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ASEAN Financing Climate Policy: The Effect of Fossil Fuel Subsidies on CPI and GHGs

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Abstract. The Association of Southeast Asian Nations (ASEAN) employs fossil fuel subsidies to promote economic development, although such action may have a negative effect on the environment. This study employs panel data analysis to examine whether ASEAN’s fossil fuel (oil, gas, coal, and electricity) subsidies decrease the consumer price index (CPI; Model 1) and, on the other hand, increase greenhouse gas emissions (GHGs; Model 2) from energy levels, using yearly data of five ASEAN countries from 2010 to 2021. The findings demonstrate that ASEAN's fossil fuel subsidies for oil, gas, coal and electricity do not reduce the CPI and, therefore, cannot be interpreted as reducing inflation. In addition, there is no effect of gas and coal subsidies on GHGs. This might be due to the small average of the five ASEAN countries from 2010 to 2021 in terms of gas and coal subsidies. Following the expectation, oil subsidy, which is the highest amount on average (4,635.44 real 2021 million USD), has a strong positive effect on GHGs. However, electricity subsidy, which is the second highest amount on average (1,963.22 real 2021 million USD), has a significant negative effect on GHGs.

Keywords: subsidy, fossil fuel, consumer price index (CPI), greenhouse gas emissions (GHGs), ASEAN.

1. Introduction

According to the Energy Institute, global energy consumption in 2022 remained 82% dominated by fossil fuels, unchanged from the previous year, leading to a 0.8% increase in greenhouse gas emissions [1]. With an emphasis on the Association of Southeast Asian Nations (ASEAN), the demand for energy has grown by almost 3% per year on average over the previous 20 years. This trend is expected to continue until 2030 [2]. The International Monetary Fund (IMF) reports that in 2015, effective fossil fuel subsidies reduced global carbon emissions by 28% and fatalities from fossil fuel air pollution by 46%, while also increasing government revenue by 3.8% of GDP [3]. This information applies to both economic and environmental policies. According to recent studies, ASEAN believes that subsidies for fossil fuels can support economic growth without interfering with the region's use of renewable energy sources for climate change policy [4, 5].

Subsidies to fossil fuels have long been a practice in many ASEAN members. Numerous factors, including political concerns, the need to preserve social stability, and the desire for economic development, drive these practices. Scholars have provided extensive documentation on the historical evolution of these subsidies. One such example [6], emphasises the significance of these subsidies for national budgets and economic decision-making. A 2016 ADB analysis examines the detrimental effects of fossil fuel subsidies on the ASEAN economy [7]. Subsidies for fossil fuels can be very harmful to government budgets. They primarily benefit the wealthy and reduce incentives for investing in renewable energy and energy efficiency. Subsidies aim to lower consumer energy costs, but there's growing worry about unintended consequences for inflation and the consumer price index (CPI). The financial impacts of fossil fuel subsidies are examined in this OECD report [8]. It also explains how these subsidies impede energy efficiency, distort market signals, and put pressure on public coffers.

To understand how fossil fuel subsidies impact the CPI, a thorough analysis of inflation dynamics is required. Battistini et al. investigate how changes in energy prices affect overall rates of inflation and, in turn, consumer purchasing power [9]. When analysing the increase in energy prices, it is crucial to take into account the remarkable economic recovery, even though there are other factors at work. Numerous studies [10, 11, 12] show the connection between fuel subsidies, CPI, and inflation in other areas. In order to clarify the intricacy of these connections, Caterina and Laderchi provide a detailed examination of the pathways via which CPI subsidies impact the CPI [13]. Scholars and policymakers can use these studies as a reference to help them make energy policy decisions that consider the broader economic effects of subsidy schemes.

The International Monetary Fund (IMF) claims that subsidies for fossil fuels have a seriously negative effect on the environment. Although subsidies are expensive, their purpose is to safeguard consumers by maintaining low costs. Subsidies have significant negative fiscal effects, including increased taxes, borrowing, or decreased spending; they also encourage inefficient resource allocation in economies, impeding growth; they encourage pollution, which contributes to local air pollution and climate change; and they are not effectively targeted at the poor, primarily benefiting higher income households [14]. As in other regions, ASEAN is facing a formidable task in trying to reconcile energy affordability with environmental sustainability [15, 16], particularly in view of the subsidies for fossil fuels and how they affect greenhouse gas emissions (GHGs).

