**JOURNAL OF ECONOMICS AND SUSTAINABILITY**
*https://e-journal.uum.edu.my/index.php/jes*

How to cite this article:
Ruslan, S. M. M., & Mokhtar, K. (2026). Green finance as a growth driver: Malaysia's transition to a sustainable economy. Journal of Economics and Sustainability. *Journal of Economics and Sustainability, 8*(2), 71-97. https://doi.org/10.32890/jes2026.8.2.5

# GREEN FINANCE AS A GROWTH DRIVER: MALAYSIA'S TRANSITION TO A SUSTAINABLE ECONOMY

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Received: 18/2/2026 Revised: 6/7/2026 Accepted: 10/7/2026 Published: 31/7/2026

## ABSTRACT

As Malaysia advances toward a sustainable economy, green finance has become a key driver of growth and environmental resilience. This study analyses its impact on GDP via capital formation, labour market dynamics, and sustainability outcomes, using ARDL and ECM models on time-series data from 1982–2023. Forecasts for 2024–2044 assess projected growth under green finance policies and structural adjustments. Results show capital investment significantly boosts GDP, while labour force expansion yields limited gains without productivity improvements. Green technology adoption may cause short-term GDP declines due to transitional costs, but it enhances long-term resilience and industrial transformation. Malaysia's robust adjustment mechanism mitigates temporary fluctuations, sustaining stability. To accelerate this shift, greater investment in green infrastructure, workforce upskilling, and targeted incentives is vital. Aligning financial systems with sustainability goals will reinforce Malaysia's position as a regional green growth leader, securing both economic prosperity and environmental stewardship.

**Keywords:** Green finance, GDP, sustainability, environmental resilience, Malaysia

## INTRODUCTION

Green finance integrates environmental sustainability into investment and financial decision-making. It includes mechanisms such as green bonds, sustainable banking, climate finance, and impact investing that promote low-carbon, resource-efficient projects (Mavlutova et al., 2023). The emergence of green finance is largely driven by climate policies, regulatory frameworks, and growing investor interest in sustainable assets. From an economic perspective, green finance is considered a crucial enabler of long-term economic stability and inclusive growth, as it aligns financial systems with environmental objectives, helping nations transition to low-carbon and climate-resilient economies (D'Orazio & Popoyan, 2019). As the global economy faces increasing pressure to decarbonize, sustainable financial instruments have gained prominence, with countries implementing policies to encourage green investments and carbon-neutral industrial development (Ordonez-Borallo et al., 2024). In particular, developing economies such as Malaysia have recognized green finance as a strategic tool for balancing economic growth with environmental conservation, making it a key area of study.

## ECONOMIC AND ENVIRONMENTAL SIGNIFICANCE

One of the primary motivations behind green finance is its dual impact on economic development and environmental sustainability. Economic theory suggests that investments in clean technologies, renewable energy, and energy-efficient infrastructure contribute directly to Gross Domestic Product (GDP) growth, while also reducing the negative externalities associated with fossil fuel-based industrialization (Mazzucato & Semieniuk, 2018). The Environmental Kuznets Curve (EKC) hypothesis further supports the idea that as economies grow, they reach a threshold where they shift towards sustainable development through increased environmental investments (Destek & Sarkodie, 2019). Green finance plays a pivotal role in accelerating this transition by facilitating capital flows into low-emission industries, green manufacturing, and circular economy models (Jiang, 2025). Empirical studies from developed and emerging economies have shown that green finance, technological innovation, and human capital significantly contribute to green economic growth, whereas financial development and economic globalization require strategic policy interventions to align with sustainability goals (Ali et al., 2024). Furthermore, financial instruments such as carbon pricing, sustainable lending policies, and Environmental, Social, and Governance (ESG) investments are increasingly used to drive low-carbon economic transformation across regions, including emerging economies (Imandojemu, 2024).

## MALAYSIA'S GREEN FINANCE LANDSCAPE

Malaysia is integrating green finance into its sustainable development strategy to achieve net-zero emissions by 2050 (SC, 2019; Fernandez et al., 2024). As an early adopter of green sukuk (Islamic green bonds), it has financed renewable energy and low-carbon infrastructure (Liu et al., 2021). The Malaysian Green Technology Financing Scheme (GTFS) further supports the adoption of clean energy and sustainable industries (Yatim et al., 2017). The Securities Commission's Sustainable and Responsible Investment (SRI) framework, introduced in 2014, led to the world's first green sukuk in 2017, mobilizing capital for clean energy and low-carbon projects (Swinburne, 2023; Capital Markets Malaysia, 2023).

