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Article

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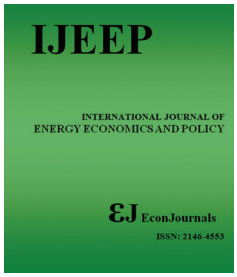

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Does Formal Constraints Reduce CO_2 Emissions? Indonesia's Empirical Case

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ABSTRACT

Rules (formal constraints) are expected to be able to shape human behavior to act based on what should and should not do accordingly. The connection of rules in the energy sector to carbon dioxide emissions depends on how far the rules are able to shape behavior as expected. The purpose of this study is to analyze the effect of rules (formal constraints) on CO_2 emissions in Indonesia. Other variables used in this study are energy consumptions (fossil energy and renewable energy), and population growth which are in line with the previous study. The method used to help answer the research question is multiple linear regression analysis with ordinary least square approach. Using time series data in the period of 1990-2017 in Indonesia, this study found that fossil energy consumption and population growth have positive and significant impacts on CO_2 emissions in Indonesia. Meanwhile, the consumption of renewable energy and the rules (formal constraints) have negative effects on the emissions of CO_2 produced. These results show that rules (Formal Constraints) can indeed shape behavior, in this case the reduction of CO_2 emissions.

Keywords: Formal Constraints, Emissions, Energy Consumption, Energy Policy, Institutions
JEL Classifications: O13, CO1, Q28

1. INTRODUCTION

Efforts to accomplish higher economic development can't be isolated from issues of energy security and ecological harm. Energy is utilized as a significant contribution for economic development on one side, yet then again, more prominent utilization of energy gives more weight to the ecological harm, even the emissions because of its utilization. With regards to maintainability economic development, improvement must be finished while making efforts to preserve the environment for the sake of providing natural resources for future generations.

In developing a strategy for sustainable development, the perspective that must be developed is a perspective on renewable energy (Jaelani et al., 2017; Leitmann, 2009). The perspective of renewable energy which includes wind, sun, waves and biomass energy will involve three main changes, namely energy demand efficiency, expanded effectiveness in energy generation, and substitution of petroleum products by sustainable power sources (Lund, 2007). This perspective has resulted a plan for implementing large-scale renewable energy strategies that must be developed to integrate renewable sources in the coherent energy system needed by energy efficiency and efficiency measures.

Indonesia has a big potential for sustainable power source, including geothermal, hydropower, biomass, wind and solar energy. In any case it is improbable that sustainable power source will reduce high dependency of petroleum derivatives in the national energy mix for the near future because its usage is still far beneath its capacity, both due to technical and economic constraints. With a total estimated of potential energy more than 273 GW (excluding marine energy potential), just about 4% of sustainable power source has been used. Hydropower is the most astounding potential sustainable power source with an

expected limit of 75 GW, and is just used by 11% of the all out potential, or around 8,111 MW. Biomass, as the second biggest sustainable power source with an expected limit of 32 GW, just around 5% has been used for electricity power (NEC, 2015). Moreover, Indonesia's geographical position at the equator and located in the ring of fire, makes Indonesia has enormous potential for geothermal and solar energy. Geothermal energy potential is estimated to be more than 28 GW, equivalent to 40% of the potential of geothermal resources in the world (Hasan et al., 2012), <5% of which has been utilized (NEC, 2015). In addition, despite its geographical superiority as an equatorial country, the utilization of solar energy in Indonesia is relatively small. With average solar radiation of 4.8 kWh/m^2/day, only about 71 MW of solar energy systems have been installed (NEC, 2015). Furthermore, Indonesia's geographical position right at the equator and also in the ring of flame, makes Indonesia has enormous potential for geothermal and solar energy. Geothermal energy's potential is evaluated to be more than 28 GW, proportionate to 40% of the capability of geothermal energy on the world (Hasan et al., 2012). Unfortunately just under 5% of which has been used (NEC, 2015). in spite of its topographical predominance as a tropical nation, the usage of solar energy in Indonesia is generally just a little. With normal sun powered radiation of 4.8 kWh/m^2/day, just around 71 MW of solar energy systems have been installed. Interestingly, wind energy's potential in Indonesia is fairly low, with low wind paces going just from 3 to 6 m/s (NEC, 2014).

