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Research Article

Does energy transition matter to sustainable development in ASEAN?

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Abstract. The energy transition towards renewable sources represents a pivotal factor in pursuing sustainable development. This study reviews the impact of renewable energy on three aspects of sustainable development, namely economic, social, and environmental aspects in ASEAN. To quantify these aspects, GDP per capita proxies for the economic dimension, unemployment rates for the social dimension, and CO_2 emissions for the environmental dimension. The data used is panel data of 10 ASEAN countries from 1996-2020. Pooled Mean Group (PMG) estimation technique is applied to identify the relationship between renewable energy and the dimensions of sustainable development. The study results reveal that renewable energy has a significant influence on sustainable development in the long run. Specifically, renewable energy is able to stimulate GDP per capita levels, thus potentially serving as a determinant of sustainable economic growth in ASEAN. Furthermore, the findings of this study suggest that renewable energy has the capacity to reduce CO_2 emissions in the long run. Efforts to increase the share of renewable energy usage are needed to mitigate the risk of environmental degradation. However, it is noteworthy that our study underscores the adverse impact of the energy transition on the social dimension, as it can potentially drive-up unemployment rates in the long run. This impact can be attributed to labor market relocations and structural changes. Novice workers in the renewable energy sector may face the risk of displacement. Consequently, this study has implications that underscore the need for inclusive approaches to elevate the usage of renewable energy. Furthermore, a well-structured policy framework is needed to encourage more investments and prepare the competent workforce in the renewable energy sector.

Keywords: CO_2 Emissions, Energy Transition, Pooled Mean Group (PMG), Renewable Energy, Sustainable Development

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1. Introduction

The World Bank's "Global Economic Report 2023" report conveys the importance of encouraging sustainable development. This ensures that future generations can also enjoy development (World Bank, 2023). Based on data from the Global Carbon Atlas (2023), the value of global CO_2 emissions will reach 36.85 thousand $MtCO_2$ in 2021, a sharp increase from the previous decade of 31.49 thousand $MtCO_2$ in 2009. This condition is crucial to follow up, considering several risks from environmental damage and climate disruption (Lantz *et al.*, 2021; Mamidi *et al.*, 2021; Piaggio & Padilla, 2012). In the future, achieving sustainable development will focus on high economic growth and ensure that social and environmental aspects run well.

Research by Sachs *et al.* (2019) explains that reducing greenhouse gas emissions can promote sustainable development goals. More specifically, this can be achieved through energy transition implementation. Several countries worldwide have made various efforts in energy transition, such as the European Union, which allocated 30% of a 750 billion Euro stimulus package for Green Investment (European Union, 2021). Germany allocated 15 billion Euros to support the use of eco-friendly vehicles. The U.S. also supports energy transition programs, using the international Paris Agreement as a starting point (Ewing *et al.*, 2022). The U.S. government aims for a 58% transition by 2030 and 80% by 2050.

In the context of developing countries, especially ASEAN, there is a strong commitment to supporting energy transition to achieve sustainable development. In Indonesia, support for energy transition is outlined in the National Medium-Term Development Plan (RPJMN) 2020-2024, with various emission reduction targets. Similarly, Malaysia's push for energy transition is documented in the National Energy Policy 2022-2040. Other ASEAN member states such as Singapore, Brunei Darussalam, Thailand, Cambodia, Philippines, Vietnam, Laos, and Myanmar fully support this condition.

ASEAN has set ambitious targets for this energy transition (Maulana *et al.*, 2023). The ASEAN Plan of Action for Energy Cooperation (APAEC) aims to achieve 23% of the total primary energy supply from renewable energy (RE hereafter) and 35% of installed electric capacity in this region by 2025. Despite the pandemic, some ASEAN Member States, such as Laos and Vietnam, have taken significant steps by increasing their installed RE capacity by 117.5% and 129.6%, respectively (Abdullah *et al.*, 2022).

Moreover, while energy transition is favourable for sustainable development, particularly in the environmental aspect (Bilgili *et al.*, 2016; Chen *et al.*, 2019; Dong *et al.*, 2020; Jia *et al.*, 2021; Mukhtarov *et al.*, 2022; Nathaniel & Iheonu, 2019;

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Ummalla & Samal, 2019), its impact also needs to be assessed from economic and social perspectives. Studies by Ferrari & Landi (2022) show that energy transition increases inflation in the European region. Energy transition makes energy prices more expensive than before, especially when energy transition policies are overly enforced, leading to a shortage in RE supply.

Some studies also find that energy transition has negative implications on the social aspect, particularly an increase in poverty and inequality (Nguyen *et al.*, 2019; Adom *et al.*, 2021; Tundys & Bretyn, 2023). Nguyen *et al.* (2019) explain that the transition to cleaner energy leads to price increases, indirectly burdening lower and middle-class populations and, in turn, contributing to poverty and inequality (Oviedo-Toral *et al.*, 2021). In addition, some studies also indicate that energy transition can reduce unemployment (Akella *et al.*, 2009; Ravillard *et al.*, 2021). Economic transition projects offer new job opportunities at a considerable cost or investment.

Overall, this situation highlights the need to carefully implement an energy transition to support sustainable development. Potential energy transition risks, especially those related to economic, social, and environmental aspects, need to be considered (Araújo, 2014; Bradshaw & de Martino Jannuzzi, 2019; Saraji & Streimikiene, 2023). The purpose of this study is to reassess the influence of energy transition policies on sustainable development in ASEAN. The study contributes in three main ways. First, it delves into the economic, social, and environmental consequences of energy transition on sustainable development, presenting a complete perspective. Second, it assesses the effects of these three aspects in the short and long term. Third, the study offers policy recommendations for energy transition in developing countries, particularly in ASEAN.

2. Literature Review

2.1 Environmental Kuznets Curve (EKC)

The relationship between environmental degradation and development is depicted in an Environmental Kuznets Curve (EKC) that hypothesizes an inverted U-shaped relationship (see Fig 1). In this model, there is an initial increase in pollution with economic development. However, the trend reverses after a certain income level (Income Inflection Point, ITP). Thus, at the highest income levels, economic growth will drive environmental improvements (López-Menéndez *et al.*, 2014).

Environmental degradation and income have a nonlinear relationship that is classified into three main effects, including scale, composition and technical effects. When economic activities expand and shift from the agrarian sector to the industrial sector, it can cause environmental degradation (scale effect). Meanwhile, the composition effect occurs when the economy pattern changes from agrarian to industrial base and then from industrial to service base. Obsolete technologies are replaced as technology advances, thus reducing pollution levels as the economy grows, this transition is referred to as the technical effect (Bölük & Mert, 2015; Gill *et al.*, 2018).

However, in the context of this study, the EKC assumes a role as an additional theoretical framework rather than serving as the primary theory guiding the research. In this regard, the EKC provides a conceptual background for understanding patterns within the data. However, it is important to clarify that the EKC does not explicitly define or depict the research model being constructed. Therefore, the inclusion of the EKC is intended to ensure that the research model captures the intricacies of the interaction between environmental factors and economic development without being constrained by the specific assumptions of the EKC.

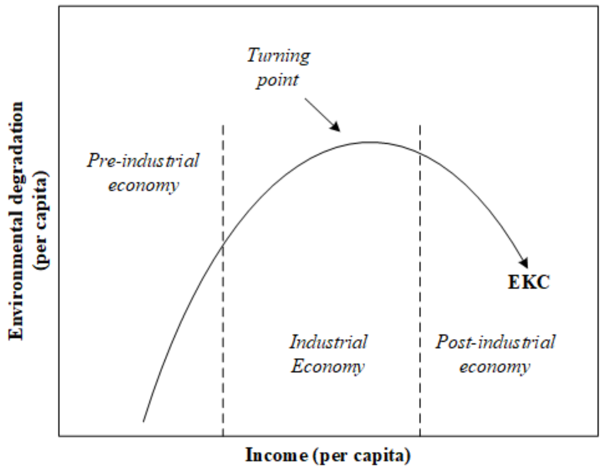

Fig 1. Environmental Kuznets Curve

2.2 Renewable Energy Led Economic Growth Hypothesis

In energy economics literature, energy consumption aligns with economic growth, as energy consumption is a fundamental driver of economic activities (Chang & Fang, 2022). Additionally, the role of RE consumption in influencing environmental quality has been extensively discussed in the literature. However, a specific focus of this research entails investigating the relationship between RE consumption and economic growth. Thus, the utilization of RE emerges as a crucial aspect for studying growth models (Yang *et al.*, 2022).