Under the Twelfth Malaysia Plan and National Energy Transition Roadmap, the government aims to attract RM300 billion (≈USD 72 billion) in green investments by 2030, building on RM40 billion secured between 2017 and 2023 (The Star, 2024). To accelerate adoption, GTFS now offers RM1 billion in credit guarantees and interest rebates (GTFS, 2023), while Bank Negara Malaysia aims to allocate 50 percent of new financing to climate-friendly investments by 2026 (Swinburne, 2023).

Through these policies and initiatives, Malaysia has developed a robust green finance ecosystem involving the government, financial institutions, and capital markets. However, despite these efforts, there are limited empirical studies on how green finance has influenced Malaysia's economic trajectory. Given the country's increasing focus on sustainable investments, this study seeks to evaluate whether Malaysia's green finance policies have contributed to economic growth while ensuring environmental sustainability. This study is structured as follows: Section 2 presents a literature review, examining previous studies on green financing and economic growth. Section 3 outlines the theoretical and conceptual framework underpinning the research. Section 4 details the methodology employed in the study. Section 5 discusses the results and findings, providing an in-depth analysis. Section 6 critically evaluates current policies and offers recommendations for improvement. Finally, Section 7 presents the conclusion by summarizing key insights and implications.

## EXISTING LITERATURE ON GREEN FINANCE AND GROWTH

Previous literature shows that green finance has been widely studied in developed economies, particularly in the European Union and North America, where sustainable investment frameworks are well established (Postula & Lipski, 2025). For instance, a comprehensive analysis of green finance and sustainable development in Europe highlights the significant impact of financial development on environmental outcomes (Afzal et al., 2021). Additionally, a global review of climate finance indicates that private investments are predominantly concentrated in the U.S., Western Europe, and other developed regions, primarily targeting mitigation efforts (Climate Policy Initiative, 2023; 2024).

Studies on emerging markets, particularly in Southeast Asia, remain limited, while countries in the region are at various stages of integrating green finance into their economic structures. A World Bank report highlights that, despite rapid growth, sustainable financial markets in the ASEAN-5 economies, such as Indonesia, Malaysia, the Philippines, Thailand, and Vietnam, remain relatively small and are far from fulfilling the funding needs for their sustainability objectives[1]. Additionally, a study by Sadiq et al. (2023) emphasizes the scarcity of studies on green finance in emerging markets, especially in Southeast Asia, where countries are at different stages of incorporating green finance into their economic frameworks.

On the other hand, several studies on China, India, and Indonesia suggest that sustainable financial practices could contribute significantly to GDP growth by enhancing energy security, technological innovation, and environmental conservation. For instance, Ouyang et al. (2023) found that the green policy of China has steered capital flow to high-tech industries, which can promote the optimization and upgrading of the industrial structure, while Du et al. (2023) conclude that green financing initiatives have played a pivotal role in accelerating the transformation of China's energy industry by driving a higher share of renewable energy in the overall fuel mix, particularly in regions with well-developed markets.

[1] https://www.worldbank.org/en/country/malaysia/publication/SFSEAreport

Conversely, Sarangi (2018) indicated that India's energy transition faces financial challenges in achieving its renewable target; hindered by limited budgetary resources, private capital mobilization issues, high capital costs, and inadequate debt financing that requires innovative financial mechanisms for success. Interestingly, a study on Indonesia's green investment strategies indicates that sustainable financial policies have stimulated economic growth while improving environmental conservation (Ronaldo & Suryanto, 2022). However, despite all this, there is a study gap in assessing how green finance has impacted Malaysia's economy, particularly in terms of capital formation, labour market dynamics, and long-term economic resilience (Sharif et al., 2024). Hence, addressing this gap is crucial for understanding whether green finance policies should be expanded or restructured to maximize economic benefits in Malaysia.

## PURPOSE OF THE STUDY

The objective of this study is to examine the relationship between green finance and economic growth in Malaysia, focusing on its contributions to GDP, capital investment, and environmental sustainability. Specifically, the study will:

a) Assess the impact of green finance on economic expansion, industrial transformation, and employment creation in green sectors.
b) Evaluate the effectiveness of Malaysia's regulatory framework in incentivizing sustainable investments and identify the need for institutional support or financial reforms.