Achieving both reduced greenhouse gas emissions and affordable energy requires coherence in policy making. Ambitious goals for environmental sustainability and climate action are included in the Sustainable Development Goals (SDGs) of the United Nations [17]. Subsidies often lead to higher carbon emissions which pose issues for the sustainability of the environment, even though their goal is to lower consumer energy costs [18]. However, thoughtful policy interventions and modifications to subsidies can greatly help reduce greenhouse gas emissions by promoting the use of cleaner energy sources and increasing energy efficiency. In keeping with international efforts to tackle climate change, future research and policy activities should concentrate on finding a balance between energy affordability and environmental responsibility.

Our research attempts to look into how CPI and GHGs are affected by energy sector subsidies (coal, gas, electricity, and oil). We have speculated that the economy may respond favourably or unfavourably to a subsidy package. On the upside, a programme like this might provide comparative economic advantages and enhance overall economic well-being. By bringing down the price of necessities and providing native producers with a cost edge over imports, subsidies would benefit consumers. Additionally, the subsidy might boost domestic production, reducing reliance on imports. These relationships must be understood by policymakers, economists, and energy analysts who are trying to navigate the difficult balance in the ASEAN region between environmental sustainability, affordable energy, and economic growth. To investigate whether ASEAN's fossil fuel (oil, gas, coal, and electricity) subsidies raise GHGs (Model 2) and lower the CPI (Model 1) from energy levels, we use panel data analysis. Taxes, government renewable energy subsidies, national energy policies and regulations, as well as international commerce and agreements, are examples of unobserved variables for both models (see Figure 1).

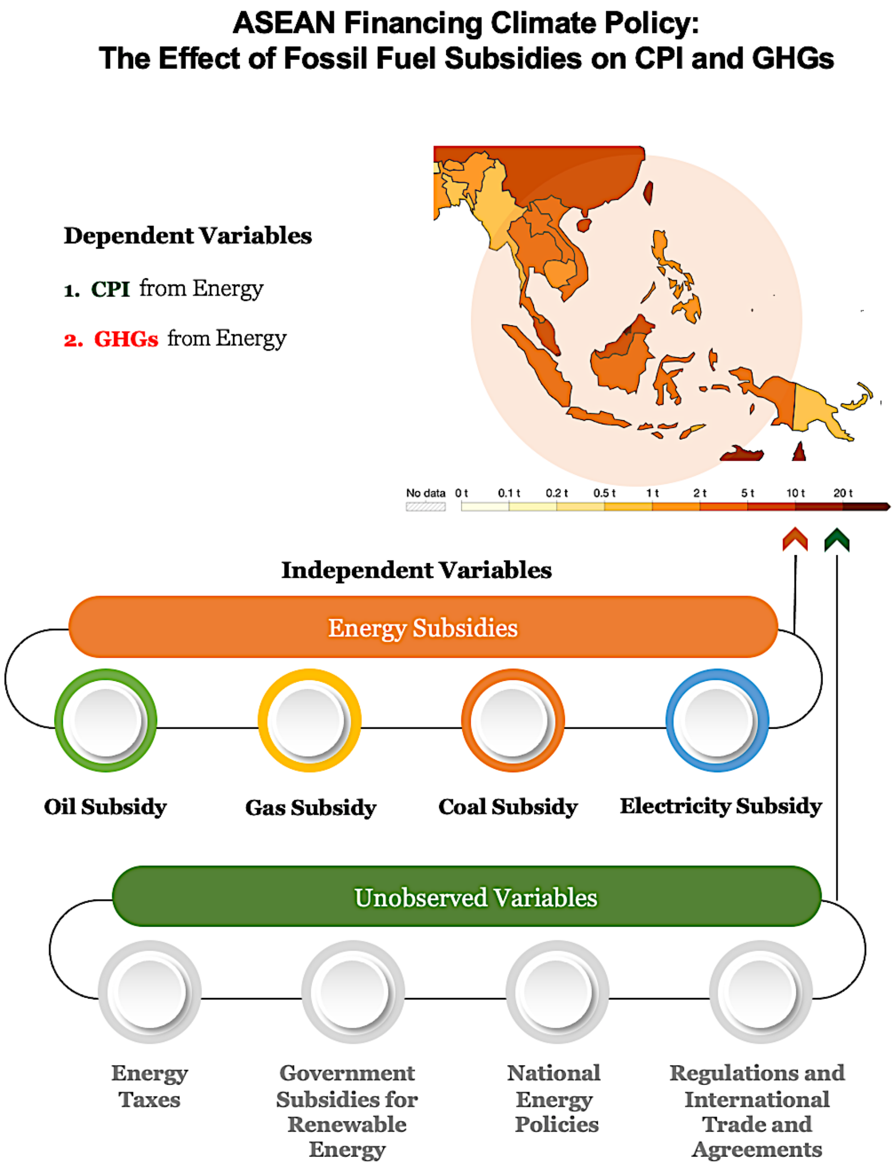

Figure 1. Research Conceptual Framework
source: The map image is developed from Our World in Data, 2023 [19]

