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An Econometric Analysis of the Causes of Environmental Degradation in Developing Countries

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ABSTRACT

Globally, efforts are being made to achieve ecological sustainability while reducing pollution's environmental impact. This study aims to analyze the links between many variables, such as GDP growth, green finance, consumption of renewable energy, natural resource rent, technological innovation in the energy sector, urbanization, and pollution, using panel data spanning 1998 to 2021. This investigation used an innovative approach to econometrics known as CS-ARDL to investigate the short-term and long-term relationships between the series. According to the results, economic growth, the monetization of natural resources, and urbanization all lead to pollution. The findings of this study, on the other hand, demonstrated that encouraging energy innovation, green funding, and using renewable energy are all realistic strategies for reducing the number of pollutants released into the environment. This study contributes to the existing body of research by examining the factors that lead to environmental pollution from the point of view of ASEAN economies. This research is a reference for governments and policymakers when selecting how much money to invest in environmentally friendly technologies to extract natural resources from these countries to have a less negative environmental effect.

Keywords: Energy Transition; Sustainable Economy; Natural resource rent; Renewable energy

1.0 INTRODUCTION

Several areas of innovation research have increased their attention to the topic of revolutionary shifts in recent years. This article examines the overlap between innovation studies (IS), social innovation (SI), and sustainability transitions (ST) research to shed light on how societies undergo goal-oriented, transformational change (GOTC). The "normative" or "strategic" shift in innovation policy has provided the framework for emphasizing transformative change. Since these three disciplines of innovation study have arisen simultaneously and independently at various points throughout history, they may offer complimentary foundations for an integrated approach to understanding better transformation processes (Choi et al., 2014).

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There has been much talk about the differences between transformation and transition, as this article uses "goal-oriented transformative change in society" to describe societal shifts motivated by the need to address pressing social problems (Tian et al., 2021). This term is broad enough to include several ways of thinking about transition and the multiple ends that innovations and transformations aim to achieve. Prioritizing economic development above other aims like sustainability, social justice, or protecting the environment is a mistake, as it treats such goals as given in other schools of thought (Ali et al., 2022). Climate change and emissions of greenhouse gases are global environmental problems. Rising worries about global warming and climate change due to carbon dioxide emissions (CO2) directly result from the worsening environmental situation. Modernization, deforestation, and the rising need for food security due to a growing global population have all been blamed by some experts for these environmental problems. The theory behind this study is that developing nations worldwide, including the economies of Indonesia, Thailand, Malaysia, and Singapore (ASEAN), have a vested interest in improving environmental quality (Cambini et al., 2020).

The electrical industry cannot continue "business as usual" without hitting roadblocks. There is increasing societal and regulatory pressure on businesses to improve society and reduce their environmental impact while still creating "sustainable" profit. Companies need to detail the risks that climate change poses to their operations and how they contribute to deteriorating environmental, economic, and social conditions (Li et al., 2016; Mohsin et al., 2021). Growing distributed energy technologies and rising citizen agencies to play a "prosumer" role are putting strain on established corporate models in the energy industry. This allows companies to incorporate eco-friendly practices into their daily operations, product creation, and client services. This may include modifying the current energy infrastructure and developing new technology and services to ease the shift to clean energy (Ofori et al., 2023).

Efforts are being made to ensure the Paris Agreement is linked to national targets for cutting carbon emissions. All countries are encouraged to preserve their ecological values while decreasing their overall energy use due to these global environmental policy measures, regardless of their affluence. This research argued that the government and stakeholders would benefit from adopting policies and ways to address these difficulties if they had a better knowledge of the dynamic link between these variables that impact environmental quality (Geddes et al., 2018; Cambini et al., 2020). Researchers have paid a great deal of theoretical attention to the environment Kuznets curve (EKC), which asserts that the pursuit of economic development (ECG) impacts environmental quality. New evidence lends confidence to the EKC theory, suggesting that increased economic growth may slow the pace of environmental decline. It was emphasized that identifying trade-offs between sustainable growth and environmental effects is becoming more difficult due to vast industrial expansion and dependence on the supply of fossil fuels (Tian et al., 2021). Non-renewable energy sources, which produce greenhouse gases, are used to power the grid and satisfy this assumption. Renewable energy use (REU)has contributed significantly to the economic growth of the vast majority of countries. REU is a practical strategy for achieving environmental protection and sustainable growth. This is why it is so important to investigate the correlation between REUs and environmental pollution (EVPs) in ASEAN countries (Deng et al., 2019). The best way to resolve the tension between green finance (GFN) and carbon emissions is a hotly debated subject among ecologists. Investment in GFN is said to be environmentally friendly. GFN equips private investors to fill the void caused by inadequate government investment in environmental initiatives. Further, tackling EVP requires attention to energy innovation (ENI). This research was undertaken because there is a need for further information on how ENI impacts EVP in these countries (Shahbaz et al., 2018; Ahmad et al., 2019).