In the growth hypothesis, RE consumption and economic growth have unidirectional causality in the long run. Hence, energy use is crucial in promoting economic growth (Xie *et al.*, 2023). Apergis & Tang (2013) mentioned that the energy-led growth hypothesis is widely confirmed in developed and developing countries. Therefore, energy consumption, especially from renewable sources, contributes significantly to sustainable economic development. In the case of country groups, several studies have explored economic growth led by RE consumption, such as the case in G7 member countries (Tugcu *et al.*, 2012), the case in developing countries (Fotourehchi, 2017), the case in Central and Eastern European countries (Marinaș *et al.*, 2018), the case in European countries (Ntanos *et al.*, 2018), and the case in N-11 countries (Xie *et al.*, 2023; Yang *et al.*, 2022).

2.3 RE and GDP per Capita Nexus

Empirical studies on the relationship between energy consumption and economic growth have witnessed rapid advancements, particularly following the influential study conducted by Kraft & Kraft (1978) that substantially impacted the U.S. economy. Subsequently, the empirical literature has proposed four hypotheses concerning the energy-growth nexus: the growth hypothesis, conservation hypothesis, feedback hypothesis, and neutrality hypothesis (EL-Karimi & El-houjjaji, 2022; Taşkın *et al.*, 2020). The energy-growth nexus has become a compelling research topic, yet various studies in existence take cases from different countries using divergent methodological approaches, leading to a lack of consensus among economists.

In addition, RE can help to achieve the aims of sustainable development. Therefore, RE development efforts usually involve three main changes: first, on the demand side, energy savings can be made; second, efficiency in energy production will increase; and third, RE sources can replace the use of fossil fuels (Lund, 2007). Several studies have been conducted to determine the effect of RE consumption on the economic conditions of a country. Fang (2011), for example, investigated the influence of RE consumption on economic welfare. The study provides evidence that using large amounts of RE sources significantly impacts the increase in GDP per capita.

Inglesi-Lotz (2016), using panel data methods, investigated the effect of RE consumption on economic growth, particularly in OECD nations. The findings show that RE consumption has a statistically significant impact on enhancing economic growth. Meanwhile, in Pakistan, J. Wang *et al.* (2022) stated that a shift from non-RE to RE sources is necessary to promote sustainable economic growth.

In addition to the positive relationship between RE consumption and economic activity, some studies have found the opposite relationship, especially in developing countries where most energy consumption still comes from traditional sources. For example, Ocal & Aslan (2013) evaluated the relationship between RE consumption and economic growth in Turkey. The findings suggested that RE consumption had a negative influence on economic growth, as RE sources are expensive investments. Fan & Hao (2020) found that the transition from traditional energy sources to RE sources can slow down economic growth, especially in countries where the main driver of economic growth comes from traditional energy consumption, such as China.

2.4 RE and Unemployment Nexus

Many countries worldwide have advocated policies to encourage the transition to RE—beyond its role in contributing to the reduction of greenhouse gas emissions—as an effort to ensure energy supply, drive technological advancements, create new job opportunities, and facilitate regional development (Proença & Fortes, 2020). Specifically, governments in various countries have prioritized the RE transition as a primary initiative to facilitate the creation of new jobs (Gielen *et al.*, 2019; Kumar. J & Majid, 2020; Smirnova *et al.*, 2021). However, it seems that there is no consensus among academics and policymakers regarding the employment benefits of RE. In particular, Stavropoulos & Burger (2020) examined the impact of RE through meta-analysis, reporting a lack of agreement among empirical studies on the employment impact of RE. Controversies primarily arise due to differences in the types of RE utilized, country samples, and methodological approaches.

It is a major concern for policymakers to formulate policies regarding the impact of RE on employment. In fact, the use of RE can help stimulate economic development through job creation (Akella *et al.*, 2009). Therefore, various studies have investigated the relationship between RE and job creation to reduce unemployment. For example, Khobai *et al.* (2020) and Musa & Maijama'a (2020) state that in the long run, unemployment can be reduced by increasing energy consumption from renewable sources.

However, Apergis & Salim (2015) found that RE consumption has a positive influence on unemployment in the European Union and Africa. Consequently, the use of energy from renewable sources will lead to an increase in technology costs, which will increase production costs and reduce energy efficiency, thereby increasing unemployment. The same findings are also shown by Rafiq *et al.* (2018) that RE consumption impacts increasing unemployment due to massive structural changes in the energy sector and economic production.

2.5 RE and CO_2 Nexus

The global effort towards achieving sustainable development has spurred increased interest in the relationship between RE and carbon dioxide (CO_2). As concerns about climate change escalate, the role of RE sources in mitigating CO_2 emissions has become a primary focus in academic research and policymaking. Consequently, the transition towards RE is often regarded as a crucial step in attaining sustainable development goals and reducing dependence on carbon-intensive energy sources (Elum & Momodu, 2017; Fais *et al.*, 2016).

The widespread use of RE is an action that can reduce CO_2 emissions and lower the likelihood of a climate disaster. Various studies have attempted to examine RE use as a factor of CO_2 emissions (Bilgili *et al.*, 2016; Chen *et al.*, 2019; Dong *et al.*, 2020; Jia *et al.*, 2021; Mukhtarov *et al.*, 2022; Nathaniel & Iheonu, 2019; Ummalla & Samal, 2019). For example, Nathaniel & Iheonu (2019) observed the relevance of RE in lowering CO_2 emissions in Africa. Using the Augmented Mean Group (AMG) estimation approach, their analysis found that five countries (Botswana, Gabon, Nigeria, South Africa, and Togo) can reduce CO_2 emission levels through RE consumption. Mukhtarov *et al.* (2022) found that CO_2 emission levels were reduced as RE use increased.

Other studies found the opposite results to some previously mentioned studies. For example, Apergis *et al.* (2010) examined 19 developed and developing nations from 1984 to 2007. Their findings revealed a positive and significant effect of RE usage on CO_2 emissions. Menyah & Wolde-Rufael (2010) found no association between RE use and CO_2 emissions in their investigation. In this case, RE consumption does not significantly reduce emissions.

3. Data and Method

3.1 Data

This study has the aim of examining how the RE transition affects sustainable development. The data used is panel data with the research locus of ASEAN countries, namely Singapore, Thailand, Malaysia, Indonesia, Philippines, Cambodia, Laos, Myanmar, Vietnam, and Brunei Darussalam with the observation period covering 1996-2020. The data is obtained from the statistical publication of the World Development Indicators (WDI) by the World Bank. RE transition in this study is employed by the percentage of RE consumption (% of total final energy consumption). RE consumption is closely related to sustainable development, such as the study investigated by Taşkın *et al.* (2020) and Z. Wang *et al.* (2023). The sustainable development in this study is measured by three aspects: economic, social, and environmental. Three variables are used to measure each aspect, including GDP per capita, unemployment rate, and CO_2 emissions. Table 1 displays the specifics of all variables in this study.

3.2 Descriptive Statistics

Table 2 provides descriptive statistics of the variables' mean, standard deviation, minimum and maximum values before the log transformation. From 1996-2020, ASEAN countries had an average per capita GDP growth rate of 3.61 percent. Almost all

Table 1
Data Description

	Variable	Measurements	Data Source
Aspects of SD	Dependent		
Economics	GDP per capita	GDP per capita growth (%)	WDI
Social	Unemployment	Unemployment rate (%)	WDI
Environment	CO_2 emissions	CO_2 emissions (kt)	WDI
	Independent		
	Renewable Energy	RE consumption (% of total energy consumption)	WDI
	Foreign Direct Investment	Net inflows (% of GDP)	WDI
	Inflation	Consumer price (%)	WDI
	Trade Openness	Export and Import of Merchandise (% of GDP)	WDI

Table 2
Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max
GDPC	3.610	3.931	-14.476	12.701
UNP	2.967	2.053	0.140	9.320
lnCO2	11093.7	131936.1	781.4614	605290.6
REC	35.185	28.942	0.000	86.620
FDI	5.657	5.845	-2.757	29.761
INF	6.217	12.339	-2.315	125.272
TO	107.924	66.370	28.792	343.488

countries had negative growth values during the Covid-19 pandemic and during the 1998 financial crisis. Indonesia had the most contracted growth rate in 1998, reaching -14.47 percent. Such data suggests that the economies of ASEAN countries are still relatively vulnerable to external shocks.