2. Methodology

Panel data analysis's ability to take individual-specific effects into account gives researchers a clear advantage and yields more accurate and reliable results. By accounting for both within-entity and between-entity changes, panel data analysis makes it easier to examine dynamic processes, policy implications, and causal relationships—all of which are essential for making well-informed decisions. Fixed effects and random effects models are commonly used by researchers to manage individual heterogeneity in panel data. The ability of these techniques [20, 21] to extract pertinent findings from difficult panel datasets (here in relation to ASEAN financing climate policy) has made panel data analysis a vital tool in contemporary research. In this study, pooled ordinary least squares (POLS), fixed effects, and random effects are all estimated using standard linear panel estimators.

2.1 Data

The data comprise ASEAN's fossil fuel subsidies (real 2021 million USD) from IEA [22], CPI (annual %) from the World Bank [23], and GHGs from energy (CO2 equivalent) from IEA [24]. Covering a period of 12 years, from 2010 to 2021, this study uses annual data from five ASEAN nations. The highest number of observations allowed was 60 (5 x 12). The panel is unbalanced due to several missing GHG data for the year 2021. Table 1 presents an overview of the primary variables that were employed in the analysis. The original observations serve as the basis for the variable's summary statistics. Variations in the data therefore originate from "between" and "within" sources because panel data combines two dimensions, i.e., cross-sections and time periods. Within variations are the changes over time for each panel, while between variations are the changes between individual panels. With the exception of coal and gas subsidies, all of the model's variables vary primarily between the countries, as can be seen in the summary statistics above [25, 26, 27].

Table 1. Summary Statistics for Variables

5 ASEAN Countries, 2010 - 2021									
Variable		**Mean**	**Std. Dev.**	**Min**	**Max**	**Observations**		
CPI: CPI	overall	119.856	20.892	98.406	171.880	N	=	60
(annual %,	between		18.040	100.130	144.970	n	=	5
2010 = 100)	within		13.104	74.886	146.766	T	=	12
GHGs: GHGs	overall	257.866	193.012	7.923	696.899	N	=	55
from energy	between		209.870	8.963	590.019	n	=	5
(CO_2 equivalent)	within		36.941	164.328	367.440	T	=	11
OS: Oil subsidy	overall	4,635.443	7967.593	0	28853.430	N	=	60
(real 2021 million	between		7885.724	17.998	18596.210	n	=	5
USD)	within		3590.492	-6822.468	14892.660	T	=	12
GS: Gas subsidy	overall	227.234	407.096	0	1676.453	N	=	60
(real 2021 million	between		166.627	0	456.448	n	=	5
USD)	within		378.337	-229.214	1610.132	T	=	12
CS: Coal subsidy	overall	104.855	259.524	0	1260.617	N	=	60
(real 2021 million	between		153.636	0	339.459	n	=	5
USD)	within		219.430	-234.603	1026.013	T	=	12
ES: Electricity	overall	1,963.222	3582.060	0	14706.180	N	=	60
subsidy	between		3094.001	65.031	7398.686	n	=	5
(real 2021 million USD)	within		2245.680	-5435.464	9270.717	T	=	12

Sources: IEA, 2023 and the World Bank, 2023
Notes: Std. Dev. indicates standard deviation.

2.2 Statistical Analysis
The tests we use for panel data analysis in this study are the panel unit root test, the Hausman test, the Pearson's correlation test, and the Breusch-Pagan Lagrange multiplier (LM) test[1].

2.2.1 Panel Unit Root Tests
Unit root testing must be completed before beginning panel data processing. Since the ADF-Fisher Chi-square (1997) and PP-Fisher Chi-square (1988) tests can handle imbalanced panels, we utilise them. The alternative hypothesis (H_A) is that at least one panel is stationary, even though the null hypothesis (H_0) states that all panels have unit roots. [30, 31]. Table 2 displays the findings for panel unit root tests. The findings indicate that the independent variables, with the exception of energy subsidies for coal (CS), are stationary, but the dependent variables (GHGs and CPI) are non-stationary according to unit root tests (no constant and no trend). This study estimates short-run models with second differences to address the nonstationarity issue.