Natural Resource Rent (NRR) may also affect the state of the ecosystem. Countries rich in natural resources are thought to advance more rapidly. Despite having abundant natural resources, certain nations have yet to make considerable economic progress. Natural resource dependence on GDP growth is an old economic theory. Hence, many experts and policymakers have made it their mission to update it. For instance, current studies suggest that industrialization and economic growth may negatively impact the environment due to the overexploitation of NRR. Academics, policymakers, and governments are concerned about the environmental impacts of urbanization (URB) activities.

This study fills a void in the literature by examining this connection between the nations (Riley et al., 2020). The discussion up to this point has shown that REU, EGC, GFN, NRR, ENI, and URB each have their distinctive impacts on EVP. ASEAN countries are exposed to a greater variety of EVP hazards in today's world, which compels these countries to put in place the required countermeasures. Therefore, the current research may help governments, institutions, policymakers, and organizations, particularly in the ASEAN countries, pursue more relevant, effective, and practical environmental safety efforts. This study provides new details that contribute to established knowledge in many ways.

1. Firstly, the complex relationship between pollution, economic expansion, and the utilization of renewable energy in the ASEAN region is investigated.
2. Secondly, the study's authors claim it will be the first of its kind to look at topics like "green finance," "resource rent," "energy innovation," "urbanization," and "environmental degradation" in emerging markets like the ASEAN countries.
3. This study employed a cutting-edge, generational cross-sectional dependence (CSD) test built using estimation processes. In addition, we estimated both the short- and long-term estimators using the novel cross-sectional-augmented autoregressive distributed lag (CS-ARDL) technique. This work used the fully modified ordinary least squares (FMOLS) robustness check methodology, in addition to the augmented mean group (AMG) and common correlated effect means group estimator (CC-MG) methods, to guarantee the accuracy of the CS-ARDL. Granger causality, a unique method for analyzing these kinds of interactions, was used to assess the quality of these relationships.
4. Lastly, we contribute by extending the applicability of the EKC theory to the ASEAN nations. Since the ASEAN nations are still under development, we looked into testing the hypothesis there. Increasing prosperity and consumer spending have the potential to improve environmental conditions, the EKC hypothesis suggests, once a developing economy begins to thrive.

The remainder of the essay is structured as follows, based on the above introduction: Section 3 details the research design, data, and empirical model, Section 4 discusses the findings, and Section 5 offers a summary and policy implications.

2.0 METHODOLOGY

It is the central premise of the EKC hypothesis that an increase in economic development (ECG) in a given area would inevitably lead to a decline in that area's environmental quality. Most nations see a surge in EVP during the early phases of growth before it levels out, as predicted by the U-shaped link between EVP and EGC. Since fostering economic growth often entails using a wide range of resources to enhance economic operations, EGC and EVP are intimately linked. The EKC implies that ECG degrades environmental quality and argues that protecting the environment would reduce environmental damage and pollution. The evidence for EKC and the correlation between rising levels of EVP pollution and rising economies has been extensively documented in scholarly publications over the last several decades. Based on this thinking, we predict EGC will be negative when accounting for EVP in ASEAN nations.

This study's findings support the idea that REU might help to reduce environmental pollution (Bracco et al., 2018). Experts in environmental protection agree that renewable energy uses (REUs), including biofuel, wind, hydropower and biomass, are superior to more conventional energy sources like fossil fuel. It shows the potential influence of improved REU efficiency on a country's EVP. Because of this inverse relationship between REU and EVP, we predict that REU will be positive in the economies we are looking at. Most nations' sustainability programs rely on the Green Finance Network (GFN), founded on the same three concepts that EGC and GFN share. This is our conceptual contribution to improving ecological conditions (Ahmad et al., 2019). It presents an example of the three GFN ideas that improve environmental circumstances, and we argue that they are sufficient mechanisms to prevent environmental degradation. GFN has gained prominence as the EVP of ASEAN nations has increased. Since ENI is> 0, the results of this research suggest that GFN has a negative correlation with EVP. According to recent research, ENI is crucial for fostering green technology innovation and uptake inside businesses. So, ecologists have proposed ENI as a method to improve our ecosystem.

