

DOES ENERGY SUBSIDY POLICY AFFECT SUSTAINABLE ENERGY DEVELOPMENT? EVIDENCE FROM INDONESIA USING GRANGER CAUSALITY TEST ON CO₂ EMISSIONS

Dede Supriatna Makbul

School of Economics and Management, Northeast Electric Power University, P.R.China

Yantao Wang*

School of Economics and Management, Northeast Electric Power University, P.R.China

Janthima Rodkrajab

School of Economics and Management, Northeast Electric Power University, P.R.China

Satria Dijaya

School of Education and Teaching Curriculum, South China Normal University, P.R.China

Abstract

This study was conducted to analyze the effect of energy subsidy on country's sustainable energy development by looking in depth at the statistic data on CO₂ emissions in Indonesia. The method used in this study is Granger Causality Test and used series data from 1986-2014. Granger Causality Test showed that energy subsidy has weak influenced (significant at 10%) to CO₂ emissions and statistically proves that energy subsidy is the reason to the change of CO₂ emissions. While industrial energy consumption has strong influenced (significant at 1%) to CO₂ emissions, and energy price has strong influenced (significant at 1%) to the change in industrial energy consumption. Based on the discussion, it clearly conduces to pro-growth, pro-job and pro-poor but not fully promote pro-environment. Therefore, we suggest that CO₂ emissions can be reduced by the cost developing green energy technologies. Energy subsidy should improve its focus on allocating funds on research that seeking renewable energy, applying environmentally friendly technologies, in order to achieve sustainable energy development, and to protect the environment from environmental degradation caused by increasing CO₂ emissions in Indonesia.

Keywords: Energy Subsidy Policy, Granger Causality Test, Sustainable Energy Development

JEL code: H20, Q56, Q58

1. Introduction

Energy has a strategic role in supporting the economy of a country. Furthermore, energy has a vital role for human life and sustainable development. The crucial role of this energy makes the countries in the world concur to make energy as one of the main priorities of development. As population increases, technological advances, increased industrialization processes, and ongoing development processes have boosted world energy consumption. The trend of world energy consumption that tends to increase indicates that energy is an important and strategic commodity for every country. The increase in energy prices as one of the implications of increasing world energy consumption which inclines to be the reason for a country to raise energy prices in the country and at the same time, energy subsidy policy is applied to ensure the sustainability of national energy and keep energy prices affordable for society, especially people with low incomes.

The energy subsidy policy is intended to maintain the stability of energy prices in the market, and to maintain the ability of all societies to purchase energy. A country enforces this subsidy policy may be intended for their primary energy consumption, manufacturing and service sectors through various channels, such as input subsidies (e.g. per unit fuel subsidy), output subsidies (e.g. per unit price support) and in terms of maintaining weaker environmental regulatory standards (Heutel and Kelly, 2013).

Energy subsidy policy does not always lead to environmental damage. If an energy subsidy policy is well designed, energy subsidy policy can certainly contribute significantly to effort environmental protection, such as energy subsidy policy to promote environmentally friendly organic farming, development of environmentally-based livestock farms, and may also support Green Technology Development efforts to reduce CO₂ emissions. However, some studies found out the negative effects of energy subsidy policy. The government provides energy subsidy by offering higher price per unit of output to the industry, this can result in over-exploitation of resources, over-production and the consequences of environmental degradation (Van Beers and Van Deen, 2001). In addition, Bajona and Kelly (2012) support this assumption by underlining energy subsidy policy that generally encourages the use of excessive energy inputs as well as reducing energy subsidy, to decrease the accumulation of causes of pollution (CO₂ emissions).

Indonesia as a developing country is still executing the presidential regulation no. 5 2006 as a response of country's problem on national energy supply and a support in the use of cleaner energy (KESDM, 2006). By doing diversification from petroleum to LPG and maintaining the reasonable price, all level of consumers has the ability to purchase the energy and support the policy. From economic aspect, the price really eases the burdens of government subsidies. Conversion from petroleum to LPG which has been running since 2007, the program has saved government subsidy for energy sector for almost Rp. 197.05 trillion. In addition, this conversion as part of government subsidy policy can also reduce air pollution and also increase job opportunities. However, does energy subsidy policy affect sustainable energy

development in Indonesia?