Table 2. Panel Unit Root Test Results

	5 ASEAN Countries, 2010-2021							
	ADF-Fisher Chi-square				**PP-Fisher Chi-square**			
	Obs.	Stat.	Prob.	Concl.	Obs.	Stat.	Prob.	Concl.
CPI	50	25.943***	0.004	I(2)	55	34.329***	0.000	I(1)
GHGs	40	27.686***	0.002	I(1)	45	37.504***	0.000	I(1)
OS	50	32.094***	0.001	I(0)	55	26.552***	0.003	I(0)
GS	32	23.605***	0.003	I(0)	36	39.543***	0.000	I(0)
CS	18	9.21**	0.056	I(2)	20	12.378***	0.014	I(1)
ES	50	27.816***	0.001	I(0)	55	35.509***	0.000	I(0)

Notes: (1) Significance is shown at the 1% and 5% levels, respectively, by *** and **.
(2) Obs., Stat., Prob. and Concl. indicate observations, statistics, probability and the conclusion number of the unit root respectively.

2.2.2 Pearson's Correlation Test
This analysis uses the Pearson's correlation test to avoid the problem of multicollinearity [32], which occurs when there is a significant connection between two or more independent variables. The results show that there isn't a multicollinearity issue because there isn't a significant connection between the independent variables (see Table 3).

[1] Since the Lagrange Multiplier test is only applicable to macro panels with lengthy time series, which is not required for this investigation, we do not use it for serial correlation [28]. Moreover, we do not use the Arellano-Bond autocorrelation test because it was designed for small-T and large-N panels. This paper, however, uses annual data of five ASEAN nations (N = 5) from 2010 to 2021 (T = 12). In situations where N is tiny, as this one is, the Arellano-Bond autocorrelation test may not be accurate [29].

Table 3. Pearson's Correlation Test Results

	5 ASEAN Countries, 2010-2021			
	Δ^2OS	Δ^2GS	Δ^2CS	Δ^2ES
Δ^2OS	1.000	0.059	0.028	0.362
Δ^2GS	0.059	1.000	0.292	0.082
Δ^2CS	0.028	0.292	1.000	0.130
Δ^2ES	0.362	0.082	0.130	1.000

2.3 Econometric Models

Panel data analysis is used to apply the econometric technique to derive the parameters of the consumer price index (CPI) and greenhouse gas emissions (GHGs) from energy source functions. A comparison of the ASEAN's fossil fuel subsidies' coefficient is then presented [33]. The CPI is the dependent variable in Model 1, while the energy subsidies for coal (CS), oil (OS), gas (GS), and electricity (ES) are the independent variables. GHGs are the dependent variable for Model 2, while the independent factors remain the same as they were for Model 1[2].

Model 1

$$\Delta^2 CPI_{it} = \alpha_0 + \beta_1 \Delta^2 OS_{it} + \beta_2 \Delta^2 GS_{it} + \beta_3 \Delta^2 CS_{it} + \beta_4 \Delta^2 ES_{it} + \Delta^2 \varepsilon_{it} \quad (1.1)$$

Model 2

$$\Delta^2 GHGs_{it} = \alpha_0 + \beta_1 \Delta^2 OS_{it} + \beta_2 \Delta^2 GS_{it} + \beta_3 \Delta^2 CS_{it} + \beta_4 \Delta^2 ES_{it} + \Delta^2 \varepsilon_{it} \quad (2.1)$$

The POLS estimator estimates β by combining time and cross sectional unit variation into a single long regression with *NT* observations by stacking data over *i* and *t*. This is computed using ordinary least squares (OLS). Since all variables are regarded as second-difference operators (Δ^2), the POLS models can be displayed as

Model 1

$$CPI_{it} = \alpha += \sum_{j=1}^{k} \beta_j x_{j,it} + \sum_{p=1}^{s} \gamma_p z_{p,i} + \varepsilon_{it} \quad (1.2)$$

Model 2

$$GHGs_{it} = \alpha += \sum_{j=1}^{k} \beta_j x_{j,it} + \sum_{p=1}^{s} \gamma_p z_{p,i} + \varepsilon_{it} \quad (2.2)$$

For Model 1, the dependent variable is the consumer price index. For Model 2, the dependent variable is the greenhouse gas emissions from energy levels, which takes a second-difference form. x stands for observed variables which are ASEAN's fossil fuel (oil, gas, coal and electricity) subsidies, which takes a second-difference form. z stands for unobserved variables, which include taxes, government subsidies for renewable energy, national energy policies, regulations and international trade and agreements (see Figure 1). The intercept, denoted by α, stands for the constants unique to each individual. β represents a column vector of parameters with k dimensions. γ represents a column vector of parameters in s dimensions. ε appears in Equations (1.1) and (2.1) as an error term ($\Delta^2\varepsilon$). *i* is country and *t* is year.

