbon gas emissions in Indonesia as mitigating climate change that is getting obvious.

KEY WORDS : Energy poverty, Renewable energy, Formal constraints, CO_2 emissions

INTRODUCTION

The increasing concern for environmental damage, along with the increasing awareness of global warming and climate change have been the trigger for many researches related to energy use. A number of agreements, meetings and conventions at international level that began in 2015 have made it possible to create broad consensus, especially regarding energy sustainability and climate change mitigation. The launch of the Sustainable Development Goals as a substitute for the Millennium Development Goals and the signing of the United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties, became the pioneer in creating this consensus.

Energy is one of the most important factors in changing the country from a developing position to an advanced one. However, at the same time the energy consumption gives a negative impact on the environment (Saboori and Jamalludin., 2013). Energy is often considered the "foundation of economic growth" (Worldbank, 2017). Industrialization of countries around the world and sustainable global economic growth depend on the availability of natural resources which can be used as energy source to power machinery, heat homes, and supply billions of individuals with electricity (McGee and Greiner, 2019). On the other hand, energy production and consumption account for around two thirds of greenhouse gas emissions (N. Gunningham, 2013) which causes environmental problems including the threat of climate change.

Reducing CO_2 emissions is an important part of climate mitigation strategies (IPCC, 2014). Gunningham (2013), through his findings, suggested that what is needed most in breaking down the energy trilemma is the 'energy revolution', which is the transformation of the energy sector from high-to-low-energy, while keeping paying attention to economic aspects, as recognized by the International Energy Agency and others (Florini and Dubash, 2011; IEA, 2011). Thus, there is a broad consensus in the literature about the need for renewable energy development which is seen as an important element of energy availability, economic development and environmental protection through efforts to reduce greenhouse gas emissions (Liu *et al.*, 2019; Aguirre and Ibikunle, 2014).

Bozkurt and Destek (2015) emphasized that the increasing environmental pollution and environmental problems along with technological developments and improvements, and running out of fossil fuels are increasingly rapidly giving rise to consideration of renewable energy sources that can reduce pollution and degradation. This is reinforced by the research of Sasana and Aminata (2019) which found that renewable energy can significantly reduce air pollution in Indonesia. Moreover, Sadorsky (2011) concluded that in the future renewable energy contributes between 50% and 80% of total energy demand; where the scenario is the most favorable scenario for the future of renewable energy based on strong commitments in terms of time, budget, individuals, government, andpolicy makers.

Although research has found that increasing the proportion of renewable energy produced by countries reduces CO_2 emissions, as an effort to mitigate carbon, it still depends on other variables. A number of researches show that the ability of renewable energy to reduce emissions depends on the size of national economy (Sugiawan and Managi, 2016; Thomb, 2017; York, J.A. Mcgee, 2017). Even in other research, carbon mitigation strategies have been found to potentially worsen the problems of inequality (McGee and Greiner, 2019). Subsidies and othervarious incentives to mitigate carbon disproportionately increase the percentage of household income spent on energy by the poor groups (Boardman, 2013).

Widespread energy use has reduced global poverty by increasing the standard of living of billions of people (McGee and Greine, 2019). However, the consumption and the energy production have also historically contributed to mass transfer and uneven socio-economic development. For example, land acquisition intended for energy use disproportionately influences affected communities leading to conflict, for example, more than 12,000 indigenous communities have been displaced due to the expansion of oil tar sand production in Alberta (Walsh and Stainsby, 2010), or in Indonesia, State Electricity Company (PT. PLN) revealed 201 cases that hampered the construction of power plants, transmission networks and substations (GI) for the 35,000 MW project. Of the 201 cases, 145 or 72% of them were land acquisition problems (Detikfinance, 2016).

Access to energy is important, especially in alleviating poverty (Worldbank, 2015). The term energy poverty then arises, referring to households with a lack of access to modern energy services, especially the provision of electricity or a cleaner form of cooking (Bouzarovski and Petrova, 2015). Access to energy is very important to satisfy basic human needs for domestic heating and sanitation, making energy poverty a social injustice that robs households of basic needs. Households living in energy poverty also usually live in poor environmental conditions, such as low-quality housing, making them more vulnerable to environmental hazards and less able to invest in improving lives. About one out of seven people - or around 1.1 billion people - in the world has no electricity and nearly 3 billion people still do cooking using fuels that produce pollution such as kerosene, wood, charcoal, and animal waste (2 Boardman, 2013; Worldbank, 2015). Households living in energy poverty are also more vulnerable to price fluctuation of energy costs and spend a large part of their income on energy consumption.