This research anticipates an inverse association between ENI and EVP, with ENI> 0. Excessive NRR use has negative consequences for the natural world. NRR satisfies the need for natural resources while providing a greener energy alternative. As a result of rapid economic development, many nations have begun to utilize their NRR resources inefficiently, leading to widespread deforestation and increased pests and diseases (Ahmad et al., 2019). Therefore, in this study, expanding NRR deployments without adequate planning may raise EVP in ASEAN economies. Therefore, we anticipate an NRREVP positive interaction with an NRR below =0. Residential, vehicular, and industrial sources of pollution may all increase in a URB. Suppose the URB bit is less than 0. In that case, we expect the URB method to raise significant concerns, such as increased energy consumption, transportation emissions, and household trash, increasing the EVP. The econometric strategy used in this investigation is formally described by equation (1), based on prior studies and the theoretical explanation of EKC.

$$\mathrm{EVP}^{\mathrm{it}} = \mathrm{f}(\mathrm{EGC}^{\mathrm{it}}, \mathrm{REU}^{\mathrm{it}}, \mathrm{GFN}^{\mathrm{it}}, \mathrm{ENI}^{\mathrm{it}}, \mathrm{NRR}^{\mathrm{it}}, \mathrm{URB}^{\mathrm{it}}) \qquad (1)$$

The chosen variables were transformed into the natural logarithm to improve distribution and readability throughout the data set. Reducing heteroskedasticity and autocorrelation, the series was modified using the natural logarithm. The log-linear equation (2)

$$\mathrm{InEVP}^{\mathrm{it}} = \psi_0 + \psi_1\mathrm{InEGC}^{\mathrm{it}} + \psi_2\mathrm{InREU}^{\mathrm{it}} + \psi_3\mathrm{InGFN}^{\mathrm{it}} + \psi_4\mathrm{InENI}^{\mathrm{it}} + \psi_5\mathrm{InNRR}^{\mathrm{it}} + \psi_6\mathrm{InURB}^{\mathrm{it}} + \varepsilon^{\mathrm{it}} (2)$$

The following ψ_1 ψ_2 ψ_3 ψ_4 ψ_5 andψ_6 are the coefficients for urbanization, energy innovation, economic growth, natural resource rent, and renewable energy utilization; 1, 2, 3, 4, 5, 6. Furthermore, I and t represent the countries and the period (1990-2020) researched, respectively. Represent the natural logarithm of the series, 0 represents the model's constant, and the model's error terms. The EVP, EGC, REU, URB, and NRR panels' data was utilized in this study. Both GFN and ENI data were collected. In Table 1, you will find a list of the chosen variables and their respective units of measurement, symbols, and data sources.

Table 1: The variables and their descriptions

Variable	Symbol	Description	Source
Environmental Pollution	EVP	Kilotons of carbon dioxide (kt) –Emission	WDI
Renewable Energy Use	REU	Consumption of Energy (in Kilograms of Oil Equivalent)	WDI
Economic Growth	EGG	Average Annual Income (USD 2,010)	WDI
Green Finance	GFN	Homemade items for protecting the environment	OECD
Energy Innovation	ENI	Environmental technology patents	OECD
Natural Resources Rent	NPR	Gross Domestic Product as a Percentage of Revenue from Natural Resources	WDI
Urbanization	URB	City dwellers as a share of the overall population.	WDI

2.1 Descriptive statistical information

Using panel data from 1998 to 2021, Table 2 gives statistically descriptive profiles of ASEAN nations. The data's standard deviation, median, and mean are shown. The standard deviation of the variables in this study is relatively large. In statistics, EVP, REU, EGC, NRR, GFN, ENI, and URB often have values of 0.751, 0.597, 0.721, 0.487.0, and 0.427. The statistics show the most significant mean values for EVP and EGC (Khan, 2019). Kurtosis, Jarque-Bera, and probability tests were used to check for data normality. According to Table 2, the data set we used for our analysis shows much volatility since the sample we used is not normally distributed. Table 2 also includes evaluation data from the correlation matrix, demonstrating that all series are tangentially related to environmental pollution. Patterns throughout different periods are compared and contrasted.

