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# THE IMPACT OF ECONOMIC GROWTH ON CIRCULAR ECONOMY PRINCIPLES: EVIDENCE ON ASEAN COUNTRIES

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## ABSTRACT

*This study investigates the impact of economic growth on circular economy (CE) principles in ASEAN countries from 2000 to 2019, using panel data analysis. While many ASEAN nations pursue CE to address sustainability, limited empirical work exists on how macroeconomic indicators influence this transition. This study specifically examines the role of gross domestic product (GDP), foreign direct investment (FDI), labour force participation (LF), and greenhouse gas emissions (GHG) on CE, proxied by renewable energy usage. Panel ordinary least squares (POLS) and panel autoregressive distributed lag (ARDL) models are applied to evaluate short- and long-run effects. Findings reveal that GDP positively influences CE adoption, whereas FDI, LF, and GHG emissions negatively affect it. The study acknowledges limitations due to annual data frequency and the exclusion of key variables such as government policy, technological innovation, and public awareness, which may introduce omitted variable bias. The assumption of ASEAN as a homogeneous panel is also recognised as a simplification given the region's economic diversity. Despite these limitations, the results offer useful insights for policymakers seeking to align economic growth with sustainable development through CE. Future research should adopt more granular data and expand the variable scope to strengthen understanding of CE dynamics in ASEAN.*

***Keywords:*** *Autoregressive distributed lag (ARDL), foreign direct investment (FDI), gross domestic product (GDP), greenhouse gas emissions (GHG), labour force (LF), panel ordinary least squares (POLS)*

## INTRODUCTION

The relationship between economic growth and sustainable development is particularly significant in ASEAN, where rapid industrialisation coexists with environmental challenges. Achieving a balance between economic expansion and ecological sustainability is essential. The circular economy (CE) presents an innovative shift from the traditional linear model, emphasising waste reduction, resource efficiency, and long-term sustainability (Motte et al., 2022). When integrated with renewable energy solutions, CE principles can drive a transition towards more resilient and environmentally sustainable energy systems, ensuring economic progress without compromising ecological integrity (Olabi, 2019).

The industrial sector aims to reduce negative externalities by adopting CE principles, including renewable and low-carbon energy sources. Transitioning from fossil fuels to renewable energy, especially in developing countries, requires gradual and comprehensive approaches, such as eliminating fossil fuel subsidies, implementing decentralised power systems, and deploying carbon capture technologies (Olabi, 2019). As stated by the Ellen MacArthur Foundation (2015), one of the core principles of CE is "renewability," emphasising the shift from finite to renewable resources. Renewable energy becomes a primary power source, supporting circular growth models and creating resilient economic systems (Tongsopit et al., 2016).

With their diverse economic landscapes and energy needs, ASEAN countries face the challenge of embracing renewable energy while adhering to CE principles. This study aims to empirically analyse how economic growth impacts the promotion of CE concepts, particularly regarding renewable energy adoption

in ASEAN countries. By examining governmental frameworks, technological innovations, investment trends, and societal dynamics, this research will explore how economic growth can drive the adoption of CE principles in the renewable energy sector.

**Problem Statement**

The traditional linear production model defined by the "take, make, dispose" approach has become increasingly unsustainable due to excessive resource exploitation and waste generation. This model significantly contributes to environmental degradation and social challenges (Jonck et al., 2018). Consequently, there is a growing need for alternative economic models emphasising sustainability, resource efficiency, and waste minimisation. The CE offers a promising framework to address these concerns.

ASEAN countries are at a pivotal stage of development. While rapid industrialisation and economic growth have improved living standards, they have also intensified environmental pressures. In alignment with the 2030 Agenda for Sustainable Development, developed and developing nations are committed to mitigating climate change. However, ASEAN faces unique challenges, including financial constraints, technological gaps, and limited institutional capacity to reduce emissions (Kumaran et al., 2022). According to the Global Climate Risk Index 2019 by Germanwatch, half of the ASEAN member states rank among the top 20 countries most affected by extreme weather events. If left unaddressed, climate change could reduce the region's GDP by 6.7% by 2100 (Triani et al., 2023).