[2] We are unable to incorporate additional independent variables due to small-T (2010 to 2021), such as consumer price index of the previous year (CPI_{it-1}) for Model 1 and greenhouse gas emissions of the previous year ($GHGs_{it-1}$) for Model 2 to be the proxy variables for other factors. However, finding out if ASEAN's fossil fuel subsidies for coal, oil, gas, and electricity depress the CPI or, conversely, boost greenhouse gases linked to energy use is the main goal of this study.

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Hence, Equations (1.1) and (2.1) can be written in the regression models as

Model 1

$$CPI_{it} = \alpha + x'_{it}\,\beta + \mu_i + \varepsilon_{it} \tag{1.3}$$

Model 2

$$GHGs_{it} = \alpha + x'_{it}\,\beta + \mu_i + \varepsilon_{it} \tag{2.3}$$

where $x'_{it}\beta = \sum_{j=1}^{k} \beta_j x_{j,it}$ and $\mu_i = \sum_{p=1}^{s} \gamma_p Z_{p,i}$.

POLS has the drawback of ignoring unobserved characteristics (μ_i) under the restriction $\sum \mu_i = 0$. Even in situations where there is no connection with any of the explanatory variables, the presence of unobserved effect in POLS may result in erroneous standard errors and inefficient estimates [34].

Fixed effects can be used to adjust for unobserved heterogeneity[3], which is a key benefit of using panel data [35]. Under the fixed effects panel assumption, the intercept (α) and the country-specific effect (μ_i) are the unobserved variables that remain unchanged. They are therefore cancelled.

Model 1

$$\ddot{CPI}_{it} = \ddot{x}'_{it}\,\beta + \varepsilon_{it} \tag{1.4}$$

Model 2

$$\ddot{GHGs}_{it} = \ddot{x}'_{it}\,\beta + \varepsilon_{it} \tag{2.4}$$

where $\ddot{CPI}_{it} = CPI_{it} - \overline{CPI}_{it}$, $\ddot{GHGs}_{it} = GHGs_{it} - \overline{GHGs}_{it}$, $\ddot{x}_{itk} = x_{itk} - \bar{x}_{itk}$ and $\ddot{\varepsilon}_{it} = \varepsilon_{it} - \overline{\varepsilon}_{it}$.

However, when the factors to be evaluated are consistent for each individual, fixed effects is inappropriate because these variables are eliminated. Since random effects regression contains time-invariant variables that disappear under fixed effects, we shall employ it in this section. Regression Equations (1.3) and (2.3) offer the fundamental unobserved effects model (UEM) for country (*i*), a randomly chosen cross-section observation in this investigation. Under certain conditions, one can obtain a consistent estimator of β in the two models by utilising the POLS estimator. The random effects of the two models are shown as

Model 1

$$CPI_{it} = \alpha + x'_{it}\,\beta + u_{it} \tag{1.5}$$

Model 2

$$GHGs_{it} = \alpha + x'_{it}\,\beta + u_{it} \tag{2.5}$$

where $u_i = \mu_i + \varepsilon_{it}$ represents the combined errors [$\mu_i \sim i.i.d\,(0, \sigma_\mu^2)$ and $\varepsilon_i \sim i.i.d\,(0, \sigma_\varepsilon^2)$], and μ_i does not depend on ε_i [33].

Hence, Equations (1.3) and (2.3), can be expressed as follows in regression models.

[3] Prior to taking first differences for all variables and after taking first differences for all variables, POLS estimation in this study is equivalent to fixed effects (first differences) estimation. Thus, only within is used for the analysis.

Model 1

$$CPI_{it} = \alpha + x'_{it}\beta + \mu_i + \varepsilon_{it} \quad (1.6)$$

Model 2

$$GHGs_{it} = \alpha + x'_{it}\beta + \mu_i + \varepsilon_{it} \quad (2.6)$$

where μ_i is between-entity error, and ε_{it} is within-entity error.