In this case, this study was conducted to identify the impact of energy subsidy policy on the sustainable energy development through dynamics of CO₂ emissions in Indonesia. The demand for energy in the community continues to increase, in addition, the government must still disburse substantial energy subsidies from the government budget. If the policy is not properly established, it will disrupt the economic stability of Indonesia and will affect the degradation of environmental quality and human life. To ensure future energy availability in an effort to support environmental sustainability, appropriate energy subsidy policies will encourage the creation of equal distribution of income (pro-growth), thus increasing the space for open employment and reducing poverty in the community (pro-poor). In addition, appropriate energy subsidy policy will also contribute to maintaining the quality of the environment and sustainable energy development (pro-environment).

2. Literature Review

The global energy issue has encouraged research on the energy sector linkages and environmental studies on the impact of energy use. Various empirical models have been adopted to examine this relationship. Dasgupta and Heal (1981) provide evidence that the relationship between economic growth and environmental protection is complementary. Kuznets (1955) says that per capita income also applies to environmental degeneration, also known as the Environmental Kuznets Curve (EKC).

2.1 CO₂ Emissions and Economic Growth

Some researchers used this EKC hypothesis to illustrate the relationship between economic growth and the environment, such as Apergis and Ozturk (2015) tested the EKC hypothesis and confirmed for 14 Asian countries. However, Ben Jebli et al (2016) tested EKC hypothesis and confirmed for 25 OECD countries. Alam et al (2016) tested EKC hypothesis for Brazil, China, India and Indonesia to examine the impact of income, energy consumption, and population growth on CO₂ emissions using Autoregressive Distributed Lag (ARDL) for data from 1970-2012. Their research found that CO₂ emissions has increased statistically significantly with increases in income and energy consumption in all four countries. Also, empirical observations from the testing EKC hypothesis imply that in the case of Brazil, China and Indonesia CO₂ emissions will decrease over the time when income increase. But the case of India found that an increase in income over the time will not reduce CO₂ emissions in the country.

Chang (2010) through Granger Causality Test found that GDP has a relevant relationship with CO₂ emissions and energy consumption. Coondo and Dinda (2002) present results of causal CO₂ emissions causality studies based on the Granger Causality test to cross-country data panels regarding per capita income and corresponding CO₂ emissions per capita data. Their results show three different types of causality relationships for different countries. In addition, Saboori et al (2012) suggest that in addition to economic growth, several other influential variables need to be considered as exploratory variables that have the potential to affect CO₂

emissions such as GDP per capita income.

2.2 Energy Subsidy Policy-Energy Consumption-CO₂ Emissions-Economic Growth

Laderchi et al (2013) found that final consumption subsidies provide perverse incentives to households for over consumption and result in environmental damage. Burniaux et al (2009) found contrary evidence that removing energy subsidies can reduce CO₂ emissions and greenhouse gases emission by 13% and 10% respectively at 20 non-OECD countries. However, so far the fuel subsidies only achieved the limited result (IMF, 2016; Keen, 2012).

Mukherjee and Chakraborty (2015), who analyzed CO₂ emissions from energy-saving subsidies by using a cross-country empirical study that includes 131 countries in the period of 1990-2010. Their study found that countries with higher CO₂ emissions have higher per capita GDP. This result further suggests that the level of economic development is a key determinant of per capita CO₂ emissions and countries with higher GDP ratios in agriculture and services are characterized by low per capita CO₂ emissions. Subsidies provided for purchasing environmentally friendly goods is also available in some countries (Toshimitsu, 2010).

KESDM (2012) in *Profile Migas Diversifikasi BBM ke BBG* mandated to reduce dependence on petroleum to 20% and increase the role of gas to 30%, coal to 33% and new and renewable energy to 17% in energy mix in 2025. By converting to gas, it would reduce 95% of carbon emission, 25% of carbon dioxide emission, 80% of HC emissions and 30% of NO_x emissions. This policy is obviously the most environmentally friendly solution in Indonesia nowadays.