Until today, Indonesia's energy sector faces challenges in the context of sustainable development. Despite the enormous potential of renewable energy, Indonesia's energy sector relies heavily on fossil fuels. In 2017, Indonesia's total fossil fuel consumption reached 168.09 Mtoe, equivalent to around 96% of total primary energy consumption (BP, 2018). Indonesia's energy sector faces challenges with regard to sustainable development. Regardless of the tremendous capability of sustainable power source, Indonesia's energy still depend intensely on non-renewable energy sources (fossil energy). In 2017, Indonesia's non-renewable energy source utilization achieved 168.09 Mtoe, comparable to around 96% of total primary energy consumption (BP, 2018). This issue is likewise exacerbated by too huge subsidies for energy's sector in order to guarantee the accessibility and openness of energy for all degrees of society. During 2012-2014 the all out of energy's subsidies was about IDR 958 trillion.

The answer to balancing or solving problems in the energy sector is the "energy revolution" which involves conversion of energy from high to low-emission energy, yet still pays attention to the economic aspects (Gunningham, 2013). As recognized by the International Energy Agency and others (Dubash and Florini, 2011; IEA, 2011), such a revolution can only be achieved through effective energy governance (Mujiyanto and Tiess, 2013). The governance here must take place not only at the national but also at global level; given the wide range of collective action challenges that are beyond the ability of each country to solve (Barrett, 2007).

In Indonesia, the energy management strategy is outlined in the form of the Law in 2007, namely Law No. 30 of 2007 concerning Energy. In article 2 of the Act clearly stated energy management strategies which are principally based on the principles of benefits, nationality, equal efficiency, economic added value, sustainability, community welfare, environmental preservation, national security, and integrity. These principles lead on the sustainability of national development and energy security With the aforementioned strategy, it is expected that energy management objectives to support national development both as industrial raw materials and as fuel can be achieved and sustainable in the sense that it can guarantee the supply and utilization of energy for the present and future generations.

In its development there has been a paradigm shift in the field of energy, which was originally seen as only a commodity that is sold to increase income used for national development, now it is directly used as development capital to achieve energy independence (Yandri et al., 2018). The change in the energy paradigm was outlined in Government Regulation Number 79 of 2014 concerning National Energy Policy. With this energy policy, it is intended to reach the target of contributing renewable energy to the national energy mix of around 23% and 31% in 2025 and 2050, respectively (Ministry of Energy and Mineral Resources, 2017). The international rule that complements national rules is the 2015 United Nations Climate Change Conference Agreement in Paris, with the result that each member country must strive to reduce greenhouse gas emissions that trigger climate change (International Energy Agency (IEA), 2015). So the next question that arises is how effective the rules in the form of written rules (formal constraints) can be implemented to reduce carbon dioxide or greenhouse gases emissions. This is the basic question that this paper tries to answer.

2. LITERATURE REVIEW

Yusgiantoro (2000) separates resources become 2 parts: Renewable and non-renewable. Renewable are resource that inexhausted which is accessible in boundless time, for example, water, woods, wind, sunlight and others. Non- renewable resource is resource that exhauted, which is the resource have a constrained stock and in a specific timeframe, for example, fossil energy. Non-renewable resource, particularly fossil energy, are progressively exhausting. Environmental damage is an issue that is then associated with economic growth.

Research conducted by Lotfalipour et al. (2010), Apergis and Payne (2009), Acaravci and Ozturk (2010), Payne (2010), Tugcu et al. (2012), Saboori and Jamalludin (2013), Sugiawan and Managi (2016), Sasana et al. (2017), and Sasana and Aminata (2019) asserted that energi utilization and economic growth are the most prominent points in the energy economy literature. Increasing concern for environmental damage, along with increasing awareness of global warming and climate change is the trigger for many studies related to this matter.

Bozkurt and Destek (2015) stated that the increasing environmental problems along with technological developments, and the depletion of fossil fuels, led to the idea of shifting to renewable energy sources that are believed to reduce pollution and degradation. This is reinforced by the research of Sasana and Aminata (2019) which found that renewable energy can significantly reduce CO_2 pollution in Indonesia.

Many studies believe that in the future renewable energy is clean energy and its availability is guaranteed. Sadorsky (2011) concluded that in the future renewable energy contributes around 50% to 80% of total energy demand. This scenario based on strong commitments in terms of time, budget, individuals, government and also policy makers.