The difference between Equations (1.6) and (2.6) and Equations (1.3) and (2.3) of POLS is that the variation across countries (μ_i) is not taken to be zero. According to the random effects regression assumption, μ_i is uncorrelated and random with respect to the independent variables (x_i). It is plausible to suppose that the dependent variable ($\mu_i \neq 0$) is influenced in some way by the unobserved variables in this study, such as taxes, government subsidies for renewable energy, national energy policies, laws, and international commerce and agreements (see Figure 1). Consequently, the random effects model is more appropriate than the POLS model [36].

3. Results and Discussion

3.1 Panel Data Analysis Results

In Table 4, it is evident that the estimation findings for the GHGs (Model 2) and the CPI (Model 1) using the three distinct estimation methods (POLS, fixed effects, and random effects) appear to be similar. The CPI model's findings demonstrate that energy subsidies' impacts on the prices of oil, gas, coal, and electricity are negligible and not statistically significant. For the GHGs model, β_1 is positive, hence oil subsidy increase is shown to relate to higher greenhouse gas emissions (GHGs) from energy levels with high significance, as expected. The effect of gas subsidy (β_2) on GHGs is negative, though not statistically significant and somewhat close to zero. As anticipated, the impact of coal subsidies (β_3) on GHGs is positive, but it is a tiny amount and not statistically significant. Interestingly, the electricity subsidy has a significant negative effect on GHGs by a tiny amount.

Table 4. Panel Data Analysis Appropriate Estimation Results

5 ASEAN Countries, 2010 - 2021						
Δ^2CPI						
Variable	**POLS**		**Fixed Effects**		**Random Effects**	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Δ^2OS: Oil subsidy	-2.01E-06	5.40E-05	-0.410924	0.302032	-0.408171	0.301858
Δ^2GS: Gas subsidy	-0.000359	0.000571	-3.50E-06	5.40E-05	-2.01E-06	5.39E-05
Δ^2CS: Coal subsidy	0.001507	0.001940	-0.000408	0.000574	-0.000359	0.000569
Δ^2ES: Electricity subsidy	-6.73E-05	7.60E-05	0.001695	0.002005	0.001507	0.001936
α_0	-0.408171	0.302454	-6.30E-05	7.60E-05	-6.73E-05	7.59E-05
R-squared	0.035		0.124		0.035	
F-statistic	0.409		0.728		0.409	

5 ASEAN Countries, 2010 - 2021						
Δ^2**GHGs**						
Variable	**POLS**		**Fixed Effects**		**Random Effects**	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Δ^2OS: Oil subsidy	0.003***	0.001	0.003***	0.001	0.003***	0.001
Δ^2GS: Gas subsidy	-0.001	0.006	-0.001	0.006	-0.001	0.006
Δ^2CS: Coal subsidy	0.025	0.026	0.025	0.027	0.025	0.027
Δ^2ES: Electricity subsidy	-0.002**	0.001	-0.002**	0.001	-0.002**	0.001
α_0	-1.055	3.421	-1.138	3.581	-1.055	3.579
R-squared	0.292		0.302		0.292	
F-statistic	4.119***		1.949*		4.119***	

Notes: Significance is indicated at 1%, 5%, and 10% levels, respectively, by ***, **, and *.

3.2 Hausman Test Results

To choose between fixed effects (FE) and random effects (RE) estimators, we apply the Durbin-Wu-Hausman test. Under H_0, while βFE is consistent but inefficient, βRE is consistent and efficient. Conversely, β_{RE} is consistent but inefficient under H_A. Random effects may be used if the test result is not significant (P-value, Prob > higher than 0.05), which indicates that the null hypothesis is not rejected. Applying fixed effects is advised if the P-value is significant, which results in the rejection of the null hypothesis. Since Table 5's results for the CPI (Model 1) and GHGs (Model 2) show that the null hypothesis—that unique errors (u_i) are unrelated to the regressors—is not rejected, random effects estimations are acceptable [33].