3. Material and Method

3.1 Data Collection and Evaluation Index

The analysis method used in this study is Granger Causality Test and processed using Eview 9.5 software. Granger Causality Test is used in this study because it can provide a systematic way to capture dynamic changes in multiple time series, as well as to view the relationship between CO₂ emissions (CO₂) to some variables such as energy subsidy (ES), energy consumption (EC), gross domestic product per capita (GDP), and energy price (EP). All data was collected from some various sources such as World Bank, Ministry of Energy and Mineral Resources of Indonesia, and Indonesian Central Bureau of Statistics, and used series data from 1986 until 2014.

3.2 VECM (Vector Error Correction) Model

VECM model required all data are stationary in same level difference. Therefore, in order to avoid the spurious regression, it is necessary to ensure all data stationarity before applying causal models. The way to check the stationarity of time series data is by using the ADF-test (Dickey and Fuller, 1981). VECM model used in this study for analyzing the effect of energy subsidies on per capita CO₂ emissions is:

$$\text{Log}(\text{CO}_{2it}) = \alpha + \beta_1 \text{Log}(\text{ES}_{it}) + \beta_2 \text{Log}(\text{ES}_{i(t-1)}) + \beta_3 \text{Log}(\text{CO}_{2i(t-1)}) + \beta_4 \text{Log}(\text{GDP}_{it}) + \beta_5 \text{Log}(\text{HEC}_{it}) + \beta_6 \text{Log}(\text{IEC}_{it}) + \beta_7 \text{Log}(\text{EP}_{it}) + \varepsilon_{it}$$

Where,

Log = the logarithmic transformation of variables

α = constant term

β_s = coefficients

CO_{2it} = per capita CO₂ emissions (in tonne per annum) of country i for year t

$\text{CO}_{2i(t-1)}$ = per capita CO₂ emissions (in tonne per annum) of country i for year t-1

ES_{it} = energy subsidy provided by country i for year t

$\text{ES}_{i(t-1)}$ = energy subsidy provided by country i for year t-1

GDP_{it} = per capita GDP of country i for year t

HEC_{it} = households energy consumption of country i for year t

IEC_{it} = industrial energy consumption of country i for year t

EP_{it} = energy price of country i for year t

ε_{it} = disturbance term

4. Result and Discussion

4.1 Stationarity Test

Stationarity test is the most important step in analyzing time series data to see whether or not the root unit is contained among the variables so that the relationship between the variables in the equation becomes valid. This stationarity test is performed on all time series data variables that will be used in VAR analysis.

Unit root test in this research model is based on Augmented Dickey-Fuller (ADF) test at the level. To determine that time series data has a root test unit or not, it is necessary to compute the ADF t-statistic value with the ADF table or see its Probability value. If the absolute value of t-statistics in the ADF test is smaller than the ADF critical value in the table with a certain level of significance, then the time series data is stationary. The probability value is accepted when the value is below at 5% significance (see Table 1). Table 1 showed that only LogGDP is stationary at the level, other variables are not stationary.

Table 1. Augmented Dickey-Fuller Test (ADF) at Level

Variable	Prob.*	Lag	Max Lag	Result
LogCO ₂	0.5657	0	6	Unstationary
LogEP	0.8861	0	6	Unstationary
LogES	1.0000	6	6	Unstationary
LogHEC	0.2900	0	6	Unstationary
LogIEC	0.5328	1	6	Unstationary
LogGDP	0.0096*	0	6	Stationary

*) Significant at 1% and 5% level

Research using data that has not stationary will produce spurious regression, it is a regression

that describes the relationship between two or more variables that seem statistically significant but the fact is not, so it can lead to misleading in research on an economic phenomenon. Therefore, unit root test needs to be addressed at the first difference level. The result of ADF test at the first difference level can be seen in Table 2.