ASEAN has initiated steps toward adopting CE principles in response to these vulnerabilities. Establishing the ASEAN Circular Economy Framework in 2021 and collaborative efforts with the European Union reflect a growing commitment to transitioning from a linear to a circular development model. Harmonisation of standards has been identified as a key strategy to enhance regional coordination and implementation of CE practices (Anbumozhi & Kimura, 2018). These initiatives are further supported by the ASEAN Circular Economy Stakeholder Platform Secretariat, which aims to accelerate progress toward Sustainable Development Goal (SDG) 12 on responsible consumption and production (Khajuria et al., 2022).

Despite these developments, the relationship between economic growth and CE adoption in ASEAN remains underexplored. The existing literature has not sufficiently examined how macroeconomic indicators, such as gross domestic product (GDP), foreign direct investment (FDI), labour force participation (LF), and greenhouse gas emissions (GHG), influence CE implementation. GDP growth may facilitate investment in sustainable industries, while FDI can either support CE through green technologies or hinder it by promoting resource-intensive sectors (Ghisellini et al., 2016; Chen et al., 2020). LF reflects industrial productivity and employment, which affect resource demand and waste generation. GH emissions serve as proxies for the environmental externalities of economic activities.

Many studies treat ASEAN as a homogenous entity, overlooking significant differences in economic structure, technological readiness, and institutional capacity among member states. For instance, Singapore demonstrates advanced environmental governance, whereas less developed countries may lack the infrastructure necessary to support CE initiatives. Such generalisations risk producing misleading policy recommendations. Moreover, key CE enablers such as regulatory quality, technological innovation, and public awareness are often excluded from empirical analyses due to data limitations. This omission may introduce bias, as these factors are critical to the success of CE transitions.

This study addresses these gaps by empirically analysing the relationship between economic growth indicators (GDP, FDI, LF, GH) and CE adoption in ASEAN countries. It also considers the potential influence of omitted variables and the diversity within the ASEAN region. By offering a nuanced interpretation of how macroeconomic forces shape CE implementation, this research seeks to inform policymakers and stakeholders working to align economic growth with sustainability in a rapidly transforming region.

**Research Questions**

1. How do GDP, FDI, LF, and GHG influence CE adoption in ASEAN countries from 2000 to 2019?
2. What are the short-run and long-run relationships between these economic growth indicators and CE?

**Research Objectives**

1. To empirically examine the relationship between economic growth variables (GDP, FDI, LF, GHG) and CE in ASEAN countries.
2. To distinguish between short- and long-run effects using panel autoregressive distributed lag (ARDL) models.

CE aims to create an ecosystem of production and consumption that minimises waste and pollution. It is built on three principles: eliminating waste and pollution, circulating products and materials at their highest value, and regenerating ecosystems. The shift to renewable energy and materials supports these principles. According to the Ellen MacArthur Foundation (2015), "renewability" is a core principle of CE, emphasising the transition to renewable sources for sustainable resource consumption (Knäble et al., 2022). This study will explore how economic factors such as GDP, FDI, LF, and GH emissions influence the adoption and effectiveness of CE practices in ASEAN countries. The operational definitions and measurements for these variables are summarised in Table 1.

## LITERATURE REVIEW

The traditional linear economic model is increasingly unsustainable for ASEAN, where resource demand is rapidly rising. Reusing materials for new products or energy sources is a low-cost, high-impact option (Genovese et al., 2015). Integrating renewable energy into the circular economy framework enhances resource efficiency, reduces emissions, and promotes economic growth. This synergy offers a promising path towards achieving long-term environmental and societal goals (Geipele et al., 2018). Renewable energy sources like solar, wind, hydro, and geothermal align with circular economy principles, aiding in the shift from a "take, make, dispose" model to a sustainable energy system (Scheel et al., 2020).