Table 5. Hausman Test Results

5 ASEAN Countries, 2010 - 2021			
Model 1: $\Delta^2 CPI_{it} = \alpha_0 + \beta_1 \Delta^2 OS_{it} + \beta_2 \Delta^2 GS_{it} + \beta_3 \Delta^2 CS_{it} + \beta_4 \Delta^2 ES_{it} + \Delta^2 \varepsilon_{it}$			
Chi-Sq. Statistic	**Chi-Sq. d.f.**	**Prob.**	**Random Effects (RE)**
4.17	4	0.3825	accept RE
Model 2: $\Delta^2 GHGs_{it} = \alpha_0 + \beta_1 \Delta^2 OS_{it} + \beta_2 \Delta^2 GS_{it} + \beta_3 \Delta^2 CS_{it} + \beta_4 \Delta^2 ES_{it} + \Delta^2 \varepsilon_{it}$			
Chi-Sq. Statistic	**Chi-Sq. d.f.**	**Prob.**	**Random Effects (RE)**
0.539	4	0.970	accept RE

Note: Chi-Sq. Statistic, Chi-Sq. d.f. and Prob. indicate chi-square statistic, degree of freedom of the chi-square and probability (Prob > X^2) respectively.

3.3 Breusch-Pagan Lagrange Multiplier Test

We employ the Breusch-Pagan Lagrange Multiplier (B-P/LM) test of independence (1980) in this investigation. When deciding between a POLS regression and a random effects regression, this test is useful. Relative to H_0, there is no correlation between country residuals. However, under H_A, this correlation exists [35]. The results in Table 6 show the Breusch-Pagan probability of 0.89 > 0.05 for CPI model meaning that, in this study, it is better to use common effects than random effects. Thus, it can be said that POLS is the most appropriate cross-section test to be applied in this model. However, the GHGs model's Breusch-Pagan probability of 0.03 < 0.05 indicates that using random effects is preferable in this study over common effects. This model accepts random effects because there is evidence of major variances throughout ASEAN countries.

Table 6. Breusch-Pagan Lagrange Multiplier (B-P/LM) Test Results

5 ASEAN Countries, 2010 - 2021			
Model 1: $\Delta^2 CPI_{it} = \alpha_0 + \beta_1 \Delta^2 OS_{it} + \beta_2 \Delta^2 GS_{it} + \beta_3 \Delta^2 CS_{it} + \beta_4 \Delta^2 ES_{it} + \Delta^2 \varepsilon_{it}$			
Test Hypothesis			**Random Effects (RE)**
Cross-section	**Time**	**Both**	
0.017309 (0.8953)	0.000644 (0.9798)	0.017953 (0.8934)	not accept RE
Model 2: $\Delta^2 GHGs_{it} = \alpha_0 + \beta_1 \Delta^2 OS_{it} + \beta_2 \Delta^2 GS_{it} + \beta_3 \Delta^2 CS_{it} + \beta_4 \Delta^2 ES_{it} + \Delta^2 \varepsilon_{it}$			
Test Hypothesis			**Random Effects (RE)**
Cross-section	**Time**	**Both**	
2.143948 (0.1431)	2.525591 (0.1120)	4.669538 (0.0307)	accept RE

Note: Probability in ( ).

4. Conclusion and Outlook

This study employs panel data analysis to examine whether ASEAN's fossil fuel (oil, gas, coal, and electricity) subsidies decrease the consumer price index (CPI; Model 1) and, on the other hand, increase greenhouse gas emissions (GHGs; Model 2) from energy levels, using yearly data of five ASEAN countries from 2010 to 2021. The results from POLS of Model 1 show that there is no effect from oil (β_1), gas (β_2), coal (β_3), and electricity (β_4) subsidies on CPI. However, the results from the random effects of Model 2 show that oil subsidy has a strongly significant positive impact on GHGs ($\beta_1 = 0.03$). Conversely, there is a substantial negative correlation between electricity subsidies and GHGs ($\beta_4 = -0.002$). Subsidies for gas (β_2) and coal (β_3), however, have no effect on GHGs.

Our conclusion is that the fossil fuel subsidies provided by ASEAN for oil, gas, coal, and electricity do not reduce the CPI. This means that they cannot be viewed as lowering inflation. In addition, there is no effect of gas and coal subsidies on GHGs. This might be due to the small average of the five ASEAN countries from 2010 to 2021 in terms of gas and coal subsidies being 227.23 and 104.86 real 2021 million USD respectively (Table 4). Following the expectation, oil subsidy, which is the highest amount on average (4,635.44 real 2021 million USD), has a strong positive effect on GHGs (see Table 1 and Table 4). However, electricity subsidy, which is the second highest amount on average (1,963.22 real 2021 million USD), has a significant negative effect on GHGs (see Table 1 and Table 4). Thus, we ought to think about whether financing for renewable energy sources could result in even bigger emissions reductions. We propose that international climate cooperation could help the ASEAN countries transition to clean energy by helping to build the infrastructure required to implement high-impact, efficient renewable energy subsidies.