Table 2. Augmented Dickey-Fuller Test (ADF) at First Difference

Variable	Prob.*	Lag	Max Lag	Result
D(LogCO ₂)	0.0010*	1	5	Stationary
D(LogEP)	0.0002*	0	5	Stationary
D(LogES)	0.0000*	1	5	Stationary
D(LogHEC)	0.0001*	0	5	Stationary
D(LogIEC)	0.0009*	0	5	Stationary
D(LogGDP)	0.0000*	0	5	Stationary

*) Significant at 1% and 5% level

Table 2 shows that all data is stationary. Thus it can be explained that all variables to be estimated in this study have been stationary on the same degree.

4.2 Granger Causality Test

Testing with Granger's Causality is intended to test the relationship between variables and not to estimate the model. Table 3 shows the results of causality test with Granger's Causality Test. Based on Granger test results as in Table 3, if the variable has a probability value that is smaller than the critical value of 5%, then it has a causality relationship.

Table 3. VECM Granger Causality Test

Dependent Variable	LogCO ₂	LogEP	LogES	LogHEC	LogIEC	LogGDP
LogCO ₂	-	0.1758	0.0761*	0.6950	0.0097***	0.6694
LogEP	0.4874	-	0.1208	0.7242	0.2546	0.7577
LogES	0.5389	0.3193	-	0.8943	0.4773	0.8661
LogHEC	0.5767	0.5335	0.4881	-	0.4049	0.8016
LogIEC	0.1101	0.0058***	0.1114	0.6212	-	0.6342
LogGDP	0.9818	0.6294	0.5906	0.8016	0.8478	-

***)Significant at 1% level, **)Significant at 5% level, and *)Significant at 10% level

From the table above, there are two causality relationship results. First, there is a one-way causality between energy subsidy and industrial energy consumption to CO₂ emissions. We can see that LogCO₂ is the reason to LogES (weak causality), it means that energy subsidy statistically is the reason to the change of CO₂ emissions. While LogCO₂ is the reason to LogIEC (strong causality) means that industrial energy consumption is the reason to CO₂ emissions. Second, industrial energy consumption is also proved influence dynamics of energy price. LogIEC is the reason to LogEP (strong causality) means that energy price is the reason of the change of industrial energy consumption. This is consistent with the theory that consumption will certainly be influenced by the price at which energy price one of the major fuels of the industrial sector.

4.3 Short-term Coefficient Result

To see the variables that effect CO₂ emissions in the short-term, VECM analysis is used for that purpose. Based on the VECM estimation result, it has found that energy price, energy subsidy, and industrial energy consumption are significant on CO₂ emissions in the short-term. However, GDP and household energy consumption are insignificant (Table 4).

Table 4. Short-term Coefficient Result on $\Delta \log \text{CO}_2$ model

Variables	Coefficient
CointEq1	0.011952
LogEP(-1)	0.014492**
LogES(-1)	3.080006*
$\Delta \text{LogGDP}(-1)$	-0.005656
$\Delta \text{LogHEC}(-1)$	3.390007
LogIEC(-1)	1.760008***
C	0.023903

***)Significant at 1% level, **)Significant at 5% level, and *)Significant at 10% level

Table 4 shows that energy price (ΔLogEP), energy subsidy (ΔLogES), and industrial energy consumption (ΔLogIEC) will effect on CO₂ emissions at short-term. Estimation results show that ΔLogEP at lag 1 period increased 1% can drive CO₂ emissions by 0.014492 unit, ΔLogES increased 1% can drive CO₂ emissions by 3.080006 unit, and ΔLogIEC increased 1% can drive CO₂ emissions by 1.760008 unit. According to the Table 4, we can build VECM model for ΔLogCO_2 at the short-term as follow:

$$\Delta \text{LogCO}_2 = 0.023903 + 0.014492 \Delta \log \text{EP}_{t-1}^{**} + 3.080006 \Delta \text{LogES}_{t-1}^* - 0.005656 \Delta \text{LogGDP}_{t-1} + 3.390007 \Delta \text{LogHEC}_{t-1} + 1.760008 \Delta \text{LogIEC}_{t-1}^{***}$$

5. Conclusion

5.1 CO₂-ES, CO₂-IEC, and IEC-EP

This study aims to determine the relationship between energy subsidy policy and CO₂ emissions and other variables. It is in order to obtain important information related to the effectiveness of energy subsidy policy to support Indonesian government efforts in realizing sustainable energy development. To get the link between energy subsidy policy and other variables, this study uses Granger Causality analysis which is part of VECM.