This study employs time-series and forecasting analysis to examine the relationship between green finance and economic growth in Malaysia, ensuring both empirical accuracy and policy relevance. The econometric analysis (using ARDL and ECM models) estimates the elasticity of green finance indicators on GDP, capturing both short- and long-run effects, while GDP forecasting (2024–2034) predicts future economic trends based on sustained green investments. This approach is crucial for understanding how financial mechanisms shape Malaysia's economic trajectory, while also addressing structural changes and market volatility. By integrating quantitative analysis with forecasting, this study provides data-driven insights to ensure that green finance aligns with long-term economic sustainability and resilience.

## THEORETICAL FRAMEWORK: GREEN FINANCE AND ECONOMIC GROWTH

This study is underpinned by several economic and financial theories that explain the relationship between green finance and economic growth:

### Endogenous Growth Theory

Endogenous Growth Theory (Romer, 1990) posits that long-term economic growth is driven by internal factors such as investment in human capital, innovation, and technology, which aligns with the idea that facilitating investments in renewable energy, sustainable infrastructure, and clean technology will lead to increased productivity and GDP growth.

### The Environmental Kuznets Curve (EKC) Hypothesis

The EKC hypothesis suggests that as economies grow, environmental degradation initially worsens but eventually declines after reaching a certain income level (Grossman & Krueger, 1995). Green finance thus plays a crucial rerating the transition to the post-Kuznets phase, where economic growth is achieved alongside environmental sustainability.

In their seminal work, Grossman and Krueger (1995) explored the relationship between economic growth and environmental quality, providing empirical evidence for the EKC hypothesis. Their study suggests that while the early stages of economic development may lead to environmental degradation, continued growth can improve environmental conditions as societies invest in cleaner technologies and enforce stricter environmental regulations.

### Sustainable Finance Theory

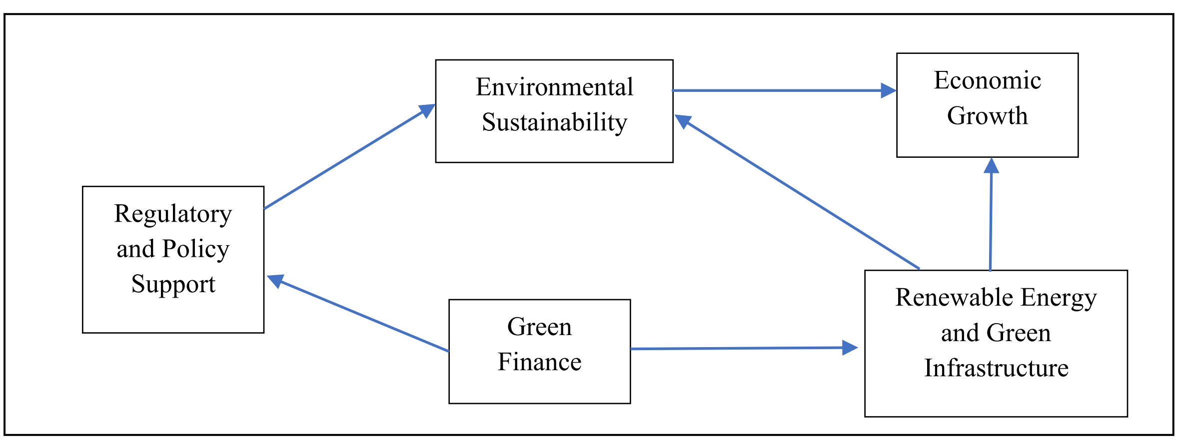
The Sustainable Finance Theory posits that financial institutions and markets can promote long-term economic stability and sustainability by incorporating Environmental, Social, and Governance (ESG) principles into their investment decisions (Bakken, 2021). This approach suggests that by prioritizing ESG factors, investors can achieve sustainable returns while contributing to broader societal goals.
Through the study, Bakken (2021) explores theoretical frameworks underpinning sustainable finance, emphasizing the integration of ESG factors into financial decision-making processes to foster economic resilience and environmental stewardship.

## CONCEPTUAL MODEL: GREEN FINANCE AND ECONOMIC GROWTH

Based on the above, a conceptual framework linking green finance, economic growth, and environmental sustainability is proposed (Figure 1).

