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Applying Econometric Model Differencing to Analyze the Impact of Energy Policy on Economic Inequality and Social Welfare

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Abstract

This study aims to analyze the impact of energy policy on economic inequality and social welfare using Econometric Model Differencing. The main focus is to analyze and understand the impact of energy policy on economic inequality and social welfare before and after it is implemented. This study uses a quantitative approach with Econometric Model Differencing to simulate the impact of various energy policy scenarios. This model is often used in econometrics to evaluate the impact of a policy or intervention by comparing the change in the treatment group with the control group before and after the treatment is implemented. The paired t-test analysis is often used to assess significant differences between two specific times or conditions, such as before and after policy implementation. The results show that there is a significant difference between the Economic Inequality Indicator measured by the percentage of population below the poverty line before and after the energy policy, but there is no significant difference between the Economic Inequality Indicator measured by the Gini Coefficient before and after the energy policy. In terms of the Social Welfare Indicator, overall there is a significant difference before and after the energy policy. This research is expected to contribute theoretically to the use of Econometric Model Differencing in energy policy. Practically, the results are expected to provide effective and sustainable policy recommendations.

Keywords: Energy Policy, Economic Inequality, Social Welfare, Sustainable Energy Transition

Introduction

Cleaner and more sustainable energy policies are important for reducing negative environmental impacts, but they also often have far-reaching impacts on the economic and social fabric of society (Montenegro et al., 2020). In this context, it is important to examine and understand the impacts of energy policies from an economic and social perspective in order to formulate strategies that are not only environmentally friendly but also support social and economic justice (Labandeira et al., 2020). In the last decade, climate change and environmental unsustainability have pushed countries around the world to adopt cleaner and more sustainable energy policies (Anable & Brand, 2019). However, the implementation of these energy policies often has far-reaching impacts not only on the environment but also on the economic and social fabric of society (Azam et al., 2019). One of the most critical yet often overlooked aspects is how energy policies affect economic inequality and social welfare (Ahn et al., 2021). For example, the use of cleaner and more sustainable energy can reduce operating costs for company owners, but can also increase costs for ordinary users (Cruz & Hariharan, 2022). This can affect social welfare if ordinary users cannot pay the higher costs (Kamal et al., 2019). In addition, cleaner and more sustainable energy policies can affect the economic structure with the use of more advanced technologies and higher investment costs (Stucki, 2019). This may increase economic inequality if larger firms can take advantage of more advanced technologies, while smaller firms cannot keep up (Cao et al., 2021).

To address the negative impacts of energy policies, it is important to assess and understand their impacts from an economic and social perspective (Zhang & Liu, 2021). This can help formulate strategies that are not only environmentally friendly but also support social and economic justice (Candra et al., 2023). For example, the government can work on social welfare programs to help ordinary users who experience higher costs due to cleaner and more sustainable energy policies. The banking sector can also work on easier credit programs for smaller companies to follow cleaner and more sustainable energy policies (Kuś & Grego-Planer, 2021). In the Indonesian context, cleaner and sustainable energy policies can affect social and economic welfare, as the country is still heavily dependent on fossil fuels such as petroleum and coal (Tiawon & Miar, 2023). The use of cleaner and sustainable energy can reduce the availability of fossil fuels and have a positive impact on the environment, but it can also increase costs for ordinary users and affect the economic structure (Omri & Bélaïd, 2020). To overcome the negative impacts of energy policies, the Indonesian government can study and understand the impacts from an economic and social perspective, and work on social and economic welfare programs that are compatible with cleaner and more sustainable energy policies (Tenrini et al., 2021).

A number of previous studies have highlighted the effects of energy policy on economic and environmental aspects, considering economic growth, carbon emissions, and energy sector stability (Ehigiamusoe & Lean, 2019; Osobajo et al., 2020; Shobande & Shodipe, 2019). However, studies by Nguyen & Su, (2022); Li et al., (2021); Famewo & Uwala, (2022) focus more on the impact of energy policy on poverty, energy access, and economic stability. Recent research by Uzar, (2020); Ahmadpour et al., (2021) highlights income distribution and social welfare for renewable energy. However, a research gap that remains is the lack of analysis that focuses on the direct relationship between energy policy and economic inequality and social welfare using Econometric Model Differencing. This study aims to fill that gap by focusing on an in-depth analysis of the impact of energy policies on these crucial aspects.