There are many efforts to overcome the problem of energy poverty, one of which is the development and use of renewable energy. Globally, renewable energy sources have been invested as alternative to fossil fuel energy sources (BNEF, 2016). The ability of renewable energy sources to replace fossil fuels since the 1960s is still very limited (York, 2012). This limitation, revealed by York (2012), is caused by an established energy system in which the use of fossil fuels as a basic energy source becomes their long-standing prevalence, and because of the availability of infrastructure, political and economic supports from fossil fuel industries. The implication is that it is difficult to use 100% renewable energy in a country. So the important question that must be addressed is whether renewable energy effectively complements existing infrastructure which still uses fossil fuels.

Oppenheim (2016) argued that the use of incentive policies such as subsidies to encourage substitution from consumers of fossil fuels to renewable energy does indeed function to reduce energy transition cost. However, renewable energy sources can also disrupt the balance by diverting consumption and related income, from one entity to another. For example, it can be seen in Germany, where the “German Renewable Energy Act” has become a trigger for the development of a low carbon renewable energy economy, carried out by applying additional cost for transitional financing. This disproportionate additional cost then affecting households with low income (Bouzarovski and Tirado Herrero, 2017). In such cases, it can be concluded that inequality can also occur in the form of energy poverty by increasing the percentage of individuals' / households' income spent on basic needs for energy.

The existence of a trade-off among carbon mitigation, as an effort to save the environment and income inequality is an interesting but is not yet widely reviewed topic. The fact that the impact on the environment from renewable energy consumption is still largely dependent on subsidies and policies implemented by the national government, as well as geographical and infrastructure conditions, allows inequality conditions to be unavoidable. This research seeks to better understand the mechanism of how national income inequality changes the relationship between renewable energy consumption and carbon emissions.

Research Hypotesis

Renewable energy consumption and income inequality are interrelated since inequality moderates the relationship between renewable energy consumption and emissions. The consumption of renewable energy is more likely to replace fossil fuels through economic incentives which consequently increase the energy burden for those who live with energy poverty. Countries with high levels of inequality will have a stronger negative correlation between consumption of renewable energy and emissions. These result is consistent with the findings of Oppenheim (2016); Bouarovski and Tirado (2017) and McGee and Greiner (2019). So, specifically, it is hypothesized that when inequality increases within a country, it will moderate the relationship between renewable energy use and its impact on the environment through thegetting stronger carbon emissions. The simple logic of this hypothesis is that the use of renewable energy which is believed to be clean and pollution free depends on the consumers' desire to substitute fossil energy for renewable energy. In doing this substitution, for households living in energy poverty, the costs incurred to do substitution is expensive so that the government provides incentive policy by providing subsidies. When there are subsidies, households living in energy poverty are willing to use renewable energy. From this statement, it can be concluded that energy poverty is the key to a potential explanation for the relationship between income inequality and renewable energy use.

MATERIALS AND METHODS

To test the hypothesis, multiple linear and moderating regression models are used. The period used in this analysis was from 1990 to 2017. Data for the national level Gini coefficient measures income inequality from income that households can spend (after tax and after transfers), using a range of 0 (equal distribution of wealth across populations) to 100 (one person occupies all the wealth in the entire population). This data is taken from the SWIID Solt database, which uses multiple algorithms to standardize observations collected from United Nations University's World Income Inequality Database (version 2.0c).

This study also used five control variables in the model: percent of urban population, percent of population 15 to 64 years of age, GDP per capita (in 2010 constant US dollar), energy consumption from fuel sources, fossils and dummy variables for formal constraints in the form of written rules regarding the use of renewable energy. The rule that forms the basis of this study is Law Number 30/2007 concerning Energy. The rule clearly states that the management of energy strategy is determined through formal rules. Management of energy as stated in the General Provisions of the Act shall mean an activity consisting of the provision, enterprise, and utilization of energy and the provision of strategic reserves and the conservation of energy resources. Management of Energy shall be carried out comprehensively from the provision to the use of energy by end users.