The Environmental Kuznets Curve (EKC) hypothesis suggests an initial deterioration in environmental quality with economic growth, followed by improvement after a certain income level is reached (Nasir & Ur, 2017). While some studies support an inverted U-shaped EKC, others propose different configurations, such as an N-shaped or a J curve, especially in the context of ASEAN countries (Zhou et al., 2018; Kasioumi & Stengos, 2022). The EKC can be influenced by circular economy practices, promoting resource efficiency and sustainable use. Integrating circular economy concepts with the EKC. The relationship between GDP and the circular economy in ASEAN was explored by examining sustainable development indicators in Malaysia, Indonesia, Thailand, Singapore, and the Philippines from 1995 to 2013. This study found that circular economy practices contribute to both economic and functional well-being (Jermsittiparsert et al., 2020). Despite the ASEAN Economic Community (AEC) pact aimed at energy security and sustainability, renewable energy adoption remains crucial to meet the region's growing energy demands and economic goals (Tongsopit et al., 2016; Veng et al., 2020).

Research indicates that GDP growth can positively impact circular economy factors, such as waste recycling

**Table 1** Description of variables

| Variable | Indicator | Justification | Literature Resource |
|---|---|---|---|
| Dependant Variables | CE | Percentage of total final energy consumption (Renewable Energy) | Geipel et al., 2018 |
| Independent Variables | GDP | Represents overall economic activity and its influence on sustainability initiatives | Jermsittiparset et al, 2020 |
| | FDI | Encourages green investments but may also cause pollution if not managed well. | (Ghisellini et al., 2016; Apergis et al., 2022) Chen et al., 2020 |
| | LF | Reflects employment levels and industrial productivity, impacting sustainability | Yassin, 2021 |
| | GHG | Measures environmental impact, relevant to CE practices | Sibuea et al., 2021 |

and resource conservation, suggesting that circular economy principles can support economic growth while preserving the environment (Hysa et al., 2020). However, the impact of CE policies on local economic growth can vary, with initial slowdowns potentially giving way to long-term benefits (Chen et al., 2020).

FDI is critical in promoting the CE by bringing sustainable practices and technologies to host countries (Ghisellini et al., 2016). However, ASEAN countries require substantial investments to meet their renewable energy targets. Regulatory challenges and limited institutional support often hinder such investments (Vakulchuk et al., 2023). Improving governance and trade policies can help enhance renewable energy utilisation and support CE goals (Huang et al., 2022).

The Pollution Haven hypothesis suggests that FDI might flow into countries with lax environmental regulations, leading to higher pollution. In contrast, the Pollution Halo hypothesis argues that FDI can bring cleaner technologies and reduce emissions in host countries (Apergis et al., 2022; Wang & Zhang, 2022). This dual perspective underscores the need for balanced policies that attract FDI while maintaining stringent environmental standards.

Labour force participation is also linked to CE. Studies show that renewable energy consumption and labour force growth positively impact economic growth in ASEAN countries (Fadilah et al., 2020; Yassin, 2021). Implementing CE principles can create job opportunities and promote sustainable development. However, challenges in adapting current accounting standards and integrating circular supply chain management must be addressed to realise these benefits fully (Kwarteng et al., 2022; Elghaish et al., 2022).

GHGs are a critical factor in assessing the impact of CE practices. Studies on Malaysia's CE practices show that green technology supports sustainable development by balancing economic growth with environmental protection (Sarpong & Alarussi, 2020). Research indicates that bioenergy, biomass, energy trade, and economic development can positively affect environmental quality by reducing carbon emissions in ASEAN (Sibuea et al., 2021). Similarly, renewable energy production, consumption, and ecological innovation lower GHG emissions while increasing energy use and industrialisation (Chien et al., 2023). To support clean power generation, policies must reduce the costs associated with renewable energy (Triani et al., 2023). CE policies such as efficient resource use in agriculture, waste prevention, and emission reduction are essential for sustainable development, particularly in ASEAN, where economic growth and environmental sustainability must be balanced (Yazdani et al., 2019). The literature indicates that GDP, FDI, LF, and GHG emissions significantly impact CE in ASEAN countries. While GDP and LF support CE through renewable energy and sustainable practices, FDI's influence depends on environmental regulations and governance quality. Integrating CE principles with the EKC framework can help policymakers adopt renewable energy technologies and practices to enhance economic development and environmental quality.