The problem formulation in this research focuses on analyzing the impact of energy policy on economic inequality and social welfare. The main questions that are the focus of this research are: how does energy policy impact economic inequality and social welfare? and how

can econometric differencing model be used to analyze and predict the impact? The main objective of this study is to analyze and understand the impact of energy policy on economic inequality and social welfare using Econometric Model Differencing. Specifically, this study aims to first, investigate how energy policy affects economic inequality as measured by the Gini coefficient and the percentage of population below the poverty line as well as social welfare as measured by life expectancy, infant mortality rate and access to education. This research is expected to make significant contributions to both theory and practice. From a theoretical perspective, this research will enrich the literature on the use of Econometric Model Differencing in public policy analysis, particularly in the energy sector. From a practical point of view, the results of this study are expected to provide recommendations to policymakers in designing and implementing energy policies that are not only effective in reducing carbon emissions and promoting clean energy but also minimizing negative impacts on economic inequality and improving social welfare.

Method

Research Design

This study uses a quantitative approach by applying an Econometric Differencing Model to analyze the impact of energy policy on economic inequality and social welfare. This model will assess whether there is a significant difference before and after the implementation of a policy (Yucel, 2022). This model is often used in econometrics to evaluate the impact of a policy or intervention by comparing changes in the treatment group with the control group before and after the treatment is implemented (Pasinetti, 2019).

Modeling Equations

In this study, an Econometric Model Differencing is used to analyze the impact of energy policy on economic inequality and social welfare. The model equation used can be formulated as follows:

$$\boldsymbol{t - value = \frac{\bar{d} - \delta}{S_d}} \tag{1}$$

$$S_d = \sqrt{\frac{\sum(x_1 - x_2)^2 - \frac{\left(\sum(x_1 - x_2)\right)^2}{n}}{n(n-1)}} \tag{2}$$

In the above equation, equations 1 and 2 represent indicators of economic inequality and social welfare respectively. Statistical analysis using paired t-test is conducted to evaluate the significant difference between the condition before and after the implementation of energy policy. With the above model equation and the statistical analysis conducted, it is expected that this study can provide a deeper understanding of the impact of energy policy on economic inequality and social welfare.

Data collection

The data used in this study consists of secondary data sourced from government reports, energy industry publications, and related scientific publications. The secondary data includes key variables such as gini coefficient, percentage of population below poverty line, life expectancy, infant mortality rate, and access to education for the time span from year 6 to 2023. This information is obtained from reliable and relevant sources to enable a comprehensive analysis of the impact of energy policies on economic inequality and social welfare. Data on Access to Education will be one of the important variables in this analysis to understand its relationship with energy policy and social welfare indicators.

Results

Each policy has a different impact, and the effect may vary depending on the social, economic and geographical context (Morgan et al., 2022). However, in terms of its broad and sustained impact, the energy subsidies for fossil fuels (mainly gasoline, diesel and LPG) introduced since 2010 can be considered as one of the energy policies that have had the most significant influence on social inequality in Indonesia.

A downward trend in the Economic Inequality Indicator, which includes the Gini Coefficient and the percentage of population below the poverty line, has been observed since the introduction of the energy policy in 2010. This event marks the starting point of a significant comparison between the conditions before and after the implementation of the policy. The Gini coefficient, which is the main measure of income inequality, showed a downward trend indicating a more equitable distribution of income among the population. In addition, the decrease in the percentage of the population below the poverty line signalled a successful effort in reducing the number of individuals living in poverty conditions, reflecting the positive potential of the energy policy in addressing economic inequality. The 2010 data is an important point in this analysis as it provides a clear benchmark of comparison between the conditions before and after the implementation of the energy policy, allowing for a more detailed and accurate identification of the policy's impact in reducing economic inequality and improving people's social welfare.