The models used in this study are as follows:

$CO_2 = f(Ren, Gini, CV)$ ... . Equation 1

In its operations, equation 1 is transformed into the following equation:

$LnCO_t^2 = \alpha + \beta 1\ LnRent + \beta 2\ LnGini_t + \beta 3\ CV_t + \mu_t$. Equation 2

To see the interaction, the effect of inequality as a moderating variable on the effect of using renewable energy on the environment is as follows:

$LnCO_t^2 = \alpha + \beta 1\ LnRent + \beta 2\ LnGini_t + \alpha 3\ CV_t + \alpha 4\ LnRen * LnGini_t + \mu_t$ .... Equation 3

Where, CO_2 : Carbon dioxide emissions resulting from energy consumption in Indonesia;

Ren: Consumption of renewable energy (toe); Gini: Indonesian Gini Coefficient (0-100); CV: Variable Control; Pop : age = the population of Indonesians of 15 to 64 years of age (productive age), urban = Indonesian population living in the city); Percap: GDP per capita constant 2010 as the base year in US $; Fossil: Consumption of fossil energy (toe); Rule : 1 = Period after Law number 30 of 2007 promulgated; 0 = Period before Law number 30 of 2007 promulgated; α: Intercept; β 1,2, ...: Estimator variable; Ln : Natural Logarithms; μ_t: Error term

RESULTS AND DISCUSSION

Descriptive statistics for allvariables can be found in Table 1. All variables are natural log (except period dummy variable). Thus, the regression model estimates the coefficient of elasticity, where the coefficient for the independent variable is the percentage estimate of the net change in the dependent variable associated with one percent increase in the independent variable.

The results of the analysis have gone through various classic assumption tests, so it can be said that the estimation results are not biased. Model 1 also shows that GDP per capita is positively related to emissions, which is consistent with previous research. Finally, in Model 1, consumption of renewable energy was found to be negatively correlated with emissions, while Gini was found to be positive. The findings for renewable energy consumption are consistent with previous research (Chiu and Chang, 2009; Shafei and Salim, 2014; Sugiawan and Managi, 2016; York, 2017; Thombs, 2018; Sasana and Aminata, 2019). Likewise, the Gini coefficient supports the findings of previous studies (Jorgenson *et al*., 2016; Knight *et al*., 2016). Unfortunately, this result is contrary to the findings of McGee and Greine (2019) who found a negative Gini coefficient on carbon emissions.

Model 2 in Table 2 includes the interaction variable between renewable energy consumption and the Gini coefficient. The interaction variable is found to be negatively and significantly correlated with carbon emissions. This finding shows that the relationship between renewable energy consumption and emissions is related to income inequality. In the most direct interpretation this finding shows that the relationship between

Table 2. Estimation Results

Variable	Model 1	Model 2
Renewable energy	-0.024*	0.021
	(0.052)	(0.889)
Gini coefcient	0.975*	-0.323**
	(0.060)	(0.026)
GDP Percapita	0.238**	0.305*
	(0.040)	(0.069)
Age	-	0.492
		(0.850)
Urban population	-	0.073
		(0.907)
Rule	-	-0.098***
		(0.009)
Fossil energy	-	1.16***
		(0.000)
Renewable*Gini	-	-1.116**
		(0.022)
C	-0.728	24.417
	(0.689)	0.689
R2 Adjusted	0.976	0.986
F-statistic	364.791	378.342
Prob(F-statistic)	0.000***	0.000***

Source: processed data, 2019

Table 1. Descriptive Statistics

Stat.Desc	CO	AGE	GINI	PERCAPITA	FOSSIL	RENEWABLE	URBAN
Mean	5.71	23.38	3.80	7.86	7.01	2.38	18.38
Median	5.80	23.39	3.76	7.79	7.10	2.68	18.41
Maximum	6.26	23.60	3.90	8.33	7.48	3.38	18.79
Minimum	4.91	23.11	3.73	7.44	6.26	0.87	17.83
Std. Dev.	0.42	0.15	0.06	0.25	0.37	0.81	0.29
Skewness	-0.35	-0.25	0.52	0.34	-0.43	-0.75	-0.34
Kurtosis	1.89	1.92	1.73	2.00	2.01	2.18	1.94
Jarque-Bera	2.01	1.66	3.14	1.71	2.00	3.38	1.83
Probability	0.37	0.44	0.21	0.43	0.37	0.18	0.40
Observations	28	28	28	28	28	28	28

Source: Processed data, 2019.

renewable energy consumption and emissions becomes increasingly negative when either income inequalityor the use of renewable energy grows.