Table 2 summarizes these descriptive statistics

Statistics	EVP	REU	EG G	NPR	GFN	ENI	URB
Mean	1.666	7.444	9.342	2.148	5.143	3.284	19.034
Median	1.874	7.776	9.418	2.598	5.372	3.227	19.047
Maximum	2.678	8.522	8.396	4.458	5.599	4.704	19.881
Minimum	−1.7334	5.207	8.255	−2.968	3.898	1.842	18.157
Std. Dev.	1.752	1.598	1.722	1.488	1.488	1.603	1.428
Skewness	−1.418	−1.943	−1.091	−1.632	−2.026	1.097	−1.102
Kurtosis	2.627	3.228	2.388	3.148	3.762	3.931	3.205
Jarque-Bera	14.378	22.406	14.577	13.009	23.028	1.217	4.483
Probability	.002**	.001**	.002**	.003**	.001**	.001***	.001**

Statistics	EVP	REU	EG G	NPR	GFN	ENI	URB
Observations	124	124	124	124	124	124	124
Correlation Matrix							
EVP	1						
REU	1.339	1					
EGG	1.497	1.513	1				
NRR	−1.817	−1.628	−1.765	1			
GFN	1.123	1.442	1.213	−1.348	1		
ENI	−1.179	1.0049	−1.105	1.285	1.028	1	
URB	1.022	−1.216	1.017	1.169	−1.079	1.028	1

2.2 A sample-based test of dependence

The econometric methods used in this study's empirical analysis are detailed below. Before computing panels, we first test for cross-sectional dependence (CSD). CSD presence may introduce uncertainty and inefficiencies into the evaluation process. Many factors, such as widespread disruptions, regional consequences, and unexpected country-specific concerns, might give birth to such problems. Therefore, the authors of this study used the CSD test, which can be represented mathematically as follows: Time, N, the number of cells in the CSD, and the i-m correlation coefficient, R, are all represented in equation (3).

$$CSD\sqrt{\frac{2T}{N(N-1)}}\sum_{i=1}^{N}1\,\varphi_i\sum_{m=i+1}^{N}1\,\partial_{im} \tag{3}$$

2.3 Unit root tests

Cross-sectional augmented Dickey-Fuller (CADF) and cross-sectional augmented Pesaran and Shin (CIPS) panel root tests, both of the second generation, were used to analyze the selected variable in this study, possible CSD and erroneous regression analysis solutions, including the CADF and CIPS tests. Researchers could evaluate the reliability and precision of the series heterogeneity, thanks to the outcomes of both stationarity tests. Equation (4) provides a mathematical description of the CADF test:

$$\Delta x_{it} = \alpha_{it} + \beta_{it-1} + \delta_I T + \sum_{j=1}^{N}1\,\gamma_{ij}\Delta x_{it-j} + \mu_{it} \tag{4}$$

This illustrates the independent variables, their dissimilarity, and the white error term.

The following equation may represent the CIPS rating:

$$CIPS = \frac{1}{N}\sum_{i=1}^{N} 1\, \varphi_i(N,T) \tag{5}$$

With (,) representing the outcome of a regression analysis using the CADF.

2.4 Panel co-integration test subsection

The co-integration method may be used to look into the co-integration relationship between the series by analyzing the stability of the residual part of the equation. In this approach, the absence of series co-integration is the null hypothesis. The formula for the co-integration test may be found in the following equation:

$$Y_{it} = \alpha_i + \psi_i t + \sum_{n=0}^{N} 1\, \beta_{ni}, X_{nit} + \mu_{it} \tag{6}$$

It shows the overall trend of the series, emphasizes the role of unique individuals, and reflects explanatory factors. This work evaluated the CSD and series heterogeneity using the co-integration method. According to the approach's null hypothesis, the series does not co-integrate in the error-correction period. Equation (7) gives a mathematical description of the model:

$$\Delta Y_{it} = \psi_{\prime_i} d_t + \alpha_i(Y_{it-1} - \beta_{\prime_i} X_{it-1}) + \sum_{j=1}^{p_i} 1\, \alpha_{ij}\Delta y_{it-j} + \sum_{j=-p_i}^{p_i} 1\, \varphi_{ij}\Delta X_{i,t-j} + \mu_{it} \tag{7}$$