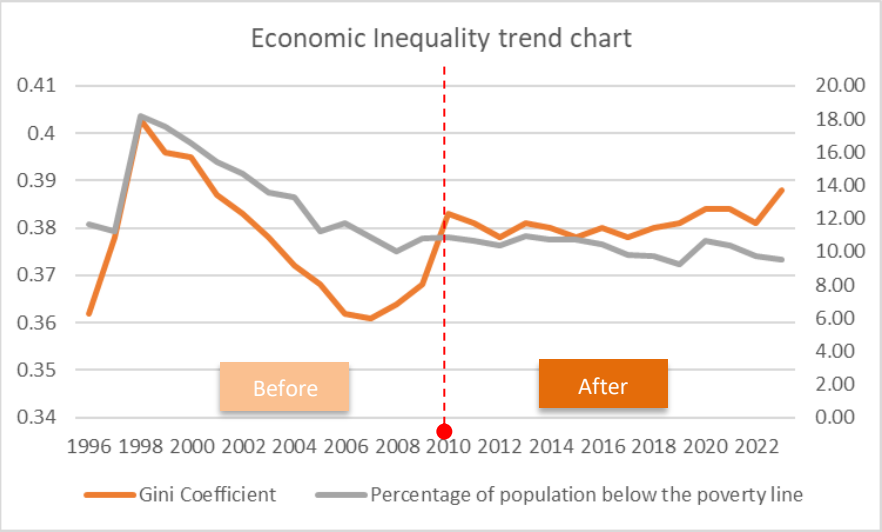

Figure 1. Economic Inequality trend chart.

Source: Data processed, (2024).

There is a downward and upward trend in the Social Welfare Indicators after the implementation of the energy policy in 2010. The downward trend is seen in the Infant Mortality Rate, which measures the number of infant deaths per 1,000 live births. This decline signalled an improvement in public health, with successful efforts to reduce infant mortality. On the other hand, an upward trend was seen in Life Expectancy, which reflects the average number of years a person expects to live. This increase indicates an improved quality of life and better health services following the implementation of energy policies. There was also an increase in Access to Education, which measures the percentage of school-age children attending school. This increase indicates an improvement in access to education, which can have a positive impact on the social and economic development of the community. Data in 2010 is used as a point of comparison to measure the impact of energy policies on social welfare. The comparison before and after the policy implementation allows the identification of significant changes in social welfare indicators, providing a solid basis for the evaluation of the policy's success in improving the overall social condition of the community.

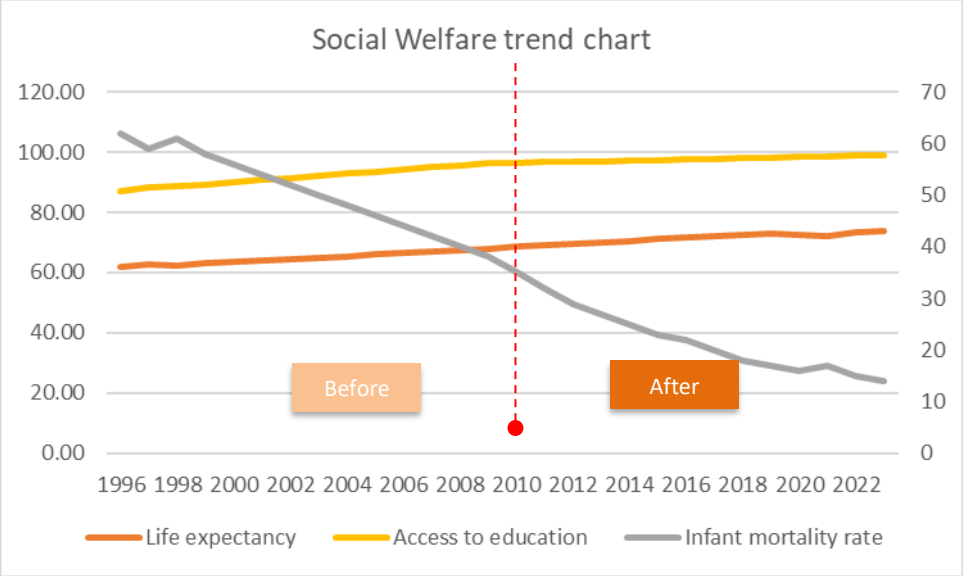

Figure 2. Social Welfare trend chart.

Source: Data processed, (2024).

The purpose of this study is to analyse the impact of energy policy on economic inequality and social welfare using Econometric Model Differencing. The analysis method used is paired t-test to distinguish significant differences between conditions before and after the implementation of renewable energy policies. Through this approach, the research aims to understand the effect of energy policy on indicators of economic inequality and social welfare. By exploring this relationship in depth, it is expected to provide a more comprehensive insight into the effectiveness of energy policies in achieving the desired social and economic goals in the context of sustainability. The results of the paired t test can be presented in the following table:

Table 2. Table of paired t tests for indicators of Gini coefficient (a), percentage of poverty line (b), life expectancy (c), infant mortality rate (d) and access to education (e).