**Figure 1.**

*Conceptual Framework: Green Finance and Economic Growth*



The conceptual framework demonstrates linkages where green finance, supported by policies and regulations, drives investments in renewable energy and green infrastructure. These investments enhance environmental sustainability, which in turn supports long-term economic growth. The interconnected elements highlight how sustainable financial practices can lead to both environmental and economic benefits. The framework is grounded in economic growth theories and empirical evidence that support the notion that green finance serves as a catalyst for sustainable development (OECD, 2015; Nguyen et al., 2025).

One of the fundamental relationships in this framework is the role of green finance in driving investments in renewable energy and green infrastructure. Green financial mechanisms, including green bonds, green loans, and sustainability-linked investments, facilitate capital allocation to renewable energy, eco-friendly transportation, and energy-efficient infrastructure (Zakari, 2022). These investments stimulate technological advancements in clean energy, improve energy security, and enhance overall economic productivity (Khan et al., 2025). By financing the development of sustainable infrastructure, green finance reduces dependency on fossil fuels, fosters innovation in clean technology, and modernizes industrial operations, thereby improving national competitiveness in the long term (OECD, 2022). Empirical studies indicate that countries with higher levels of green investment tend to experience sustained economic growth, as cleaner industries generate higher-value employment and long-term efficiency gains (UNEP, 2024). In the context of Malaysia, initiatives such as the issuance of green bonds and sukuk (Islamic green bonds), as well as the Green Technology Financing Scheme (GTFS) have successfully mobilized capital for renewable energy projects, reinforcing the transformative potential of green finance in economic expansion (Bank Negara Malaysia, 2022).

Another significant dimension of this framework is the impact of green finance on environmental sustainability. Investments in clean energy, low-carbon transportation, and resource-efficient industrial processes play a pivotal role in reducing greenhouse gas (GHG) emissions, enhancing air and water quality, and promoting climate resilience (Khan et al., 2022). The Environmental Kuznets Curve (EKC) hypothesis suggests that as an economy grows, environmental degradation initially intensifies but eventually declines once the country reaches a certain level of income and invests in cleaner technologies (Stern, 2004). In other words, green finance can hinder green growth unless supported by green energy and production, emphasizing the need for a financial system aligned with sustainability (Nguyen et al., 2024).

Furthermore, the conceptual framework highlights the direct relationship between green finance and economic growth, emphasizing how sustainable investments contribute to industrial modernisation, and job creation (Tufail et al., 2024). Economic theory suggests that investments in emerging industries such as renewable energy and green manufacturing drive long-term productivity gains by fostering industrial diversification and technological upgrading (Sachs et al., 2019). Empirical evidence from ASEAN economies, including Malaysia, indicates that increased investments in the green sector contribute to higher growth rates, greater economic resilience, and enhanced labour market outcomes (ADB, 2024). In Malaysia, studies project that green investment initiatives could contribute RM80 billion to GDP and create approximately 350,000 high-skilled jobs by 2030, demonstrating the economic benefits of sustainability-driven financial strategies (MITI, 2023).

Finally, regulatory and policy support serve as crucial enablers in shaping the green finance landscape and determining its economic impact. The success of green finance in driving sustainable economic growth largely depends on the strength of government regulations, incentives, and policy frameworks that guide investment decisions (Alamgir & Cheng, 2023). Tax incentives, subsidies, and carbon pricing mechanisms play a critical role in lowering financial barriers to green investments, encouraging both the private and public sectors to allocate capital toward sustainable projects. Central banks and financial regulators are also instrumental in establishing green lending policies and sustainable investment guidelines that influence banking and financial institutions to prioritize environmentally friendly projects (World Bank Group, 2022). In Malaysia, policies such as the Sustainable and Responsible Investment (SRI) Framework, the National Energy Transition Roadmap (NETR), and the upcoming carbon tax initiatives provide institutional and regulatory support for green financing mechanisms, ensuring that investments align with long-term economic and environmental sustainability goals (MITI, 2023). Additionally, several other initiatives have been introduced to further support green financing and sustainability efforts. Table 1 provides a summary of these schemes and their key features.

Malaysia's green financing ecosystem operates as an interconnected framework where regulatory policies, financial incentives, and market mechanisms work together to drive sustainable investments. The carbon tax and National Energy Transition Roadmap (NETR) set sustainability targets, pushing industries toward low-carbon solutions. Financial mechanisms like the Green Technology Financing Scheme (GTFS) and tax incentives lower investment risks, making green projects more attractive. Market-based tools such as the Voluntary Carbon Market (VCM) and Sustainable Aviation Fuel (SAF) production create opportunities for businesses to offset emissions and invest in clean energy alternatives.