The series' trend is represented by $d_t = (1,t)'$, and the CSD is indicated. The period is defined by and $\psi_{\prime_i} = \psi_{\prime_i} and \psi_{2_i})'$ provides estimates for the elasticity. Mathematical forms for the test statistics for the two groups using this approach are given in Equations (8), (9), (10), and (11):

$$G_\tau = \frac{1}{N}\sum_{i=1}^{N} 1 \frac{\eta_i}{S.E(\grave{\eta_i}} \tag{8}$$

$$G_a = \frac{1}{N}\sum_{i=1}^{N} 1 \frac{T\eta_i}{1-\sum_{j=1}^{k} \quad \grave{\eta_{ij}}} \tag{9}$$

The following formulas are used to get the statistical results of the panel co-integration method:

$$P_\tau = \frac{\grave{\eta_i}}{S.E(\grave{\eta_i})} \tag{10}$$

$$P_a = T\eta_i \tag{11}$$

The pace with which the long-term equilibrium replaces the short-term equilibrium is shown by the values of, and, respectively.

2.5 Models for Projecting Future Values

Short-term and long-term estimators proposed by the CS-ARDL were investigated. The estimates produced by CS-ARDL are more dependable and accurate than those given by other estimation techniques, like the pooled mean group (PMG). It is possible to use CS-ARDL techniques to deal with heteroscedasticity, endogeneity, and serial correlation. To calculate the CS-ARDL, one uses the following formula:

$$\Delta EVQ_{i,t} = \delta_i + \sum_{j=1}^{m} 1\, \delta_{it} EVQ_{i,t-j} + \sum_{j=0}^{m} 1\, \delta_{it}' X_{i,t-j} + \sum_{j=0}^{1} 1\, \delta_{it}' \bar{\tilde{Z}}_{i,t-j} + \mu_{it} \quad (12)$$

This allows us to express the mean of the cross-section $\bar{\tilde{Z}}_t = \Delta EVQ_{i,t}$ Variables such as ECG, REU, GF, NRR, ENI, and URB are the model's explanatory sequence benchmarks.

2.6 Evaluation of stability

Our short-term and long-term forecasts were evaluated using the AMG and CC-MG. This study used the AMG and CC-MG model because of their scalability and ability to provide reliable, bias-free results. SPSS E-views (Version 12) from the Statistical Package for the Social Sciences were used for the statistical analysis. Using the most up-to-date iteration of the Granger causality test, we looked at the data to see whether the series correlated. This method helps address CSD's potential and determine whether our model exhibits slope variability. The null hypothesis of the D-H Granger causality test is that there is no relationship between the two variables. However, an internal causal relationship inside the model constitutes the alternative hypothesis. Equation (13) is a mathematical expression of the D-H non-causality test.

$$Y_{it} = \alpha_i + \sum_{m=1}^{M} 1\, \psi_i^m, Y_{i(m-t)} + \sum_{m=1}^{M} 1\, \lambda_i^m, Z_{i(m-t)} \quad (13)$$

3. EMPIRICAL RESULTS AND DISCUSSION

3.1 The results of a cross-sectional dependency analysis

This part calculates the slope of similarity and performs a CSD test on the research variables as the first step in our econometric model analysis. The SHT findings suggest variation in the ASEAN economies since the SHT null hypothesis is excluded, as seen in Table 3. The results show that a trustworthy method will be used in the stages of our investigation to evaluate CSD and heterogeneity.

Table 3 summarizes the results of the Slope of Homogeneity analysis

H0: curve coefficient is homogenous			
	P-Stats	Adjusted	P-stats
6.219	.001	11.052	.001*

A * (one per cent) indicates a significant result.

We use three different CSD testing strategies in our dataset to tackle the difficulties CSD poses. An overview of the three CSDs used in this study is provided in Table 4 (Umair et al., 2022). The results of the tests indicate that the absence of CSD in the cross-section of the variables should be rejected at the 1% significance level. Spillovers, technical progress, modernization, and economic development are all areas in which ASEAN countries will likely influence one another.