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Appendix

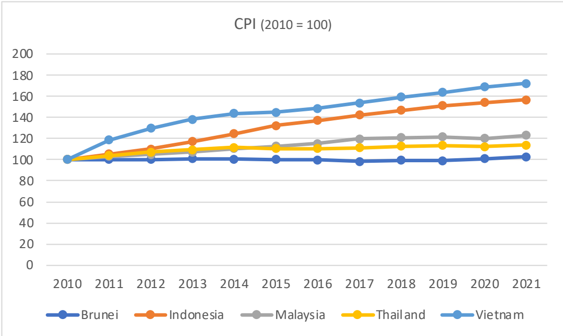

Figure A1. CPI for Five ASEAN Countries

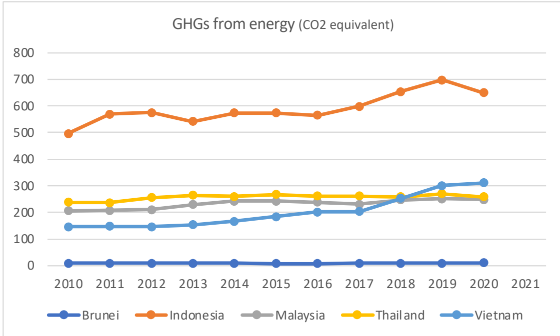

Figure A2. GHGs for Five ASEAN Countries

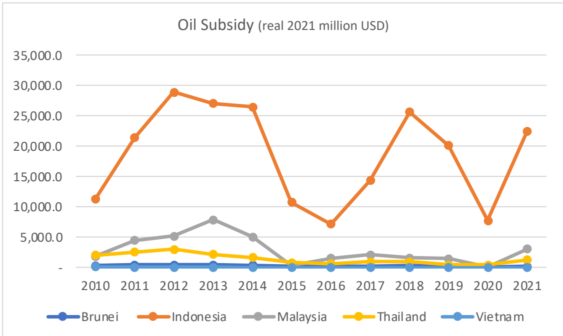

Figure A3. Oil Subsidy for Five ASEAN Countries

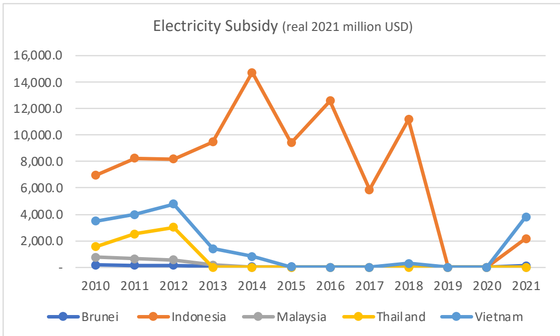

Figure A4. Electricity Subsidy for Five ASEAN Countries

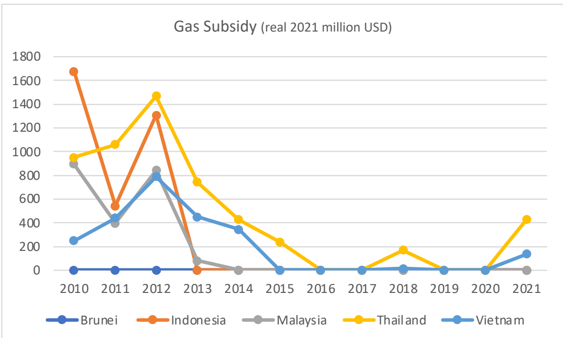

Figure A5. Gas Subsidy for Five ASEAN Countries

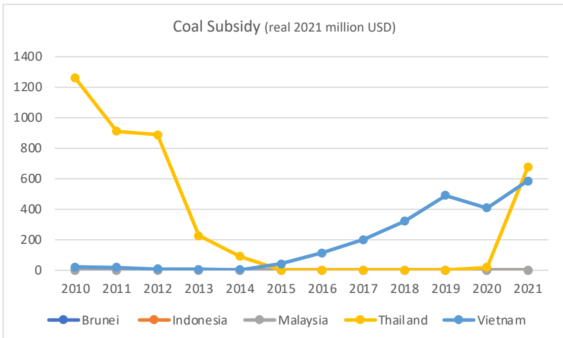

Figure A6. Coal Subsidy for Five ASEAN Countries