The average unemployment rate of ASEAN countries during the study period was 2.96 percent. This figure is relatively lower than the average world unemployment rate in 2020 of 6.9 percent. In detail, Brunei Darussalam had the highest unemployment rate in 2017 at 9.32 percent. Despite being a developed country in ASEAN, Singapore has an average unemployment rate above the ASEAN rate of 4.21 percent.

Another sustainable development element, CO_2 emissions, has an average value of 11093.7 kt for ASEAN countries. Among these nations, Indonesia stands out as the top contributor to CO_2 emissions, recording the highest CO_2 emission rate of 605290.6 kt in 2019. A higher level of emissions signifies that economic activities involved in producing goods and services are not yet aligned with environmentally friendly activities, resulting in negative environmental externalities as a consequence of economic growth. However, the number of CO_2 emissions produced tends to decrease when the beginning of the COVID-19 pandemic occurs, given the many restrictions on community activities.

ASEAN countries have relatively low RE consumption, with an average value of only 35.18 percent during the observation period. Most ASEAN countries, such as Indonesia, Laos, Cambodia, Vietnam, and Myanmar, have consumed above-average RE. Laos had a RE consumption rate of 86.62 percent of the total energy consumed in 1999. RE is urgently needed to deal with climate and environmental issues, especially to achieve sustainable growth. This achievement can be understood from the benefits of RE that can decrease greenhouse gas emissions, enhance energy security, and broadly provide millions of people access to cleaner, reliable, and affordable energy.

3.3 Research Model Specifications

This research model is adopted from the research model of Taşkın *et al.* (2020), who also conducted a study on RE and sustainable development in OECD countries. The empirical model we use is as follows.

First, the general form of our research model:

$$SD_{it} = \alpha_0 + \beta_1 REC_{it} + \beta_2 FDI_{it} + \beta_3 INF_{it} + \beta_4 TO_{it} + \varepsilon_{it} \tag{1}$$

Second, our research sub-model forms:

$$GDPC_{it} = \alpha_0 + \beta_1 REC_{it} + \beta_2 FDI_{it} + \beta_3 INF_{it} + \beta_4 TO_{it} + \varepsilon_{it} \tag{2}$$

$$UNP_{it} = \alpha_0 + \beta_1 REC_{it} + \beta_2 FDI_{it} + \beta_3 INF_{it} + \beta_4 TO_{it} + \varepsilon_{it} \tag{3}$$

$$lnCO2_{it} = \alpha_0 + \beta_1 REC_{it} + \beta_2 FDI_{it} + \beta_3 INF_{it} + \beta_4 TO_{it} + \varepsilon_{it} \tag{4}$$

SD_{it} represents the sustainable development dimension consisting of $GDPC_{it}$,UNP_{it}, and $lnCO2_{it}$ where each indicates gross domestic product per capita, unemployment rate, and CO_2 emission. REC_{it} is the level of RE consumption as independent variable.

This study also uses several control variables including FDI_{it} is foreign direct investment, INF_{it} is inflation rate, and TO_{it} is trade openness. The notation α_0 is a constant. β_1, β_2, β_3, β_4 are the coefficients of each independent variable. ε represents the error term. Country and years are denoted by i and t, respectively.

In connection with the previous equation, the coefficient of β_1 in equation (2) will exhibit a positive value since it is assumed that the usage of RE will stimulate economic growth. Whereas, the signs of β_2 and β_3 in equations (3) and (4) are expected to be negative, as the usage of RE is assumed to encourage the creation of new jobs and reduce CO_2 emissions.

3.4 Analysis Method

This study uses Pooled Mean Group (PMG) to estimate the nexus between RE transition and sustainable development in ASEAN in the short and the long run. The initial step of the method involves employing unit root tests for panel data to identify the stationarity of the variables. Secondly, a cointegration test will be conducted to determine the presence of a long-run relationship among the variables used.

The identification of the stationarity of the variables in this study uses several various of unit root tests, including the Augmented Dickey-Fuller (ADF)-Fisher proposed by Dickey & Fuller (1979), the Fisher-Philips-Perron (PP) test introduced by Phillips & Perron (1988), the Levin, Lin, and Chu (LLC) test introduced by Levin *et al.* (2002), and the Im, Pesaran and Shin (IPS) test developed by Im *et al.* (2003), These tests are with the underlying assumption that the each individual time series is cross-sectionally independently distributed (Taşkın *et al.*, 2020). The basic formula of the unit root test can be written as follows:

$$\Delta Y_{it} = \alpha Y_{it-1} + \sum_{j=1}^{pi} \Delta Y_{it-1} + X`_{it}\delta + \varepsilon_{it} \quad (5)$$

Where Δ is the first order operator, Y_{it-1} is the dependent variable i in period t, the equation assumes that $\alpha = \rho - 1$, if $|\rho| < 1$ or the null hypothesis is rejected, then Y has no unit root and is stationary. However, if $|\rho| = 1$ or the null hypothesis is accepted then Y contains a unit root and is therefore not stationary.

After conducting unit root identification, the next step is to conduct a cointegration test. This study applies the Johansen-Fisher cointegration test constructed by (Maddala & Kim, 1999) by offering two approaches, namely Fisher statistics from trace test and maximum eigenvalue test. The null hypothesis in the Johansen-Fisher test describes that there is no a cointegration relationship, while the alternative hypothesis indicates the presence of cointegration.

Next, we will estimate the model using the PMG method. This method was introduced by Pesaran *et al.* (1999). PMG estimation allows intercepts, parameters, and error variances to be different between cross-sections in the short run, but the coefficients will be the same in the long run. Pesaran *et al.* (1999) explained that PMG allows for the estimation of common long-run coefficients without making unreasonable assumptions about the identical dynamics of each cross-section. Furthermore, PMG is appropriate for panel data with more time series than observations (T > N). Equation (6) shows the PMG or panel ARDL (p,q,q,...,q) model:

$$Y_{it} = \sum_{j=1}^{p} \lambda_{ij} Y_{i,t-j} + \sum_{j=1}^{q} \delta`_{ij} X_{i,t-j} + \mu_i + \varepsilon_{it} \quad (6)$$

Where i = 1, 2, 3, ..., n is countries, t = 1, 2, 3, ..., t is time period, X_{it} (k x 1) is a vector of independent variables for country I, λ is the lag coefficient of the dependent variable, δ is the coefficient of k x 1 vector, j denotes lag, μ represents the fixed effects and ε is the error term.

4. Result and Discussion

4.1 Environmental Kuznets Curve (EKC) in ASEAN

The achievement of sustainable development is closely tied to environmental degradation issues. Economic activities often catalyze various environmental problems. The Environmental Kuznets Curve (EKC) suggests that the initial growth in economic indicators tends to worsen CO_2 emission level. However, after reaching a certain point, economic growth is followed by environmental improvement. As indicated in the country-specific plots presented in Fig 2**,** four nations exhibit similarities to the inverted U-shaped EKC namely Singapore, Thailand, Malaysia, dan Indonesia. Therefore, the EKC hypothesis is valid for these countries. The findings are supported the prior studies by Saboori & Sulaiman (2013), Sohag *et al.* (2015), and Sarkodie & Strezov (2019). This implies that an increase in economic growth, facilitated by sustainable technology intensification, in these countries can contribute to a reduction in CO_2 emissions. Furthermore, the adoption of clean technologies by various industries will enhance efficiency, promote sustainable environments, and make the economic system more information-intensive (Narcisse *et al.*, 2023).