Table 4: The CSD results are summarized

Series	Breusch-Pagan LM	Pesaran scaled LM	Bias-Corrected Scaled LM
EVP	89.308**	24.761**	24.694**
REU	83.226**	23.005**	22.938**
EGC	148.807**	42.514**	42.447**
NRR	63.441**	17.293**	17.227**
GFN	66.561**	18.194**	18.127**
ENI	34.237**	13.088**	13.023**
URB	185.618**	52.564**	52.497**

Markings of * (10%), ** (5%), and *** (1%) indicate increasing degrees of importance.

3.2. Assessing stationary in a panel

After we have resolved the CSD problem in our study series, we must ensure that the series is rationalized and integrated with the correct sequence. In this study, we tested for unit roots using the CADF and CIPS methods. There were some deviations from horizontality in the EVP, REU, EGC, NRR, GFN, ENI, and URB, as shown in Table 5. After the first divergence I (1), the candidate series converged. Using this method, we may evaluate whether or not the selected time series are long-term co-integrated (Brown et al., 2020).

Table 5: The results of panel unit root testing for the second generation (CADF and CIPS)

Series	CADF		CIPS		Order of Integration
	Level	First-difference	Level	First Difference	I (1)
EVP	−2.795	−8.237***	−2.148	−7.962**	I (1)
REU	−1.979	−9.165***	1.152	−7.819**	I (1)
EGC	−2.334	−4.748***	1.067	−5.107**	I (1)
NRR	−1.742	−8.274***	-1.805	−8.498**	I (1)
GFN	−2.311	−4.407***	2.677	−5.833**	I (1)
ENI	−1.005	−9.469***	−2.418	−7.905**	I (1)
URB	−1.111	−9.619**	−2.548	−7.798**	I (1)

Note: *** (1%) symbolizes the level of significance.

3.3. Long-term predictions of elasticity

Current research methods, such as the CS-ARDL, are used to shape long-term co-integration collaboration in a series, and then the strength of the short- and long-term link between the variables is evaluated. Table 6 displays the anticipated intermediate and results of the CS-ARDL method.

Table 6: The CS-ARDL findings are summarized

Variables	Coefficient	Std. Error	Prob.
Short-run estimates			
REU	−1.282*	0.109	0.002
EGC	1.303*	0.024	0.001
NRR	1.042	0.092	0.313
GFN	−1.029**	0.007	0.004
ENI	−1.023**	0.658	0.002
URB	1.575**	0.408	0.001
EMC (−1)	−1.75**	0.845	0.001
Long-run estimates			
REU	−1.135**	0.036	0.001
EGC	1.356**	0.109	0.003
NRR	1.008	0.016	0.117
GFN	−1.0468**	0.038	0.001
ENI	−1.038**	0.015	0.002
URB	1.428**	0.122	0.007

Note: *** indicates a 1% significance level.

Study shows that an increase in REU of 1 percentage point in the ASEAN economies resulted in an improved environmental quality of 0.132 percentage points over the long term (He et al., 2021). The considerable expenditures made by these nations in cutting-edge REU technology and creative ways of thinking may be one explanation for this result. Our findings corroborate earlier studies that imply REU might boost ecological conditions. Our findings coincide with those of earlier studies. According to various research, embracing more renewable energy sources adds to higher pollution (Soundarrajan &Vivek, 2016).

Our investigation revealed that EGC and EVP perform effectively together. A 1% rise in EGC impact may be accountable for a 0.350% rise in EVP in the ASEAN financial prudence. The optimistic and statistically significant coefficient estimate for EGC in the ASEAN economies, which suggests that the quantity of the impact is larger than the total of the impacts of method and composition, validates the existence of EKC. The ASEAN nations may withstand relatively high pollution levels as they are just beginning their periods of quick economic progress. Again, there is a strong relationship between EGC and EVP, as forestry, soil, land, power, and reserves are all significant inputs necessary for economic growth.

4.0 DISCUSSION

Although a positive link existed between the NRR of ASEAN economies and EVP, the relationship was not statistically significant. Our study reveals that a 1% increase in NRR usage harms the ecosystem. If adopting NRR would quickly increase economic development, ultimately resulting in a fall in environmental quality in these countries, these results may make sense (Zhou & Li, 2022). These findings imply that the ecological integrity of ASEAN economies is compromised by the profits earned from mining and processing NRR. Consistent with the findings of other environmental experts, we found that reckless use of NRR may increase EVP (Shahbaz et al., 2018). Green GFN was shown to have a statistically significant inverse relationship to EVP in the ASEAN frugality. This demonstrates that GFN has the potential to improve ecological conditions. Our findings indicate that a one per cent increase in GFN may lead to a 0.046 per cent decrease in EVP over the long run. That is why businesses that put money into "green production" are more likely to use methods that reduce pollution. Putting GFN first might lead to less emission. Our results show that the EKC assumption is reasonable since they improve GFN to reduce EVP in ASEAN countries (Ayerbe et al., 2022). This study's findings corroborate previous research that found GFN to be a practical and efficient financial tool for bettering environmental quality.