Exploring the moderating nature of the relationship between renewable energy consumption and CO_2emissions by income inequality, Model 2 shows that population variables, age group and urbanization, do not correlate significantly with emissions; this is contrary to the previous findings. Sasana *et al.* (2017) for example, found that Indonesia's population growth has a positive influence on increasing CO_2. This can be explained through the findings of the research by Yeh and Liao (2017) which concluded that population growth has a positive effect on CO_2 emissions due to human activities. The larger the population, the more activities people carry out, both distribution and consumption production, which ultimately increases CO_2 emissions. Furthermore, research conducted by Casey and Galor (2016) implied that a slower population growth of 1% could be accompanied by an almost 7% increase in per capita income which is able to reduce carbon emissions. If the population continues to grow, which results in continuous accumulation of carbon emissions, then it increases climate change with the risk of forest fires by the end of 2020 (Knorr *et al.*, 2016). These results strongly show that population policy must be part of an approach to combating global climate change. These conflicting findings could be caused by the limited analysis time frame (1990-2017)

The next finding of this research is that fossil energy consumption has a positive and significant impact on CO_2 emissions. This finding is in line with the existing theory that fossil energy consumption can increase CO_2 emissions. The process of burning fossil fuels as it is known will release air pollutant elements and compounds such as total suspended solid (TSS/dust), carbon monoxide, total hydro carbon, nitrogen oxides, sulfur oxides, leadparticles andphotochemical oxidants (Soedomo, 2001) . The result of this study is also in line with the research conducted by Saboori, and Sulaiman (2013). They concluded that fossil energy consumption has a positive relationship with CO_2 emissions. Granger's long-term causality test shows that there is a two-way causal relationship between CO_2emissions, and consumption of coal, gas, electricity and oil. This result implies that reducing energy consumption such as coal, gas, electricity and oil seems to be an effective way to control CO_2 emissions. Danish et al. (2017) also found that fossil energy consumption has a positive effect on CO_2 emissions. Fossil energy consumption is the main cause in producing CO_2 emissions. Other studies by Pao and Tsai (2011) in Brazil, Pao *et al.* (2011) in Russia, and Al-Mulali (2011) in 15 countries in the Middle East and North Africa (Middle East North Africa) also found similar things.

The latest finding in this study shows a negative and statistically significant influence between the rule (formal constraint) in the form of Law No. 30/ 2007 on Energyand carbon dioxide emissions in Indonesia. This is in accordance with the theory which states that rule is constraint in nature and shapes human behavior (North, 2000).The result of this study is also in line with the research conducted by Darwanto *et al.* (2020). They concluded that the population growth and fossil energy consumption have a positive and significant effect on CO_2 emissions. Meanwhile, rules (as formal constraint) has a negative effect on CO_2 emissions. Law No. 30/ 2007 on Energy is proved to be statistically able to reduce CO_2 emissions by 0.098%. The impact caused is still small and far from the expectation. However, this becomes a benchmark for the importance of rules in this case is a formal rule in achieving or forming behavior. Coordination and transparency and enforcement of rules which must then be carried out both by the central government and the regional government, so that the energy mix target in 2025 and the reduction of carbon dioxide emissions, which is the goal of forming the behavior of Law No. 30/2007 on Energy and other formal rules, can be achieved.

CONCLUSION

The empirical result from the analysis above provides support, in general, for the hypothesis proposed. The finding that income inequality serves to moderate the relationship between renewable energy and CO_2 emissions confirms the proposition that, on average, income inequality and implementation and use of energy infrastructure are closely related to each other.

Changes in income inequality function to improve the relationship between renewable energy consumption and emissions in the ways discussed above show that countries that best address income inequality and energy poverty are most likely to do so by utilizing renewable energy generation system to expand the reach of the country's energy infrastructure in total. The result of this expansion is not only the reduction of energy poverty, but also the failure to replace the existing fossil fuel system. Thus, in these countries, even though more energy is given to more people. CO_2 emissions from the fossil fuel energy sector continues, so it requires energy management that is synergistic and continuous.

This research also reveals how important the rules in this case are formal constraints as constraints that shape human behavior in accordance with what is desired. Starting with Law No. 30/2007 on Energy, the rule must inevitably be mutually agreed upon, so as to bring up supporting policy strategies in the form of other written rules and proven capable, in this case is reducing CO^2 emissions.

Based on these conclusions, several suggestions are proposed. (1) The Indonesian government must enforce existing policies so that awareness of these rules is deeply rooted so as to provide results of further behavior and in accordance with what is expected by the rules. Therefore, coordination between institutions is absolutely necessary (2) Political will from the government to reduce energy subsidies and divert them to increase the development of technological innovations to increase the use of renewable energy needs to be improved, this is to encourage renewable energy from the supply side, and most importantly (3) a clear rule is required in the form of formal written rules for the demand side of renewable energy, in order to complement the existing formal rules (from the supply side). The aim in this rule is nothing but to increase the demand for renewable energy, so that the investment in renewable energy released could be utilized optimally.

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