However, the Philippines demonstrates a different result that reveals U-shaped EKC curve, indicating a potentially different relationship between economic growth and environmental quality. This suggests that economic development activities in the Philippines have the potential to drive higher CO_2 emission levels. U-shaped EKC can occur when a country is excessively reliant on particular sector leading to higher CO_2 emissions (Wang *et al.,* 2021). This result is plausible that the Philippines is a developing country relatively dependent on manufacturing activities. Therefore, it is imperative for Philippines to transition to environmentally friendly technologies and resources to enhance industrial composition effects**.** Moreover, it is noteworthy that the majority of ASEAN countries remain in the ascending phase of the EKC. It underscores that ASEAN countries have the potential to generate scale effect in driving economic growth, as production activities will demand more at the cost of the environment. The different result of EKC is presumed to be due to differences in economic levels and uneven economic development across each nation.

4.2 Correlation Matrix

This research displays a correlation matrix to identify the potential presence of multicollinearity in the variables used in this study. Gujarati & Porter (2009) explains that one of the detections of multicollinearity can be known if the correlation coefficient value is more than 0.8. Table 3 displays all correlation values between different variables which are less than 0.8, so it can be said that this study avoids multicollinearity problems. Generally, the correlation between the RE variable and GDP per capita shows a positive value, but a different sign of correlation with unemployment and CO_2 emissions in all ASEAN countries.

4.3 Unit-Root Test Result

This study applies unit root tests for panel data, namely LLC, IPS, ADF-Fisher, and PP-Fisher, to see the data stationarity among the variables. The unit root test results can be found in Table 4. The null hypothesis, which there is a unit root, is accepted by most variables, except for GDPC, FDI, and CPI, at level or I(0). In general, we can infer that all the variables exhibit at first-order stationarity or I(1).

Table 3
Matrix Correlation

Variable	GDPC	UNP	lnCO2	REC	FDI	INF	TO
GDPC	1						
UNP	-0.438	1					
lnCO2	-0.169	0.170	1				
REC	0.498	-0.600	-0.488	1			
FDI	0.021	-0.025	-0.180	-0.209	1		
INF	0.102	-0.156	-0.229	0.430	-0.116	1	
TO	-0.154	0.217	0.102	-0.610	0.601	-0.213	1

Table 4
Unit Root Test

Variable	Unit Root Test			
	Level	P-value	1st diff.	P-value
		Levin, Lin & Chu		
GDPC	-1.154	0.124	-10.910***	0.000
UNP	0.455	0.675	-7.545***	0.000
lnCO2	0.899	0.816	-4.403***	0.000
REC	1.956	0.975	-3.442***	0.000
FDI	-1.094	0.137	-9.414***	0.000
INF	-5.678***	0.000	-19.539***	0.000
TO	-0.717	0.237	-12.014***	0.000
		Im, Pesaran and Shin W-stat		
GDPC	-4.660***	0.000	-12.266***	0.000
UNP	-0.405	0.343	-11.846***	0.000
lnCO2	3.848	0.999	-5.8145***	0.000
REC	4.007	1.000	-5.340***	0.000
FDI	-2.501***	0.006	-9.631***	0.000
INF	-4.322***	0.000	-17.272***	0.000
TO	-0.083	0.467	-10.887***	0.000
		ADF-Fisher		
GDPC	67.457***	0.000	158.000***	0.000
UNP	24.066	0.239	161.513***	0.000
lnCO2	5.428	0.999	72.643***	0.000
REC	4.353	0.999	62.606***	0.000
FDI	41.712***	0.003	121.559***	0.000
INF	54.125***	0.000	232.759***	0.000
TO	18.096	0.581	137.728***	0.000
		PP-Fisher		
GDPC	68.711	0.362	219.811***	0.000
UNP	21.613	0.362	132.270***	0.000
lnCO2	25.420	0.186	147.727***	0.000
REC	7.098	0.996	122.711***	0.000
FDI	50.829***	0.000	298.351***	0.000
INF	77.088***	0.000	535.103***	0.000
TO	18.741	0.539	147.575***	0.000

Notes: ***), **), and *) Stationarity at 1%, 5%, and 10% levels, respectively

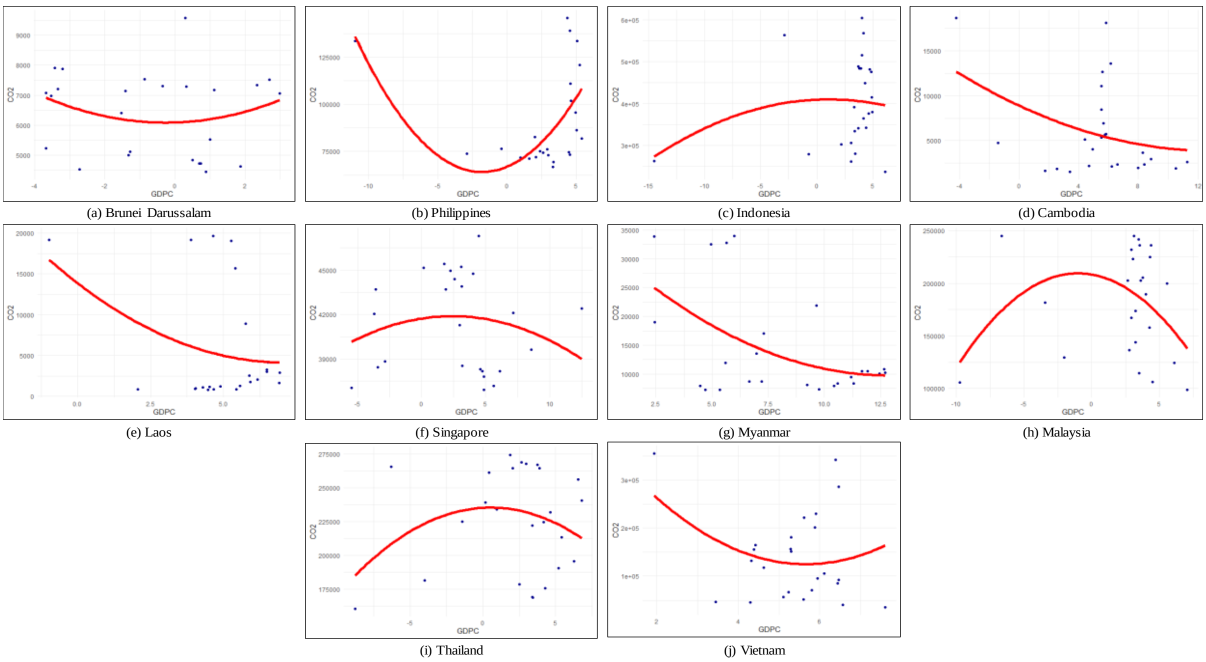

Fig 2. Environmental Kuznets Curve (EKC) by Country

4.4 Cointegration Test

Furthermore, the Johansen-Fisher panel cointegration test is employed to determine the presence of a long-run relationship among the variables (Maddala & Kim, 1999). Table 5 displays the statistical results of the cointegration test of the three models in this study. The cointegration results clearly show that the trace and max-eigen test probability values are below the

Table 5
Fisher Johansen Panel Cointegration Test

Model	No of CE(s)	Trace test	Prob.	Max-eigen test	Prob.
GDPC	At most 2	40.41***	0.004	34.78***	0.021
UNP	At most 2	47.18***	0.001	37.68***	0.010
lnCO2	At most 2	45.51***	0.001	35.42***	0.018

Notes: ***), **), and *) are cointegrated at 1%, 5%, and 10% levels, respectively.

Table 6
Results of Renewable Energy and Economic Aspect of Sustainable Development (GDP per capita)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Long Run Equation				
REC	0.198	0.041	4.847	0.000***
FDI	0.278	0.099	2.790	0.006***
INF	-0.049	0.058	-0.853	0.396
TO	-0.028	0.004	-6.285	0.000***
Short Run Equation				
COINTEQ01	-0.743	0.242	-3.068	0.003***
D(GDPC(-1))	0.167	0.197	0.850	0.397
D(GDPC(-2))	0.215	0.111	1.938	0.056*
D(REC)	20.191	24.283	0.831	0.408
D(REC(-1))	18.917	19.769	0.957	0.341
D(REC(-2))	-16.518	15.139	-1.091	0.278
D(FDI)	0.048	0.077	0.623	0.535
D(FDI(-1))	-0.383	0.191	-2.002	0.048**
D(FDI(-2))	-0.189	0.175	-1.078	0.284
D(INF)	0.181	0.219	0.825	0.411
D(INF(-1))	0.100	0.238	0.420	0.675
D(INF(-2))	0.335	0.190	1.765	0.081*
D(TO)	0.060	0.023	2.610	0.011**
D(TO(-1))	0.006	0.020	0.299	0.766
D(TO(-2))	0.009	0.034	0.258	0.797
C	0.620	1.775	0.349	0.728

Notes: ***), **), and *) are significant at 1%, 5%, and 10% levels, respectively.