Understanding the relationship between ENI and EVP is critical for ASEAN nations. Even if ENI pushes ASEAN nations to explore and embrace higher environmental sustainability, there is still a negative correlation between ENI and EVP. Our results show that a 1% increase in ENI results in a 0.502% permanent fall in EVP. Therefore, ENI supports programs that reduce emissions, increase efficiency, and move toward carbon neutrality. It has been reported that the environmental quality in 10 developing countries has improved because of ENI's actions. New evidence has emerged in favour of this viewpoint. Contrary to widespread opinion, ENI works against efforts to protect the environment in BRICS countries (Alharbi et al., 2023).

The empirical studies on the effect of URB on the EVP for the ASEAN economies have shown a confident and statistically significant connection between the two variables. If there is a 1% increase in URB, there may be a 0.426 per cent increase in EVP. More people living in metropolitan areas means more individuals are likely to disobey environmental laws, which might be an economic explanation for this outcome (Zhang, 2018), (Al Mamun et al., 2022). This finding is not shocking since many individuals in ASEAN nations migrate to urban areas for better economic, social, and governmental situations. Coal, natural gas, and energy sources are the primary tools for accomplishing these goals. Reports suggest that URB accelerates how these nations utilize high-energy facilities like air conditioners, heaters, and kitchen appliances. Our results are consistent with those of the research. However, our study found findings contradicting other research (Deng et al., 2019).

Finally, the error of the reduction co-efficient value (EM-1) is negatively correlated with the pollution of the environment, indicating that ASEAN's economy, which is impacted by 73% of EVP in the short term, should offer a workable solution for ecological destruction in the long run. In this study, we compared the AMG and CC-MG techniques for assessing robustness (Adebayo et al., 2021). According to Table 8, the CS-ARDL estimates agree with the AMG and the CC-MG. All chosen series have identical signs, further validating the precision of the CS-ARDL analysis.

As a result, the causal relationship between series in panel data cannot be established using these approaches. It is vital to investigate the causal link to advise stakeholders and policy experts on coordinated and integrated initiatives. The researchers used an innovative method to explore the linkages between various variables (Bouzahzah, 2022). These findings suggest that the potential for EVP in the sample countries might be significantly mitigated by adopting policies prioritizing renewable energy sources, economic development, green finance, and energy innovation (Ayough et al., 2023). In addition, our D-H causality data shows that the rent on natural resources, urbanization, and ecological well-being are all interconnected. As a result, it follows that any policy formulation in generally applicable terminology that promotes NRR, URB, and URB may decrease EVP in the ASEAN nations.

5.0 CONCLUSION AND RECOMMENDATIONS

Academics, politicians, and scientists from all over the world are now focusing the majority of their attention and energy on finding a solution to the problem of the environment deteriorating. This study contributes to the corpus of past research by investigating the relationship between EVP and the economies of the ASEAN countries, as well as the use of renewable energy, green financing, economic development, natural resource rent, energy innovation, and urbanization in the ASEAN countries. The current body of research on EKC and the variables leading to environmental degradation in ASEAN countries is expanded upon by our work, which adds theoretical depth (Liu & Feng, 2023). This study was the first to verify the co-integration connection between the series, and it employed the CS-ARDL technique to examine both short- and long-run interaction.

According to the findings of our study, there is a correlation that is both positive and statistically significant between urbanization, resource rent, pollution, and economic development (Wang et al., 2020). (2) Environmental degradation, using renewable energy sources, green finance, and technological advancement all have a negative and mutually reinforcing connection with one another (Soundarrajan & Vivek, 2016). (3) The D-H causality test demonstrated a one-way, causal connection between the use of renewable energy sources, increased economic growth, increased green financing, energy innovation, and improved environmental quality. The D-H test findings indicate a two-way causal link between ecological health, urbanization, and the price of natural resources.

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