In conclusion, the selection of GDP, FDI, LF, and GHG emissions is grounded in established environmental-economic theories. Specifically, the EKC hypothesis provides a framework to understand the non-linear relationship between economic growth and environmental degradation. The Pollution Haven and Pollution Halo hypotheses further justify the inclusion of FDI, highlighting its dual potential to either exacerbate or mitigate ecological harm depending on governance quality. LF and GHG emissions serve as proxies for production intensity and environmental stress, both central to evaluating the sustainability of growth. These variables capture the interaction between economic drivers and environmental pressures relevant to CE development.

## METHODOLOGY

This study investigates the impact of GDP, FDI, LF, and GHG on CE principles in ASEAN countries from 2000 to 2019. Panel data regression analysis controls for dependencies and assesses the relationship between these variables. The study uses secondary data primarily from the World Bank.

The methodology begins with discussing panel data regression, which combines cross-sectional and time-series data. Panel regression models, including ordinary least squares (OLS), analyse the relationship between economic indicators and circular economy principles. The model proposed by Hysa et al. (2020) serves as

the foundation for the analysis. The analysis employs balanced panel data and utilises E-Views software for calculations. All variables are transformed into semi-linear logarithmic forms to ensure the consistency and reliability of results. The model for CE is defined as follows:

POLS for CE:

$$CE_{it} = \beta_0 + \beta_1 GDP_{it} + \beta_2 FDI_{it} + \beta_3 LF_{it} + \beta_4 GH_{it} + e \quad (1)$$

Unit root test for CE:

$$CE_t = \beta_0 + \beta_1 GDP_{t-1} + \beta_2 FDI_{t-1} + \beta_3 LF_{t-1} + \beta_4 GH_{t-1} + \varepsilon_t \quad (2)$$

ARDL for CE:

$$\Delta CE_t = \beta_0 + \beta_1 CE_{t-1} + \beta_2 GDP_{t-1} + \beta_3 FDI_{t-1} + \beta_4 LF_{t-1} + \beta_5 GH_{t-1} + \sum_{i=1}^{p} \beta_{6i} \Delta CE_{t-i} + \sum_{i=1}^{p} \beta_{7i} \Delta GDP_{t-i} + \sum_{i=1}^{p} \beta_{8i} \Delta FDI_{t-i} + \sum_{i=1}^{p} \beta_{9i} \Delta LF_{t-i} + \sum_{i=1}^{p} \beta_{10i} \Delta GH_{t-i} + \varepsilon_t \quad (3)$$

Long run ARDL:

$$CE = \theta_0 + \sum_{i=1}^{p} \theta_1 \Delta CE + \sum_{i=1}^{p} \theta_2 \Delta GDP_{t-i} + \sum_{i=1}^{p} \theta_3 \Delta FDI_{t-i} + \sum_{i=1}^{p} \theta_4 \Delta LF_{t-i} + \sum_{i=1}^{p} \theta_5 \Delta GH_{t-i} + \varepsilon_t \quad (4)$$

Short run ARDL:

$$\Delta CE_t = \beta_0 + \sum_{i=1}^{p} \beta_{1i} \Delta CE_{t-i} + \sum_{i=1}^{p} \beta_{2i} \Delta GDP_{t-i} + \sum_{i=1}^{p} \beta_{3i} \Delta FDI_{t-i} + \sum_{i=1}^{p} \beta_{4i} \Delta LF_{t-i} + \sum_{i=1}^{p} \beta_{5i} \Delta GH_{t-i} + \beta_6 CE_{t-1} + \beta_7 GDP_{t-1} + \beta_8 FDI_{t-1} + \beta_9 LF_{t-1} + \beta_{10} GH_{t-1} + \lambda ECT_{t-1} + \varepsilon_t \quad (5)$$

This model assesses the impact of GDP growth, FDI net inflows, LF, and GH on CE in ASEAN countries. The study conducts hypothesis testing to evaluate the significance of these variables on CE.