5% and 1% significance levels, so it rejects the null hypothesis. Hence, it can be inferred that a cointegration relationship exists among all the models employed in this study.

4.5 Renewable Energy and Economic Aspect of Sustainable Development (GDP per capita)

Table 6 shows the estimation results of the RE impact on GDP per capita as a proxy for the economic aspects of sustainable development. PMG estimates show that there is no impact between RE and GDP per capita in the short run. However, RE shows significantly positive effect on per capita GDP in the long run with a coefficient of 0.198, meaning that an increase of 1% in the usage of RE will raise the growth of GDP per capita in ASEAN countries by 0.198 percent. The study findings align with previous studies of Fotourehchi (2017) which shows that the usage of RE can accelerate long-term economic growth in developing countries. Additionally, the empirical results are also in line with the findings of earlier study with different country objects such as Asia Pacific countries (Zafar *et al.*, 2019), OECD countries (Taşkın *et al.*, 2020), N-11 countries (Xie *et al.*, 2023), and developing countries (Syzdykova *et al.*, 2020).

Our results imply that RE requires special attention from ASEAN governments as it has the potential to play a pivotal role of achieving sustainable economic development. In addition, the resilience of the RE sector has demonstrated its durability during the challenges posed by Covid-19 pandemic. The report of ASEAN Energy in 2020 stated that the RE sector was quite resilient during the Covid-19 pandemic. The total share of RE increased by 1.4 percent from 2019 to 2020. However, it is noteworthy that the share of RE in the ASEAN region is still relatively small, reaching only 18.8 percent in 2020 and far below the proportion of non-RE, which reached 81.2 percent. Therefore, it is imperative to accelerate efforts in transitioning to RE sources to achieve the target of 23 percent RE share and 35 percent installed RE capacity by 2025 in ASEAN (Kresnawan & Beni, 2022).

Efforts to accelerate the energy transition can be made with a strategy that includes increasing investment in the RE sector. Our research results show that foreign direct investment has a positive effect on the level of GDP per capita. This finding implies that foreign investment inflows need to be effectively directed towards strengthening the capacity of the RE sector. Based on the 2020 Southeast Asia Energy Outlook Report, the average energy investment in ASEAN from 2016 to 2020 is around 70 billion USD, but the clean energy category is below 30 billion USD. Moreover, spending on solar PV and wind energy is only US$10 billion, the lowest globally and only above countries in sub-Saharan Africa. Thus, ASEAN countries need to boost their investments in the RE sector to achieve a cleaner and more sustainable energy transition.

4.6 Renewable Energy and Social Aspect of Sustainable Development (Unemployment)

Table 7 displays the PMG estimation results between RE and the unemployment rate as a proxy for the social dimension of sustainable development. The impact of RE exhibits positive significantly on the unemployment rate in ASEAN countries, with a coefficient of 0.086. An increase in the usage of RE by 1 percent will lead an increase in the unemployment rate by 0.086 percent. The result of this study is supported by the prior findings of Saboori *et al.* (2022) that the RE use has an anti-labor creation effect. The findings imply that the energy transition

Table 7
Results of Renewable Energy and Social Aspect of Sustainable Development (Unemployment)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Long Run Equation				
REC	0.086	0.014	6.341	0.000***
FDI	-0.065	0.134	-0.488	0.627
INF	-0.173	0.036	-4.768	0.000***
TO	0.110	0.025	4.367	0.000***
Short Run Equation				
COINTEQ01	-0.062	0.053	-1.189	0.238
D(UNP(-1))	0.026	0.218	0.122	0.903
D(UNP(-2))	-0.490	0.228	-2.150	0.034**
D(REC)	2.348	1.489	1.576	0.119
D(REC(-1))	3.436	3.684	0.933	0.354
D(REC(-2))	-0.817	0.688	-1.187	0.239
D(FDI)	0.006	0.0161	0.360	0.720
D(FDI(-1))	-0.028	0.030	-0.924	0.358
D(FDI(-2))	-0.027	0.031	-0.868	0.388
D(INF)	-0.039	0.058	-0.674	0.502
D(INF(-1))	0.006	0.040	0.154	0.878
D(INF(-2))	-0.086	0.074	-1.162	0.248
D(TO)	0.002	0.007	0.306	0.760
D(TO(-1))	-0.005	0.003	-1.595	0.114
D(TO(-2))	0.003	0.005	0.608	0.545
C	-0.328	0.274	-1.197	0.234

Notes: ***), **), and *) are significant at 1%, 5%, and 10% levels, respectively.

may lead to relocation and structural changes potentially in the labor market, so there are workers who must be eliminated, especially novice workers in the RE sector. Conversely, this study has different results than prior study of Khobai *et al.* (2020), who demonstrated a negative long-term relationship between RE consumption and unemployment in South Africa.

ILO (2018) has predicted that a transition to a green economy, including the use of renewable energy, has the potential to create 24 million of new jobs, but 6 million jobs will be lost. ASEAN has great potential to provide potential labour during the green economy transition where the productive age (20-59) dominates the population structure of ASEAN countries reaching more than 50% (ASEAN, 2020). However, the majority of the workforce in ASEAN countries still predominantly comprises primary education, accounting for approximately 40%. The highest proportion is observed in the lower and middle income nations such as Vietnam, Philippines, and Myanmar (Bayudan-Dacuycuy & Lanzona, 2023).

The incapacity of ASEAN countries to provide the necessary workforce in the green economy transition can lead to inequality in employment opportunities and drive up unemployment. The report on policy readiness for green jobs in ASEAN reveals that the majority of ASEAN countries lack an active labor market policy framework to facilitate the green economy transition. Of the 12 policy areas observed, only the Philippines and Singapore succeeded in integrating these policy elements into the green economy transition policy framework (ILO, 2021). This situation underscores the imperative for ASEAN countries to undertake a comprehensive analysis of the labor market, identifying the required skill and potential job opportunities within the green sector.

Furthermore, The effect of the energy transition on the workforce will largely depend on the structure of the economy, industry sectors, competencies, and available policies. Yılancı *et al* (2020) provide evidence that countries invest largely in the sources of RE and R&D, such as Germany, France, and Japan, will encourage the creation of employment in the sector of RE. The presence of investment will play an important role in driving a positive RE transition for job creation. Furthermore, policy support for RE, such as tax amnesty, production incentives, and special tariffs, will promote job creation during the transition of energy (Strunz *et al.*, 2016).

It is acknowledged that the RE transition is in need of a higher skill set and multidisciplinary, so expertise in diverse fields such as technology, information, and communication, will be indispensable. Malaysia, Singapore, and the Philippines have already established policy frameworks to promote skill development in the green energy transition. In Malaysia, 11th Malaysia plan has identified new necessities, capacities and competencies of green skills for both the public and private sectors. Philippines has outlined employment outcomes through several programs such as the public utility jeepney (PUJ) modernisation program, the National Organic agricultural program, and the Anahaw-Philippine Sustainable Tourism Certification. Meanwhile, Singapore initiated Environmental Services Industry Transformation Map (ITM) which one of its primary objectives is to build a resilient and competent workforce.

However, restricted access and the need to acquire the necessary skills in the RE sector is the challenge for ASEAN countries (Bilqis *et al.*, 2023). In addressing the challenge, It is imperative for ASEAN countries to implement comprehensive strategies. This includes investing in educational programs and vocational training to enhance the skill sets of their workforce. Various stakeholders, including policymakers, companies, educational institutions, and other stakeholders, must collaboratively provide training programs that involve formal and on-the-job training in the RE sector. Initiatives like knowledge-sharing platforms and cross-sector partnerships can play a pivotal role in overcoming the obstacles associated with the RE transition. Then, the collaboration between ASEAN nations and experienced countries in implementing RE sources, such as European countries, may hold the potential for mutual benefit. The collaborative effort signifies the potential transfer of valuable knowledge and skills which are subsequently adapted to local project development.