**Table 1.**

*Summary of Green Initiatives in Malaysia*

| Initiative | Description | Operation | Targets/Outputs |
|---|---|---|---|
| Carbon Tax (Planned for 2026) | A tax on carbon emissions targeting the iron, steel, and energy sectors to encourage the adoption of low-carbon technologies. | Emitters will be taxed based on their carbon emissions. Revenue generated will fund green technology programs and research. | Incentivize industries to reduce emissions and invest in sustainable technologies. |
| Green Technology Financing Scheme (GTFS) | A scheme providing easier access to financing for green technology projects through government guarantees and interest subsidies. | Offers a 60 percent government guarantee on loans and a 2 percent interest rate subsidy for eligible green technology projects. | Facilitate RM3.5 billion in green investments by 2025, promoting the adoption of sustainable technologies. |
| Voluntary Carbon Market (VCM) | A platform for trading carbon credits to offset emissions, encouraging investments in carbon reduction projects. | Allows companies to purchase carbon credits from certified projects to offset their emissions | Enhance corporate sustainability efforts and stimulate investments in emission reduction |

| Initiative | Description | Operation | Targets/Outputs |
|---|---|---|---|
| | | voluntarily. | projects. |
| National Energy Transition Roadmap (NETR) | A strategic plan to transition towards sustainable energy sources, including the development of carbon capture, utilization, and storage (CCUS) technologies. | Implements policies and projects to reduce reliance on fossil fuels and promote renewable energy adoption. | Achieve carbon neutrality by 2050 and reduce greenhouse gas emissions by 45 percent by 2030. |
| Sustainable Aviation Fuel (SAF) Production | Initiative to produce SAF starting in 2027 to reduce carbon emissions in the aviation sector. | Develop facilities to produce SAF, aiming for an initial production capacity of one million metric tons per year. | Achieve net-zero emissions in aviation by 2050 and position Malaysia as a leading SAF producer. |

Revenue generated from carbon pricing mechanisms is reinvested into green initiatives, creating a self-reinforcing cycle of sustainability-driven economic growth. This integrated approach ensures that financial investments align with long-term economic and environmental goals, positioning Malaysia as a leader in green finance and climate resilience.

## METHODOLOGY

This study employs time-series and forecasting analysis to examine the relationship between green finance and economic growth in Malaysia. The analysis is structured into two key components:

a) Econometric Analysis – Estimating the elasticity of green finance indicators on Malaysia's GDP through regression analysis, ARDL and ECM models.

b) GDP Forecasting (2024–2034) – Applying ARDL and ECM forecasting models to predict the short and long-run Malaysia's economic growth trends.

To maintain theoretical clarity, the pre-log functional form is first presented to illustrate the fundamental relationship between green finance and economic growth. However, due to unit inconsistencies and interpretability concerns, a log transformation will be applied in the subsequent analysis to ensure proper estimation, allowing for coefficient interpretation as elasticities and enhancing model consistency.
The objective is to illustrate the impact of green financing on Malaysia's economy, which is modeled through the following function:

$$Y_t = ACF_t^{\alpha} LF_t^{\beta} GT_t^{\gamma} \tag{1}$$

where:

- $Y_t$ = GDP
- $CF_t$ = Gross Capital Formation ( % of GDP) (as a proxy for capital stock)
- $LF_t$= Labour force

- $GT_t$ = Total greenhouse gas emissions (used as an inverse proxy for green technology adoption, assuming lower emissions reflect greater adoption of clean technology).
-

## DATA COLLECTION

The data is utilized from multiple institutions to ensure a comprehensive analysis. The World Bank provides key economic indicators, including GDP and greenhouse gas emissions, while the Department of Statistics Malaysia offers labor force statistics. Additionally, Bank Negara Malaysia supplies data on capital formation, which is essential for evaluating the environmental impact of green finance initiatives. The study covers the period from 1982 to 2023, capturing long-term trends and developments in Malaysia's green finance landscape.