Gunningham (2013) stated that Indonesia, as other common developing countries, prefers cheap energy sources by ignoring environmental sustainability. But in its development, Shukla et al. (2017) states that developing countries in Southeast Asia seek to shift to renewable natural resources by initiating efforts to shift to various types of renewable energy to reduce dependence on fossil fuel use while managing energy demand growth. So that basically environmental sustainability, it is still able to be resolved if appropriate forms of governance can be developed and used.

The term governance, according to Williamson (2000), is the third level of the evolution of the New Institutional Economics theory based on social analysis. It is the level called "the play of the game" where the rights and obligations play their role. The "rules of the game" itself refers to institutional understanding (North, 1990). The rules or restrictions or constraints are basically made to form a pattern of harmonious interaction between individuals in carrying out political, social and economic interactions. North (1990) divided boundaries or constraints into two: informal and formal. Informal constraints are boundaries whose existence in society is generally unwritten. Customs, traditions, taboo, agreements, conventions and the like with various names and designations are classified as informal constraints. Whereas formal constraints are written rules such as legislation, agreements, contractual agreements, economic, business, political and other rules, including agreements that apply at international, national, regional and local levels. How effective these boundaries are in shaping the interaction or behavior of an individual depends on how far the rules are carried out by individuals and groups associated with these rules. North (1990) states that the effective measure of a rule or policy will depend on a number of things, such as limited government coercive power, the way to administer an organization or state (bureaucracy), or the existence of other creeds strongly believed by society.

The Indonesian Government's commitment to mitigate trilemma energy, embodied in Government Regulation 79/2014 as a supporter of Law No. 30 of 2007, to support the diversification of energy sources in stages and reduce high dependence on fossil fuels. In 2025, renewable energy is expected to contribute 23% of the total energy mix, so that it is expected to reduce 50% of total greenhouse gas emissions in 2035 (BPPT, 2014). The Indonesian government has also sought to improve efficiency in the energy sector by gradually reducing the amount of its energy subsidies and reallocating fund to make new investments in energy infrastructure. If this policy is balanced with good coordination between the central government and the regional government, supported by a clean bureaucracy (free from personal interests and corruption), then the three objectives of the trilemma of energy can be achieved.

3. MATERIALS AND METHODS

This study examines the influence of Pop, fossil energy consumption, renewable energy consumption, and the formal dummy variable constraints (Law No. 30 of 2007) on CO_2 emissions in Indonesia from 1990 to 2017. Secondary data used is obtained from various sources such as the World Bank and Indonesian Ministry of Finance. In analyzing the influence of independent variables (energy subsidies, fossil energy consumption, renewable energy consumption, and population growth) on the dependent variable (CO_2 emissions), multiple linear regression analysis (ordinary least square [OLS]) with time series data is used. The research model is as follows:

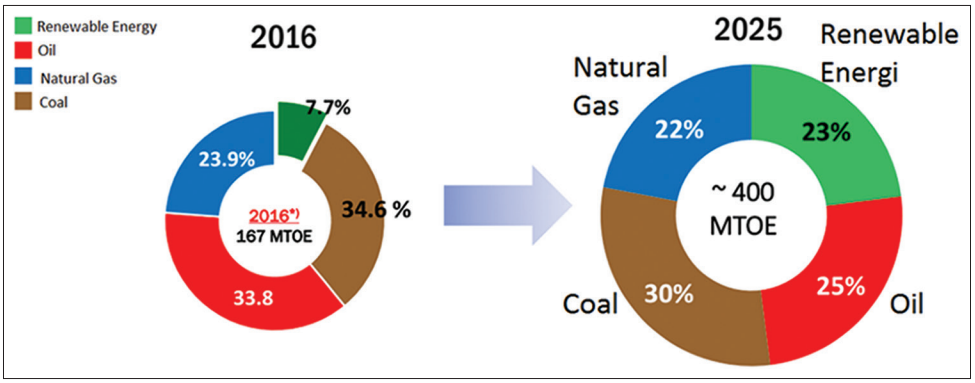
$$CO_2 = f(Pop, Fossil, Ren, Rule) \quad (1)$$

In its operation, equation 1 is transformed in the form of the following equation:

$$LnCOt2 = \alpha + \beta 1\ Popt + \beta 2\ Fosilt + \beta 3\ Rent + \beta 4\ Rulet + \mu t \quad (2)$$

Where: CO_2: Carbon dioxide emissions resulting from energy consumption in Indonesia; Pop: Indonesia's population growth; Fossils: Consumption of fossil energy; Ren: Consumption of renewable energy; 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 variables; Ln: Natural Logarithms; μt: Error term.