Table 8
Results of Renewable Energy and Environmental Aspect of Sustainable Development (CO_2 Emissions)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Long Run Equation				
REC	-0.031	0.001	-31.616	0.000***
FDI	0.031	0.008	3.967	0.000***
INF	-0.026	0.003	-9.440	0.000***
TO	0.018	0.001	16.587	0.000***
Short Run Equation				
COINTEQ01	-0.167	0.086	-1.946	0.055*
D(LNEMIS(-1))	-0.065	0.208	-0.311	0.757
D(LNEMIS(-2))	-0.080	0.127	-0.627	0.532
D(REC)	0.330	0.382	0.864	0.390
D(REC(-1))	0.900	0.929	0.968	0.336
D(REC(-2))	0.136	0.179	0.762	0.448
D(FDI)	-0.010	0.006	-1.695	0.094*
D(FDI(-1))	-0.009	0.004	-2.135	0.036**
D(FDI(-2))	0.001	0.005	0.176	0.860
D(INF)	0.0117	0.004	2.959	0.004***
D(INF(-1))	0.005	0.003	1.519	0.132
D(INF(-2))	0.002	0.002	1.194	0.236
D(TO)	-0.001	0.001	-0.492	0.624
D(TO(-1))	-0.001	0.001	-0.961	0.339
D(TO(-2))	-0.002	0.001	-1.775	0.079*
C	1.925	1.119	1.720	0.089*

Notes: ***), **), and *) are significant at 1%, 5%, and 10% levels, respectively

4.7 Renewable Energy and Environmental Aspect of Sustainable Development (CO_2 Emissions)

Table 8 depicts the findings of PMG estimation, which examines the nexus between RE and CO_2 emissions as a proxy for the environmental aspects of sustainable development. in the short term, RE does not exhibit effect on CO_2 emissions. However, an intriguing result is shown in long term that RE has significant negative impact on CO_2 emissions, with the magnitude of coefficients 0.031. This suggests that an increase of 1% in RE usage will lead to a 0.031 percent reduction in CO_2 emissions. This finding aligns with prior research by Susilowati *et al.* (2023), demonstrating that RE consumption can lead to a decrease in CO_2 emissions. In addition, our results are also in line with several empirical studies in various countries in strengthening the role of RE use to reduce CO_2 emissions such as Indonesia (Sasana & Putri, 2018), Azerbaijan (Mukhtarov *et al.*, 2022), European Union countries (Busu & Nedelcu, 2021), developed countries (Rahman *et al.*, 2022), and Pacific (Aimon *et al.*, 2023).

ASEAN is currently facing significant challenges in CO_2 emissions production. The trend of CO_2 emissions resulting from energy consumption in ASEAN has consistently risen over the past two decades, with the energy sector being the largest contributor (ASEAN, 2021). In the Paris Agreement process, it was projected that GHG emissions in ASEAN would increase from 2,200 $MtCO_2e$ in 2015 to 3,700 $MtCO_2e$ by 2030. Meanwhile, assessments by Paltsev *et al.* (2018) based on the baseline emission scenario for ASEAN paint a picture that by 2030, there will be an emissions gap of 400 $MtCO_2$ (unconditional target) and 900 $MtCO_2$ (conditional target). Consequently, ASEAN is obligated to reduce emissions by 11% and 24% based on those targets respectively.

As the primary contributors to CO_2 emissions, the energy and power sectors need to undergo a swift transformation during the energy transition. It is crucial to implement a more efficient energy transformation by restricting the use of fossil fuels, decarbonizing electricity, and increasing the utilization of RE sources. Then, our empirical results show that augmenting the proportion of RE while reducing the consumption of non-RE, such as fossil energy, will reduce CO_2 emissions. As part of the energy generation process, the usage of RE, namely wind power and solar, does not produce CO_2 emissions due to the fact that the energy sources are harnessed from natural element such as the sun and the weather. In more detail, Mukhtarov *et al.* (2022) explained that efforts to reduce emission figures through RE consumption can be understood through the approach of substitution effects. It implies that within this framework, RE will be allocated to fulfil some parts of the energy demand, thereby leading to a substitution and displacement of the usage on non-RE sources. Consequently, a diminished usage of non-RE will result in reduction in CO_2 emissions.

The importance of utilizing RE is reinforced by the potential that ASEAN is currently experiencing rapid growth in its energy and electricity consumption. ASEAN's energy consumption is projected to grow by approximately 80%, while electricity usage is expected to reach 115% during the period from 2015 to 2030 (Paltsev et al., 2018). Indonesia, Thailand, Vietnam, Malaysia, and the Philippines are set to contribute significantly to the total energy and electricity consumption expected to reach 93% by the year 2030. The surge in the use of renewable energy sources such as wind, solar, biomass, and hydro will be crucial to meet the substantial energy and electricity demands in ASEAN. This transition to renewable energy sources aligns with the imperative to address the challenges posed by rising CO_2 emissions in the region.

4.8 Stability Test

In this research, the Cumulative Sum (CUSUM) and Cumulative Sum of Squares (CUSUMSQ) tests are employed to examine the stability and consistency of parameters in the model (Marimuthu *et al.*, 2021). The CUSUM and CUSUMQ tests can help to detect the stability of long-term parameters and structural changes in each cross-section along with short-term changes. Fig 3 shows the results of the CUSUM and CUSUMSQ tests of each country for economic aspect model. The results re veal that the mean trends fall within the critical bounds at a 5% significance level, signifying the stability of the parameter of the estimation of economic aspect model. The empirical finding reveals that RE can escalate GDP per capita in the long run is reliable. However, considering the mean values deviating from