For analytical consistency, ASEAN countries are treated as a balanced panel dataset in this study, assuming a certain degree of structural and policy similarity. However, it is essential to note the region's significant economic and institutional heterogeneity. For example, high-income countries like Singapore possess stronger environmental regulation and technological capability than developing economies like Myanmar or Laos. While this uniform treatment supports generalisable regional insights, it may obscure country-specific dynamics. As such, the findings should be interpreted with caution and complemented by future country-level or subregional analyses.

While this study uses annual panel data due to availability constraints across ASEAN countries, it is acknowledged that more granular data, such as quarterly or monthly series, could offer improved sensitivity to short-run fluctuations and policy shocks. Moreover, essential variables such as government policy strength, technological readiness, and public awareness, which are widely recognised as key enablers of circular economy transitions, were excluded due to a lack of consistent data across all countries. These omissions may introduce variable bias and should be addressed through expanded datasets or case-specific analyses.

## RESULTS AND DISCUSSION

### Empirical Results

This section employs ARDL analysis to investigate the impact of economic growth on CE principles in ASEAN countries. Descriptive statistics (Table 2) provide insights into the dataset, covering CE, GDP, FDI, LF, and GHG. The variables' mean and median values are presented, with the Jarque-Bera test indicating normal distribution for CE. The correlation matrix (Table 3) illustrates the relationships between CE and its independent variables. Positive correlations are observed between GDP and CE/GH, while negative correlations exist between CE and FDI/LF.

### Regression Analysis

#### *Hypothesis Testing on Research Question One*

Results (Table 4) demonstrate significant associations between CE and its determinants. GDP, FDI, LF, and GH are significant at the 5%. The coefficients indicate that GDP positively influences CE, while FDI, LF, and GH have negative effects. For R2, 50% of the dependent variable (DV) variation can be explained by the independent

**Table 2** Descriptive statistics

| | CE | GDP | FDI | LF | GH |
|---|---|---|---|---|---|
| Mean | 34.196 | 5.720 | 5.324 | 1.847 | 4.961 |
| Median | 30.835 | 6.010 | 3.436 | 1.845 | 5.122 |
| Maximum | 85.710 | 14.520 | 29.690 | 1.913 | 6.009 |
| Minimum | 0.000 | -2.508 | -2.757 | 1.785 | 3.822 |
| Std. Dev. | 28.153 | 3.140 | 5.887 | 0.035 | 0.618 |
| Skewness | 0.320 | -0.079 | 2.136 | 0.090 | -0.298 |
| Kurtosis | 1.826 | 3.843 | 7.353 | 1.862 | 1.983 |
| Jarque-Bera | 14.884 | 6.1362 | 310.048 | 11.054 | 11.569 |
| Probability | 0.0005 | 0.0465 | 0.000 | 0.004 | 0.003 |
| Sum | 6839.240 | 1144.055 | 1064.876 | 369.4630 | 992.1970 |
| Sum Sq. Dev. | 157729.8 | 1961.699 | 6896.941 | 0.249158 | 76.03040 |
| Observations | 200 | 200 | 200 | 200 | 200 |

**Table 3** Correlation matrix

| | CE | GDP | FDI | LF | GH |
|---|---|---|---|---|---|
| CE | 1 | | | | |
| GDP | 0.608*** | 1 | | | |
| FDI | -0.205 | 0.095 | 1 | | |
| LF | -0.370* | -0.244 | 0.142 | 1 | |
| GH | 0.316** | 0.345** | 0.091 | 0.141 | 1 |