Based on the results above, this study illustrates how this subsidy policy has a negative and positive effect. The positive effect of the energy subsidy policy is described as the government's effort to maintain the stability energy development (stability of energy prices in the market). It is also to maintain the stability of energy prices in the market in response by industries where changes in energy prices affect the amount of energy consumption of the industrial sector to keep producing energy output. Changes in the structure of energy consumption in the industrial sector are described as the government's efforts to maintain the stability of industrial growth which ultimately the government participates in maintaining the stability of economic growth (pro-growth). The stability of economic growth in the industrial sector will certainly have an impact on the possibility of increasing the number of

employment (pro-job). Furthermore, increased employment will assist government efforts in reducing unemployment and poverty problems (pro-poor). This shows that the energy policy had been implemented by the Indonesian government since 1986-2014 has successfully encouraged sustainable energy development in Indonesia.

The negative effect about the existence of this energy subsidy policy can be seen through the causal relationship between energy subsidy and CO₂ emissions, causality between industrial energy consumption and CO₂ emissions, also industrial energy consumption and energy price. This study found a direct causal relationship between the energy subsidy policy and industrial energy consumption to change in CO₂ emissions. In addition, a direct causal relationship is also found between industrial energy consumption and energy prices. From this result gives an illustration of how energy prices affect the amount of energy consumption of the industrial sector, at the same time the government enacted an energy subsidy policy to stabilize energy prices in the market and further will affect the amount of energy consumption in industrial sector. The Industrial sector is illustrated by the relationship of Granger causality as one of the factors affecting CO₂ emissions. By analyzing the short-term coefficient, we found that by increasing 1% of industrial energy consumption will increase CO₂ emissions by 1.760008 unit. This condition happens because energy is the main input for industrial sector activity in producing goods and services. At the same time, the higher productivity of industrial sector will further encourage the increment of CO₂ emissions. We also found the causality of energy subsidy policy has negative effect of the change of CO₂ emissions, by increasing 1% of energy subsidy will affect CO₂ emissions increase as much as 3.080006 unit. Energy price also has negative effect to the change of CO₂ emissions by increasing 1% of energy price will increase CO₂ emissions by 0.014492 unit. CO₂ emissions policy imposed by the Indonesian government since 1986-2014 has not supported the government's efforts in preserving the environment (pro-environment).

5.2 Energy Subsidy Policy Recommendation

Ensuring the sustainable energy development in Indonesia especially to support environmental conservation from the environment degradation is the next step that should be considered. Therefore, based on the results of this study, there are two points that could be addressed in energy subsidy policy:

a. Energy subsidy policy on energy supply side

This policy covers the government's efforts in implementing the development of energy infrastructure as well as the cooperation of government and private parties to support government efforts in supporting sustainable energy development.

b. Energy subsidy policy on energy demand side

This policy includes the development of new and renewable energy. This type of energy subsidy should be free from other types of energy subsidies such as electricity subsidies, fuel subsidies, etc.

Acknowledgment

The work of this study is supported by Social Science Fund of Jilin Province (2017JD45).