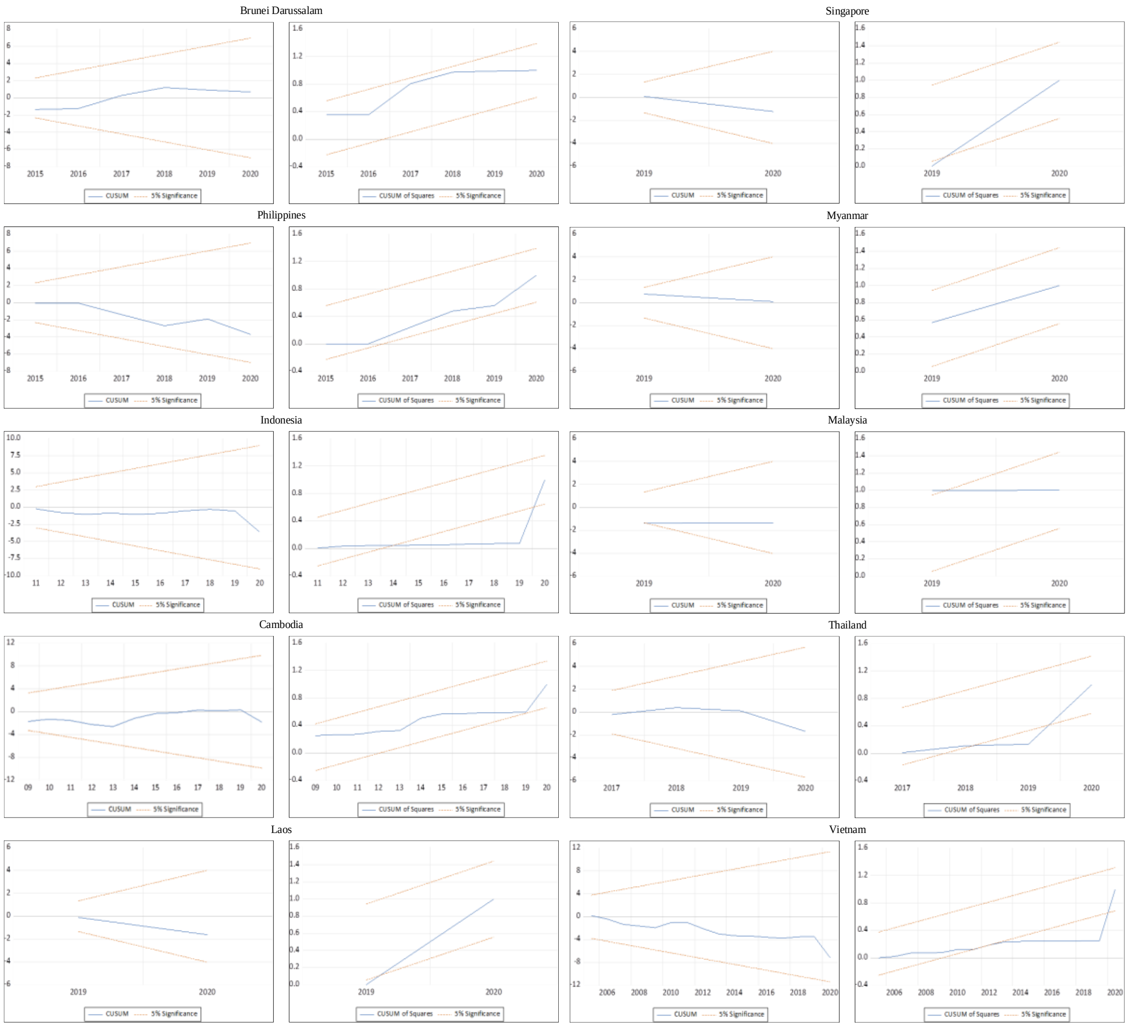

Fig 3. Cumulative Sum and Cumulative Squares (CUSUM and CUSUMSQ) Graph for Structural Breaks of the Panel Members for Economic Aspect Model

the critical bounds in CUSUMSQ suggests structural changes in Indonesia, Thailand, and Vietnam, particularly noticeable after the period of 2013-2014.

The results of the CUSUM and CUSUMSQ tests of social aspects model are presented in Fig 4. The analysis reveals that the mean trends consistently are situated within the critical bounds at a 5% significance level. This observation signifies the stability of the parameter estimates in the social aspect model. The empirical evidence suggests that the impact of RE on leading higher unemployment in the long run is robust and consistent. Additionally, Fig 5 presents the outcomes of the CUSUM and CUSUMSQ tests for each country in the context of

Table 9
Robustness Estimation of 3 Models

Variable	GDPC		UNP		lnCO2	
	Coeff.	t-Statistic (Prob.)	Coeff.	t-Statistic (Prob.)	Coeff.	t-Statistic (Prob.)
Constant	-1.619	-0.889 (0.375)	1.362	3.288 (0.001)***	12.755	92.852 (0.000)***
REC	0.081	2.670 (0.008)***	0.024	3.438 (0.0001)***	-0.062	-27.293 (0.000)***
FDI	0.084	1.333 (0.184)	-0.033	-2.323 (0.021)**	-0.002	-0.439 (0.661)
INF	-0.062	-3.037 (0.002)***	-0.007	-1.529 (0.128)	-0.000	-0.187 (0.852)
TO	0.021	2.215 (0.028)**	0.009	4.262 (0.000)***	-0.000	-0.256 (0.798)
F-statistic		10.910		135.270		1031.825
Adj. R-Sq		0.341		0.875		0.982
Obs	250		250		250	

Notes: ***), **), and *) are significant at 1%, 5%, and 10% levels, respectively.

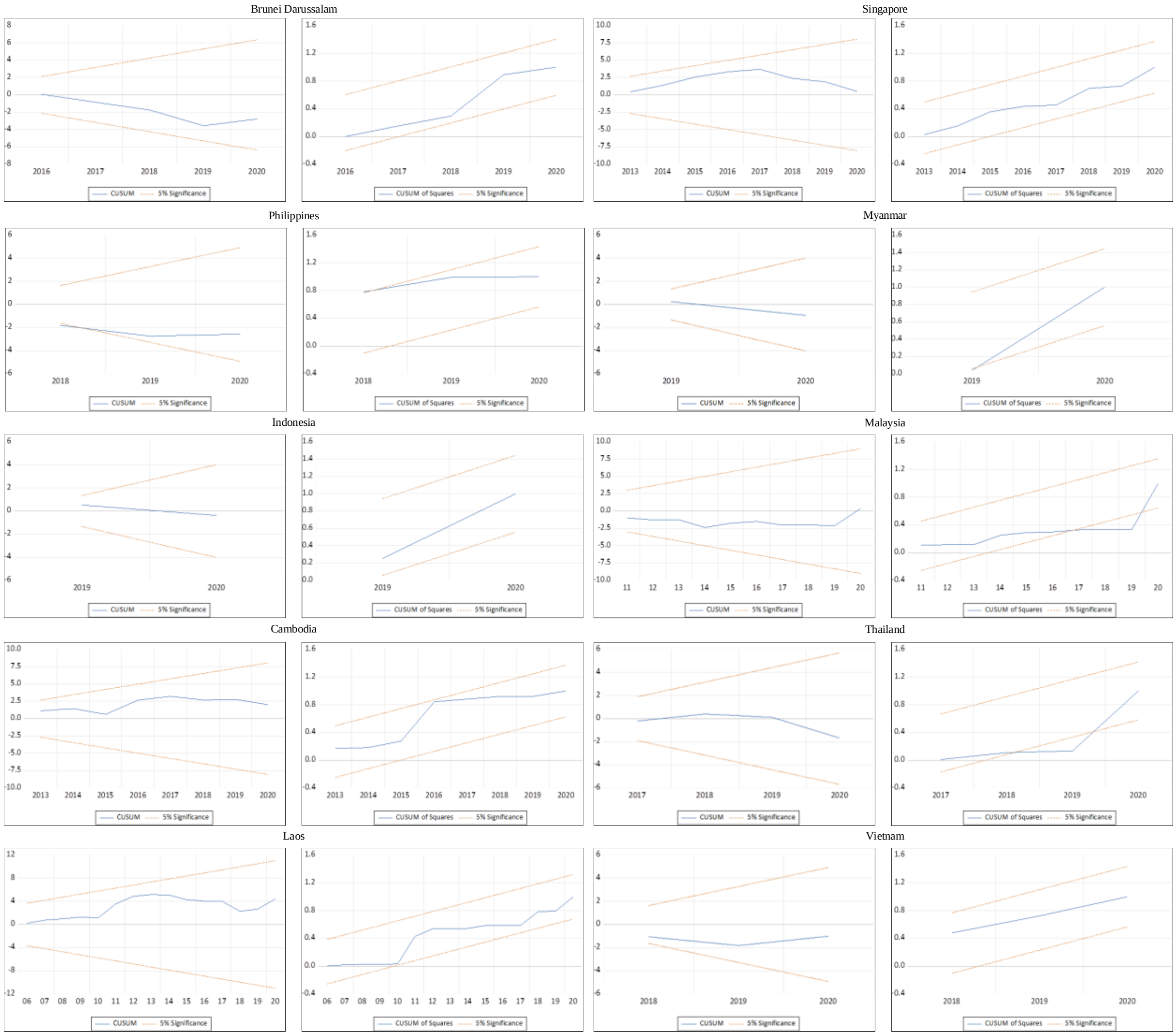

Fig 4. Cumulative Sum and Cumulative Squares (CUSUM and CUSUMSQ) Graph for Structural Breaks of the Panel Members for Social Aspect Model

the CO_2 emission model. The results demonstrate that the mean trends constantly lie within the critical bounds at a 5% significance level, indicating the stability of the parameter estimation for the CO_2 emission model. The empirical evidence further supports the reliability of the assertion that RE has a potential long-term impact on reducing CO_2 emission. All these results satisfy stable conditions in the ARDL model. Therefore, we can conclude that the parameters of each model in this study are stable throughout the ASEAN panel and study period.

4.9 Robustness Test

To confirm the robustness of the findings in this research, we try to estimate our model using a fixed effect model. The analysis results presented in Table 9 show no difference from the previous estimation for the significance of the effect between the RE consumption variable and the three dependent variables as proxies for sustainable development, namely GDP per capita, unemployment rate, and CO_2 emissions. Overall, the sign of influence of the control variables exhibits no statistically significant difference when compared to the previous estimation results. The findings underscore the robustness of the model employed in this study, which consistently generates reliable estimates.