*Notes*: *** Represents a 1% level of significance, ** 5% level of significance, and * 10% level of significance

variables (IV). Another 50% cannot be explained. This can be supported by (Jermsittiparsert et al., 2020) since this article also gained less than 60% for their $R^2$ in the POLS testing. Augmented Dickey-Fuller (ADF) tests (Table 5) confirm stationarity for CE in first differences, indicating suitability for ARDL analysis. GDP and FDI are stationary at the level, while LF and GH are stationary in first differences, supporting the use of ARDL. The energy mix, technological limitations, and infrastructure constraints of ASEAN countries may limit the extent to which circular economy principles can reduce greenhouse gas emissions (Chien et al., 2023). These elements must be investigated to understand the complex relationship between circular economy plans and emission reduction in ASEAN.

### *Hypothesis Testing on Research Question Two*

The panel ARDL model examines short-term and long-term relationships between the variables. The long-run coefficients (Table 6) indicate the enduring effects of GDP, FDI, LF, and GH on CE. The model shows that a 1% increase in GDP results in a 1.72% increase in CE, highlighting the positive impact of economic growth on circular economy principles. Conversely, a 1% rise in FDI, LF, and GH leads to declines in CE by 0.77%, 241.11%, and 48.99%, respectively, suggesting that increased foreign investments and LF, as well as higher GHG, hinder the progress of the circular economy in ASEAN countries. The Akaike Information Criterion (AIC) identifies the optimal lag order for the model as ARDL (2,1,1,1,1), with a dependent variable lag order of 2 and an independent variable lag order of 1. This specification indicates that the model incorporates lagged values of the dependent variable up to lag two and each independent variable up to lag 1, accounting for delayed effects in the relationships.

The error correction term (COINTEQ01) measures how quickly deviations from the long-run equilibrium are corrected. The coefficient for COINTEQ01 is -0.077 (Table 7), indicating that 7.7% of the disequilibrium in CE from the previous year is corrected annually. This negative coefficient is statistically significant at the 5% level, confirming that the model adjusts towards

**Table 4** The impact of economic growth on CE

| Variables | Coefficient (P-value) |
|---|---|
| CE | 324.269** (0.000) |
| GDP | 4.514** (0.000) |
| FDI | -1.133** (0.000) |
| LF | -191.947** (0.000) |
| GHG | 9.015** (0.000) |
| Observation | 200 |
| R2 | 0.507 |
| F statistic | 0.000 |

*Notes*: *** Represents a 1% level of significance, ** 5% level of significance, and * 10% level of significance
CE = 324.27 + 4.51 GDP – 1.13 FDI – 191.95 LF + 9.02 GH

**Table 5** ADF unit root test result

| Variables | Coefficient (P-value) | Integration Order |
|---|---|---|
| CE | 42.656** (0.001) | 1st Difference I (1) |
| GDP | 43.235** (0.002) | Level I (0) |
| FDI | 41.830** (0.003) | Level I (0) |
| LF | 43.884** (0.002) | 1st Difference I (1) |
| GHG | 51.761** (0.000) | 1st Difference I (1) |

*Notes*: *** Represents a 1% level of significance, ** 5% level of significance, and * 10% level of significance

equilibrium over time. In the short run, the coefficients for the differences of GDP, FDI, LF, and GH are not statistically significant, suggesting that short-term fluctuations in these variables do not significantly impact CE. However, the error correction mechanism is crucial in bringing the system back to equilibrium, reflecting the importance of long-term strategies for maintaining a sustainable circular economy.

Circular economy ideas in ASEAN countries could boost long-term economic growth by enhancing productivity and innovation, leading to higher GDP (Ekins et al., 2019). This model can create green jobs, new business opportunities, and investments in sustainable industries. While the ASEAN circular economy aims to reduce greenhouse gas emissions through efficient resource use, energy-intensive recycling and increased transportation for remanufacturing might raise emissions over time (Triani et al., 2023). Balancing circular practices with emission reduction goals complicates the transition to a sustainable economic model.