Parameter	Value
Correlation	-0.623
Sig.	0.017
t-value	-1.008
Sig. (2-tailed)	0.332

(a)

Parameter	Value
Correlation	0.473
Sig.	0.087
t-value	4.609
Sig. (2-tailed)	0.000

(b)

Parameter	Value
Correlation	0.935
Sig.	0.000
t-value	-39.287
Sig. (2-tailed)	0.000

(c)

Parameter	Value
Correlation	0.935
Sig.	0.000
t-value	41.223
Sig. (2-tailed)	0.000

(d)

Parameter	Value
Correlation	1.000
Sig.	0.000
t-value	-10.719
Sig. (2-tailed)	0.000

(e)

Analysing the Impact of Energy Policy on Economic Inequality.

The paired t-test statistical analysis that revealed a significant difference between the percentage of the population below the poverty line before and after the implementation of the energy policy highlights the potential impact of the policy on economic inequality. This is evident from the P-value of 0.000. A significant change in the percentage of population living below the poverty line may indicate the success of the energy policy in reducing poverty levels in the community. On the other hand, the result that there is no significant difference between the Gini Coefficient before and after the energy policy reflects the complexity of measuring the impact of this policy on economic inequality from an income distribution perspective. This is evident from the P-value of 0.332. This suggests that although the Gini coefficient did not change significantly, further evaluation is needed to understand the deeper impact of renewable energy policies on economic inequality. The changes seen in the percentage of population below the poverty line may be an early indication of the effectiveness of energy policies in reducing economic inequality, while the lack of significance in the Gini Coefficient may raise questions related to aspects of income distribution that may not be directly visible in a given period. This analysis highlights the importance of in-depth and continuous research in understanding the impact of renewable energy policies on economic inequality. Further investigating the external factors and mechanisms underlying the relationship between energy policies and economic inequality indicators may provide new insights needed to design more effective and inclusive policies in the future.

Analysing the Impact of Energy Policy on Social Welfare.

The paired t-test statistical analysis showing significant differences between the Social Welfare Indicators, which include Life Expectancy, Infant Mortality Rate, and Access to Education before and after the implementation of the energy policy, provides substantial insights in understanding the impact of the renewable energy policy on the social welfare aspects of the community. Significant changes in Life Expectancy indicate the potential positive impact of energy policies on the quality of life of the population. The increase in Life Expectancy may reflect improved access to health services, a cleaner environment, and increased awareness of the importance of maintaining health in the context of sustainability. In addition, the significant decrease in Infant Mortality Rate indicates that energy policies have contributed to improving the well-being of children and families. This can be attributed to increased access to better healthcare, better nutrition, and a safer environment. A significant increase in Access to Education is also an important outcome of energy policy. Better access to education can bring long-term benefits in improving individual capabilities, employment opportunities, and overall social welfare. A deeper understanding of these outcomes is important to provide a solid basis for policy makers to continue and improve energy policies that have a positive impact on people's social welfare. Further analyses of the mechanisms underlying the relationship between energy policies and social welfare indicators may provide new insights needed to design more inclusive and sustainable policies in the future.

Discussion

Statistical analyses show that energy policy has a potential impact on economic inequality, particularly evident from the significance of the change in the percentage of the population below the poverty line. This is reinforced by data from the Central Bureau of Statistics of the Republic of Indonesia (BPS) which shows a decrease in the percentage of the population below the poverty line from 10.7% in 2010 to 7.0% in 2023 (bps.go.id, 2024). This significant decline demonstrates the success of energy policy in reducing poverty levels, particularly in rural and remote areas that were previously marginalised from adequate energy access. However, the statistical analysis also shows the complexity of measuring the impact of energy policy on economic inequality from an income distribution perspective. This is evidenced by the absence of a significant difference in the Gini Coefficient, which is an indicator of income inequality, between the period before and after the implementation of the energy policy. BPS data shows that the Gini Coefficient in Indonesia fluctuates over the period 2010-2023, with a slight decrease from 0.38 in 2010 to 0.36 in 2023 (bps.go.id, 2024). This fluctuation shows that other factors outside of energy policy, such as economic growth, inflation, and other government policies, also play a role in influencing income distribution.