Figure 1: Energy mix 2016 dan energy mix target 2025



Source: Ministry of Energy and Mineral Resources, 2017

4. RESULTS AND DISCUSSION

In the equation, the rule variable is applied as a dummy variable. The rules that form the basis of this research are Law No. 30 of 2007 concerning energy. The rule clearly states the energy management strategy, meaning that the rule of game of energy is determined through formal rules. Energy management as stated in the General Provisions of the Act is the implementation of energy supply, exploitation and utilization activities as well as the provision of strategic reserves and conservation of energy resources. This means that energy management is carried out starting from the provision to the end use by energy users/consumers. With such a strategy, it is hoped that energy management objectives to support national development both as industrial raw materials and as fuel can be achieved and are sustainable in the sense that they can guarantee the supply and utilization of energy for the present and future generations. On its development, this law is strengthened by other rules. Especially for renewable energy, the rules are specifically regulated in Government Regulation Number 79 of 2014 concerning National Energy Policy. This energy policy is intended to achieve the target of contributing renewable energy to the national energy mix of around 23% and 31% in 2025 and 2050 respectively. This policy also aims to save energy consumption through 17% and 39% energy efficiency (with the Business as Usual scenario) in 2025 and 2050 (PP No. 79 of 2014).

This policy is considered very ambitious (Yandri et al., 2018). It is predicted that energy consumption will continue to increase sharply along with population growth of around 1.49% per year and economic growth of around 5-7% per year [32,31]. So, it is estimated that by 2050 the contribution of renewable energy can only reach 13.7% (for high scenarios) or 14.9% (for low scenarios). Therefore, great effort is needed from all parties in the country, both in terms of supply and demand to achieve this goal.

In this study, four independent variables and one dependent variable were used. Independent variables are fossil energy consumption, renewable energy consumption, population growth, and rules (formal constraints), while the dependent variable is CO_2 emissions. These variables are analyzed using multiple linear regression or OLS. Estimated results from the independent variables to the dependent variable are shown in Table 1. Based on the estimation results presented in Table 1, the following equations are obtained:

$$Lnco2 = 0.007\ Fossils - 0.024\ Renew + 2{,}058 * Pop - 0.099\ Rule + 34{,}529 \quad (3)$$

The discoveries in this examination are that population growth has a positive and noteworthy effect on the degree of CO_2 emission. The results of this study indicate that population growth increases by 1% multiplied by CO_2 emissions by 2.58%. This is in accordance with the past clarification which expresses that the more greater population in a nation the more prominent the potential for expanded CO_2 emission because of the high energy utilization and the unavoidable consumptive nature, as per what BPPT affirmed in 2016.

Table 1: Estimation results

Variables	Coefficients	Std. Error	t-Statistics	Prob.
Fosil	0.0750	0.002	4.622	0.000***
Renew	−0.024	0.012	−1.998	0.052*
Pop	2.058	0.698	2.946	0.007***
Rule	−0.098	0.034	−2.875	0.009***
C	34.529	13.231	2.61	0.016**

Source: Processed from secondary data, 2019

Sasana et al. (2017) found that Indonesia's population growth has a positive influence on increasing CO_2. This can be explained through the findings of the research conducted 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 released. Furthermore, research conducted by Casey and Galor (2018) implied that a population growth of 1% slower can be accompanied by an increase in per capita income of almost 7% while being able to reduce carbon emissions. If the population continues to grow which results in continuous fertilization of carbon emissions, then it increases climate change with the risk of forest fires by the end of 2020 (Knorr et al., 2016). A little bit different from others, Sulaiman and Abdul Rahim, 2018 found that population was not a determinant of CO_2 emissions in the long run. However, in the short run, population were significant in determining CO_2 emissions. Therefore, population checking measures could be a short-run effective measure to lower the emissions level (Sulaiman and Abdul-Rahim, 2018). However these results strongly show that population policy must be part of an approach to combating global climate change.