## Diagnostic Test

Diagnostic tests for serial correlation and heteroscedasticity are conducted to validate the robustness of the ARDL model. The Residual Serial

**Table 6** Long run test for CE and its determinants

| Variable | Coefficient | Std. Error | t-stat | Prob |
|---|---|---|---|---|
| Gross Domestic Product (GDP) | 1.718** | 0.487 | 3.525 | 0.000 |
| Foreign Direct Investment (FDI) | -0.771** | 0.360 | -2.141 | 0.034 |
| Labour Force Participation (LF) | -241.113** | 43.377 | -5.559 | 0.000 |
| Greenhouse gas Emission (GH) | -48.995** | 6.870 | -7.132 | 0.000 |
| C | 57.083 | 26.416 | 2.161 | 0.033 |

*Notes*: *** Represents a 1% level of significance, ** 5% level of significance, and * 10% level of significance
CE = 57.083 + 1.718*GDP – 0.771*FDI- 241.113*LF- 48.995*GH

**Table 7** Short run estimation for REC

| Variable | Coefficient | Std. Error | t-Statistic | Prob.* |
|---|---|---|---|---|
| COINTEQ01 | -0.077 | 0.034 | -2.205 | 0.029 |
| D(CE(-1)) | 0.0497 | 0.110 | 0.453 | 0.651 |
| D(GDP) | -0.038 | 0.118 | -0.328 | 0.744 |
| D(FDI) | -0.095 | 0.065 | -1.449 | 0.150 |
| D(LF) | -43.201 | 55.624 | -0.777 | 0.439 |
| D(GH) | -19.190 | 12.980 | -1.478 | 0.142 |

Correlation LM test results (Table 8) show a probability value of 0.6556, greater than 0.05, indicating no serial correlation in the residuals. This confirms the independence of the errors, ensuring that the model's assumptions are not violated. Using the LR Test, the heteroscedasticity test yields a probability value of 0.4677, which is also greater than the significance levels of 1%, 5%, and 10%. This result indicates homoscedasticity, meaning the variance of the residuals is constant across observations. The absence of heteroscedasticity further supports the reliability of the model.

These diagnostic tests affirm that the ARDL model is appropriate and robust for explaining the relationship between economic growth and circular economy principles in ASEAN countries. The model successfully passes the required tests, ensuring that the findings are reliable and can be confidently used to inform policy and strategic decisions to promote a circular economy in the region.

**Table 8** Diagnostic test result

| Diagnostic Test | Probability |
|---|---|
| Residual Serial Correlation LM Test (VAR) | 0.6556> 0.05 |
| Heteroskedasticity (LR Test) | 0.4677 > 0.05 |

## CONCLUSION

This study examined the relationship between economic growth and circular economy (CE) adoption in ASEAN countries from 2000 to 2019, using macroeconomic indicators such as gross domestic product (GDP), foreign direct investment (FDI), labour force participation (LF), and greenhouse gas emissions (GHG). The findings from panel ordinary least squares (POLS) and panel autoregressive distributed lag (ARDL) models reveal that while GDP positively influences CE, FDI, LF, and emissions have negative effects, indicating that economic growth alone is insufficient without supportive policies. The results also underscore the importance of sustained policy efforts in the long run to promote CE adoption effectively. Despite certain limitations, including the use of annual data, the exclusion of variables like regulations, technological innovation, and public awareness, and the assumption of ASEAN as a uniform group, the study provides valuable insights linking macroeconomic structures to CE implementation. To strengthen CE outcomes, policymakers should tailor strategies to individual country contexts, promote green FDI and employment, invest in innovation and renewable energy, and raise public awareness. Future research should integrate broader CE drivers and higher-frequency data to

capture policy impacts better and support sustainable, inclusive economic development across ASEAN.

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