References

- Alam, M.M., Murad, M.W., Noman, A.H.M., and Ozturk, I. (2016) "Relationship among Carbon Emissions, Economic Growth, Energy Consumption and Population Growth: Testing Environmental Kuznets Curve Hypothesis for Brazil, China, India and Indonesia", *Ecological Indicators*, vol. 70, pp. 466-479.
- Apergiz, N., Ozturk, I. (2015) "Testing Environmental Kuznets Hypothesis in Asian Countries", *Ecology Indicator*, vol. 52, pp. 16-22.
- Bajona, Claustre & David Kelly. (2012) "Trade and the Environment with Pre-Existing Subsidies: A Dynamic General Equilibrium Analysis", *Journal of Environmental Economics and Management*, vol. 62, no. 2, pp. 253-278.
- Ben Jebli M., Youssef, S.B. & Ozturk, I. (2016) "Testing Environmental Kuznets Curve Hypothesis: The Role of Renewable Energy and Non-Renewable Energy Consumption and Trade in OECD Countries", *Ecology Indicator*, vol. 60, pp. 824-831.
- Burniaux, J.M., Chanteau, J., Dellink, R., Duval R., and Jamet, S. (2009) *The Economics of Climate Change Mitigation: How to Build The Necessary Global Action in A Cost-Effective Manner*, Paris: OECD Publishing.
- Chang, C.C. (2010) "A Multivariate Causality Test of CO₂ Emissions, Energy Consumption and Economic Growth in China", *Applied Energy*, vol. 87, pp. 3533-3537.
- Coondo, D., Dinda, S. (2002) "Causality between Income and Emission: A Country-Group Specific Econometric Analysis", *Ecology Economics*, vol. 40, no. 3, pp. 351-367.
- Dasgupta, P.S., Heal, G.M., James N. (1981) *Economic Theory and Exhaustible Resources*. UK: Cambridge University Press. Resources Policy.
- Dickey D.A., Fuller W.A. (1981) "Likelihood ratio statistics for autoregressive time series with a unit root", *Econ: J Econ Soc*, pp. 1057-1072.

Heutel, G., Kelly, D.L. (2013) “Incidence and Environmental Effect of Dictionary Subsidies”, Cambridge: NBER Working Paper, pp. 18924.

IMF. International Statistics Yearbook 2016. IMF: Washington, DC.

Kuznets, S. (1995) “Economic Growth and Income Inequality”, *Am. Econ. Rev.*, vol. 45, pp. 1-28.

Keen, M. (2012) “Trends and Reform Options for Fossil Fuel Subsidies”. [Online], Available: http://www.unep.org/greeneconomy/Portals/88/documents/research_products.pdf [2017-06-26].

[KESDM] Kementerian Energi dan Sumber Daya Mineral. (2006) “Kebijakan Energi Nasional” [Online], Available: <http://jdih.esdm.go.id/peraturan/Perpres%20No.%2005%20Thn%202006.pdf> [2017-07-06].

[KESDM] Kementerian Energi dan Sumber Daya Mineral. (2012) “Penyediaan, Pendistribusian, Dan Penetapan Harga Bahan Bakar Gas untuk Transportasi Jalan”. [Online], Available: <http://migas.esdm.go.id/post/read/Program-Diversifikasi-BBM-ke-BBG> [2017-07-06].

Laderchi, C. R., A. Oliver and C. Trimble. (2013) “Balancing Act: Cutting Energy Subsidies While Protecting Affordability”, The World Bank, Washington, DC.

Mukherjee, S., Chakraborty, D. (2015) “Does Fiscal Policy Influence per Capita CO₂ Emissions? A Cross Country Empirical Analysis”, *Fiscal Policies and The Green Economy Transition*, pp. 1-22.

Saboori, B., Sulaiman, J., Moh, S. (2012) “Economic Growth and CO₂ Emission in Malaysia: A Cointegration Analysis of The Environmental Kuznets Curve”, *Energy Policy*, vol. 51, pp. 184-191.

Toshimitsu, T. (2010) “On the paradoxical case of a consumer-based environmental subsidy policy”, *Economic Modelling*, vol. 27, no. 1, pp. 159-164.

Van Beers C. And J.C.J.M. Van Den Bergh. (2001) “Perseverance of Perverse Subsidies and Their Impact on Trade and Environment”, *Ecological Economics*, vol. 36, no. 3, pp. 475-486.