In the analysis shown in Table 9, the second and third columns display the outcomes of the GDP per capita model estimation as the dependent variable by applying the fixed effect approach. Notably, it shows the statistically significant positive impact of RE consumption with a coefficient of 0.081. Furthermore, the second model, investigating the effect of RE consumption on unemployment rate, exhibits a significant positive result with a coefficient of 0.024. Finally, the third mod el estimation points out that RE consumption affects CO_2 emissions negatively significant. These findings align with the long-term PMG estimation results in this study.

5. Conclusion

5.1 Conclusion

The energy transition is not only aimed at reducing negative externalities on the environment, but also needs to be directed to influence social and economic aspects to achieve sustainable development. This research aims to investigate the impact of RE on economic, social, and environmental factors of sustainable development, reflected by three variables: GDP per capita, unemployment rate, and CO_2 emissions. We use panel data from AS EAN countries over the period 1996-2020. We employ

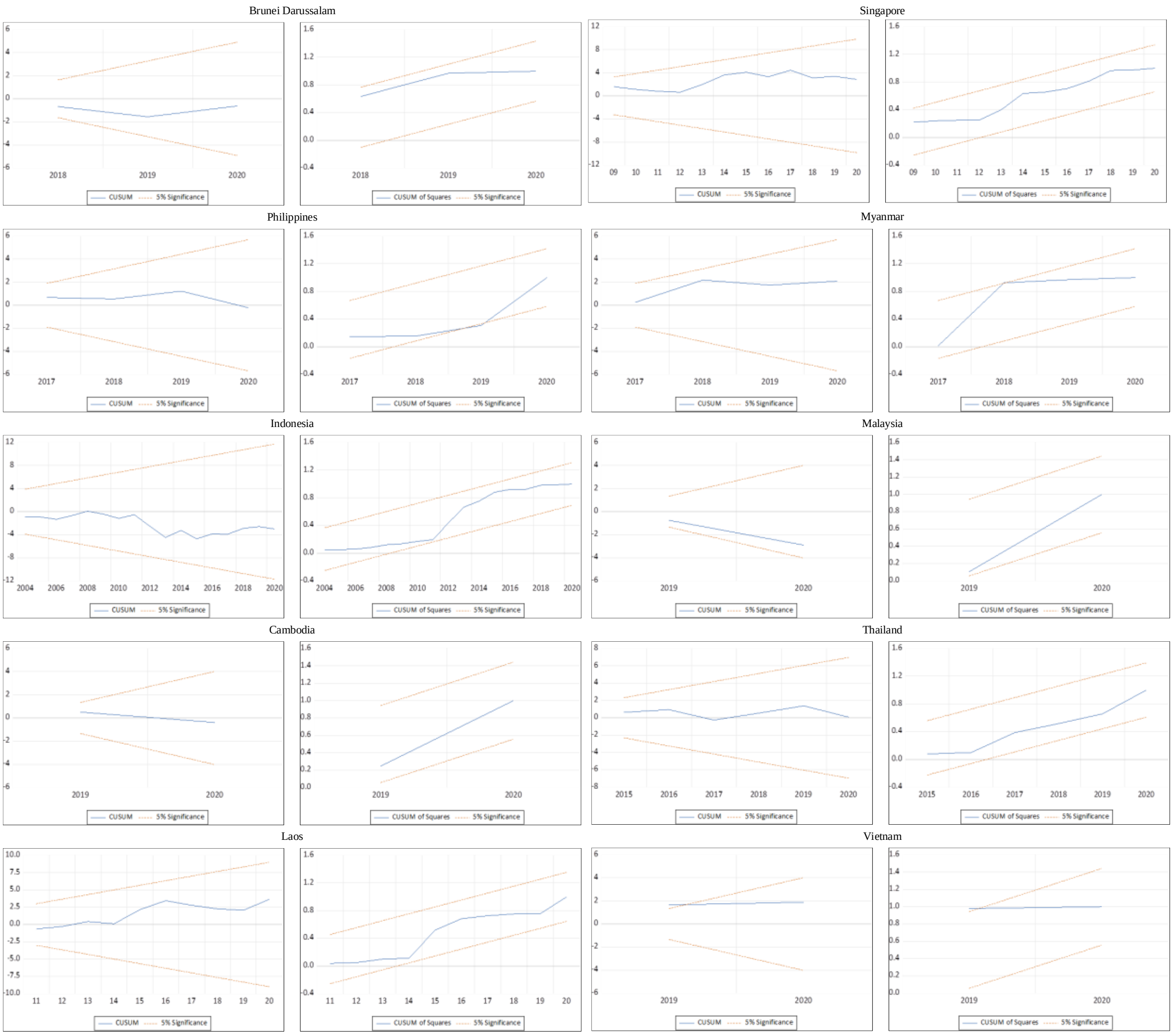

Fig 5. Cumulative Sum and Cumulative Squares (CUSUM and CUSUMSQ) Graph for Structural Breaks of the Panel Members for Environmental Aspect Model

the Pooled Mean Group (PMG) estimation to assess the relationships between RE and these three dimensions of sustainable development.

Based on the identification of the EKC hypothesis, four countries, namely Singapore, Thailand, Malaysia, and Indonesia, validate an inverted U-shaped curve where the economic growth tends to lead the better environmental quality. However, Philippines exhibits a U-shaped curve, indicating a potential risk of higher CO_2 emissions from economic development. This highlights the need for the Philippines to transition to eco-friendly technologies. furthermore, the majority of ASEAN countries are in the early stages of the EKC, suggesting the potential for increased environmental degradation as they pursue economic growth.

The results of PMG estimation confirm the pivotal role of energy transition on sustainable development in ASEAN.In more detail, the RE transition can drive GDP per capita levels in the long run, indicating that RE can be one of ASEAN's economic growth accelerators. It requires efforts to augment the proportion of the usage of RE, which has demonstrated resilience in the face of the Covid-19 pandemic. Furthermore, the statistical estimates suggest that the long-term effect of RE use can result in a reduction of CO_2 emissions, although this effect is found statistically insignificant in the short-term Environmental quality can be enhanced by increasing the share of RE usage. Efforts to reduce CO_2 emissions through RE consumption can be recognized from the substitution effect mechanism.

Nevertheless, this study implies that the energy transition can potentially raise unemployment rates in ASEAN countries in the long term. The adverse effect of the transition of energy on unemployment can be mitigated by preparing the labor force with the requisite skill sets in the technology and RE sector.

This research, however, exhibits various limitations that warrant consideration. Firstly, the energy transition is solely proxied by renewable energy variable. Therefore, future studies can employ other energy transition variables to get a more holistic perspective. Secondly, this research does not explore the technological dimension of RE sources in specific way. In this regard, future studies may delve the technological aspects to a comprehensive understanding of energy transition. Lastly, given the diverse developmental statuses of ASEAN countries, it would be intriguing to conduct future studies focus on developed and developing countries comparatively.

5.2 Policy Implications

This study indicates that the use of RE needs to be continuously increased and supported through appropriate policy frameworks, especially in encouraging more investment in RE infrastructure and preparing a competent workforce in the sector. Thus, ASEAN countries can achieve sustainable development through RE transition, which involves sustainable economic growth, CO_2 emission reduction, and unemployment rate control. Specifically, we try to provide some recommendations that can be useful for policymakers:

1. In the context of energy use, increasing the efficiency of using non-RE sources is a wise step that can be taken to reduce CO_2 emissions. However, to achieve significant emission reductions, the RE use must be a top priority. Efforts to improve the percentage of RE use in the energy mix can be successful if inclusive measures are implemented, such as making it a public commodity, regulating prices to make it more affordable, and providing appropriate subsidies or incentives.
2. There is a need to increase investment rates, particularly in developing RE technologies. Large and sustainable investments rely heavily on investor confidence. Therefore, a clear, transparent, and fair regulatory framework is needed to provide certainty to investors. In addition, the regulations implemented can minimize risks and provide adequate incentives. This can be achieved by simplifying planning, licensing, and regulatory processes and providing data and information that support such investments.
3. The government also needs to prepare the workforce for the changes in the labor market structure during the energy transition. Appropriate regulations and relevant curricula need to be prepared to equip the domestic workforce with the necessary skills and knowledge in the sector of RE. This attempts to reduce the potential increase in unemployment due to changes in the labor market structure associated with the energy transition.

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