Although energy policy in 2010 had a positive impact on poverty reduction, there is still income inequality that needs to be addressed. This suggests that more in-depth analyses are needed to understand the mechanism underlying the relationship between energy policy and income inequality. Further research using more complex econometric models and considering other factors that may affect income distribution, such as access to education, health services, and employment, may provide more comprehensive insights into the impact of energy policy on Economic Inequality. The Differencing Econometric Model is used to analyse and predict the impact of energy policy on Economic Inequality. This model allows for a more

in-depth evaluation of changes in economic inequality indicators such as Percentage of population below poverty line and Gini coefficient. Although the Gini coefficient does not show significant changes, further analyses are needed to understand the overall impact of energy policy.

Statistical analysis shows that the energy policy in 2010 had a positive and significant impact on people's social welfare. This is evidenced by a marked increase in social welfare variables such as Life Expectancy, Infant Mortality Rate, and Access to Education after the implementation of the energy policy. Data from the Central Bureau of Statistics of the Republic of Indonesia (BPS) shows that Life Expectancy in Indonesia has consistently increased from 68.0 years in 2010 to 72.5 years in 2023 (bps.go.id, 2024). This increase indicates improved access to health services, a cleaner environment, and increased awareness of the importance of maintaining health. Energy policies, such as the development of renewable energy infrastructure and increased access to clean energy, have contributed to improving people's quality of life. This is evidenced by the decline in respiratory and cardiovascular diseases associated with air pollution from fossil-fuelled power plants.

BPS data also shows that the Infant Mortality Rate in Indonesia has significantly decreased from 38 deaths per 1,000 live births in 2010 to 25 deaths per 1,000 live births in 2023 (bps.go.id, 2024). This decrease signifies an improvement in family welfare, especially in rural and remote areas that were previously marginalised from adequate energy access. Energy policies that provide access to clean and sustainable energy have helped improve the quality of life of mothers and children. This is evidenced by the decline in maternal and child mortality due to pregnancy and childbirth complications associated with energy shortages and inadequate access to health services. Improved Access to Education is also a significant result of energy policy. BPS data shows that the percentage of school-age children attending school in Indonesia has increased from 96.3% in 2010 to 99.0% in 2023 (bps.go.id, 2024). This increase provides long-term benefits to individual capabilities, employment opportunities, and overall social welfare.

Energy policies that provide access to electricity and internet in remote areas have helped improve the quality of education in Indonesia. This allows students in remote areas to access better information and learning resources, thus increasing their chances of getting a quality education and improving their skills. The Differencing Econometric Model is used to analyse and predict the impact of energy policy on social welfare. This model allows an in-depth understanding of the relationship between energy policy and social welfare variables. With this approach, we can see how energy policies directly affect aspects of social welfare such as Life Expectancy, Infant Mortality Rate, and Access to Education. Through this analysis, we can gain the necessary insights to design more inclusive and sustainable energy policies in the future.

Conclusions

From the analysis using Econometric Model Differencing to evaluate the impact of energy policy on economic inequality and social welfare, the findings show that energy policy has significant implications on these aspects. The significant change in the percentage of population below the poverty line indicates the effectiveness of energy policies in reducing poverty levels, while the complexity in measuring the impact on the Gini coefficient suggests the need for further evaluation. In the context of social welfare, the marked improvement in variables such as life expectancy, infant mortality rate, and access to education after the implementation of energy policy confirms the role of this policy in improving people's social welfare.

The recommendations in this study are first, to conduct further research to better understand the mechanism underlying the relationship between energy policy and economic inequality and social welfare. Next, methodological improvements by developing more holistic and inclusive analytical methods to measure the impact of energy policies on economic inequality and social welfare. Next, collaboration and awareness by encouraging cooperation among stakeholders and public awareness of the importance of sustainable energy policies to achieve the goals of reducing economic inequality and improving social welfare. Finally, policy evaluation is by conducting periodic evaluations of the implemented energy policy to ensure that the policy continues to have a positive and inclusive impact on society. With the implementation of these recommendations, it is expected that sustainable energy policies can continue to make a positive contribution to reducing economic inequality and improving people's social welfare, creating a more just and prosperous society as a whole.

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