The following result in this study is that fossil energy utilization has a positive and critical effect on CO_2 discharges. The estimation results demonstrate that if fossil energy utilization rises by 1%, CO_2 emission also will increases by 0.075%. This finding is in accordance with the current hypothesis that fossil energy utilization can build CO_2 discharges. The process of burning fossil fuels as it is known will release air pollutant elements and compounds, such as total suspended solids, carbon monoxide, total hydro carbon, nitrogen oxides, sulfur oxides, lead particles and photochemical oxidant (Soedomo, 2001). The result of this examination are likewise in accordance with the study that directed by Saboori and Sulaiman (2013). They presumed that fossil energy utilization has a positive association with CO_2 discharges. Granger's long-term causality test shows that there is a two-way causal relationship between CO_2 emissions, and consumption of coal, gas, electricity and oil. These results imply that reducing energy consumption such as coal, gas, electricity and oil seems to be an effective way to control CO_2 emissions. Darwanto et al. (2019) also confirmed in empical case in indonesia that lessening energy consumption particularly fossil's energy is a viable solution to control CO_2 discharges. However the outcomes will at the same time hinder economic growth. Therefore, policy with a purpose to proficient utilization of energy, either fossil or renewable is essential. Danish et al. (2017) likewise discovered that fossil energy utilization positively affects CO_2 emission. Fossil energy utilization is the fundamental driver in creating CO_2 discharges. Other studies are 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 third finding from this study is that renewable energy consumption has a negative and significant impact on CO_2. These results indicate that if renewable energy utilization rises by 1%, CO_2 emissions will decrease by 0.024%. This finding is in accordance with the hypothesis that improving the utilization of sustainable power source can cause a reduction in CO_2 discharges creation. Sugiawan and Managi (2016) found that the utilization of sustainable power source over the long time adversely influenced CO_2 emission. Sustainable power source is viewed as more environmentally-friendly and could decrease contamination, so the effect on CO_2 discharges is negative. The turning point of the decrease in carbon dioxide emissions due to the consumption of renewable energy is when Indonesia's GDP per capita reaches USD 7.729. Zoundi (2017) also discovered that sustainable power source utilization negatively affects CO_2 emission. In the long term, expanding sustainable power source utilization will supplant fossil energy. Thus a suitable policy is needed related to efficient consumption of energy resources and consumption of renewable resources.

The latest and most important finding in this study shows a negative and statistically significant influence between the rules (Formal Constraints) in the form of Law No. 30 of 2007 and carbon dioxide emissions in Indonesia. This is in accordance with the theory which states that rules are constraints and shape human behavior (North, 1990). Law No. 30 of 2007 is proved to be statistically able to reduce CO_2 emissions by 0.098%. The resulted impact is still small and far from the expectation. But this becomes a benchmark for the importance of rules, in this case are a formal rules, 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 of 2007 and other formal rules, can be achieved.

5. CONCLUSIONS

Based on the results of the research discussed, several conclusion can be drawn: (1) the result of this examination demonstrate that the factors of population growth and fossil energy utilization have a positive and noteworthy effect on CO_2 emission in Indonesia in 1990-2017. So that in relation to climate change, the dependency on fossil energy must be reduced, besides that, this research also proves that population policy is also needed to reduce the impact of climate change; (2) the consumption of renewable energy and formal rules (Formal Constraints) have a negative and significant impact on CO_2 emissions in Indonesia. This proves that renewable energy is the energy of the future, where there is no trade-off between energy utilization and environmental damage. Renewable energy can be developed in Indonesia by diverting energy subsidies which have been a stimulus for fossil energy consumption to investments in renewable energy development. This research also reveals the importance of the rules, in this case are formal constraints, as constraints that shape human behavior in accordance with what is desired. Starting from Law No. 30 of 2007 concerning energy, the rules 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, reducing CO_2 emissions.

In view of this study's result, a few recommendations are proposed. (1) The Indonesian government must enforce existing policies so that awareness of these rules is increasingly entrenched so as to provide results of further behavior that in accordance with expectations stated in the rules. Therefore, coordination between institutions is absolutely necessary; (2) political will from the government to reduce energy subsidies and divert them to expand the advancement of technological developments in order to build the utilization of sustainable power source which is should be improved. This is to encourage renewable energy from the supply side and most importantly: (3) "the rules of game" are 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 these rules are nothing but to increase the demand for renewable energy, so that the investment in renewable energy released will be utilized optimally.

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