## REGRESSION ANALYSIS

The first part of the study applies a log-log regression model to quantify the impact of capital formation, labour force, and green technology adoption on Malaysia's GDP growth. This approach helps estimate the elasticities of these factors in contributing to economic expansion.
The following regression model is used to analyse the impact of green finance on GDP:

$$ln\, Y_t = \ln A + \alpha \ln CF_t + \beta \ln LF_t + \gamma \ln GT_t + \varepsilon_t \tag{2}$$

where:

- $Y_t$ = GDP
- $CF_t$ = Capital Formation ( % of GDP)
- $LF_t$= Labour Force
- $GT_t$ = Green Technology Proxy (Inverse of $CO_2$ Emissions)

## AUTOREGRESSIVE DISTRIBUTED LAG (ARDL) MODEL

The Autoregressive Distributed Lag (ARDL) $(p, q, r, s)$ model captures both short-run and long-run relationships between GDP and its key determinants: capital formation (CF), labour force (LF), and green technology adoption (GT). The general form of the ARDL model is:

$$GDP_t = \alpha_0 + \sum_{i=1}^{p} \beta_i GDP_{t-i} + \sum_{j=0}^{q} \gamma_j CF_{t-j} + \sum_{k=0}^{r} \delta_k LF_{t-k} + \sum_{m=0}^{s} \theta_m GT_{t-m} + \varepsilon_t \tag{3}$$

where:

- $\alpha_0$ is the intercept.
- $\beta_i$ represents the lagged effects of GDP.
- $\gamma_j$, $\delta_k$, $\theta_m$ represent the short-run effects of capital formation, labour force, and green technology adoption, respectively.
- $\varepsilon_t$ is the error term.

The long-run equation derived from the ARDL model is:

$$GDP_t = \phi_0 + \phi_1 CF_t + \phi_2 LF_t + \phi_3 GT_t + u_t \quad (4)$$

where $\phi_1$, $\phi_2$, $\phi_3$ capture the long-run equilibrium relationships.

## THE ERROR CORRECTION MODEL (ECM)

While the ARDL model confirms long-run relationships, the Error Correction Model (ECM) is tested to quantify the speed of adjustment of GDP back to equilibrium following short-term shocks. The ECM is specified as:

$$\Delta GDP_t = \lambda_0 + \sum_{i=1}^{p-1} \lambda_1 \Delta GDP_{t-i} + \sum_{j=0}^{q-1} \lambda_2 \Delta CF_{t-j} + \sum_{k=0}^{r-1} \lambda_3 \Delta LF_{t-k} + \sum_{m=0}^{s-1} \lambda_4 \Delta GT_{t-m} + \psi ECT_{t-1} + \upsilon_t \quad (5)$$

where:

- $\Delta$ represents the first difference (short-run effects).
- $\lambda_0$ is the intercept.
- $\lambda_1, \lambda_2, \lambda_3, \lambda_4$ represent short-run coefficients for GDP, capital formation, labour force, and green technology, respectively.
- $ECT_{t-1}$ is the Error Correction Term obtained from the long-run equation, measuring the speed of adjustment to equilibrium.
- $\psi$ is the error correction coefficient
- $\upsilon_t$ is the error term.

## GDP FORECASTING

To project Malaysia's future economic growth, GDP forecasting is employed to estimate trends from 2024 to 2044. The analysis integrates ECM and ARDL models to assess the short- and long-term impacts of green finance on Malaysia's economic trajectory, providing an evaluation of its sustainability and growth potential.

### *4.5.1 Short-Run GDP Forecasting Model (ECM-Based)*

The ECM is used for short-term GDP projections. This model quantifies how GDP reacts to short-term shocks and adjusts toward the long-run equilibrium.

$$\Delta GDP_t = \lambda_0 + \sum_{i=1}^{p-1} \lambda_1 \Delta GDP_{t-i} + \sum_{j=0}^{q-1} \lambda_2 \Delta CF_{t-j} + \sum_{k=0}^{r-1} \lambda_3 \Delta LF_{t-k} + \sum_{m=0}^{s-1} \lambda_4 \Delta GT_{t-m} + \psi ECT_{t-1} + \upsilon_t \quad (6)$$

where:

- $\Delta$ represents the first difference operator, capturing short-run changes.
- $\lambda_0$ is the constant term.
- $\lambda_1, \lambda_2, \lambda_3, \lambda_4$ are short-run coefficients for GDP, capital formation, labour force, and green technology adoption, respectively.

- $ECT_{t-1}$ is the error correction term, capturing the speed at which GDP returns to its long-run equilibrium.
- $\psi$ is the error correction coefficient
- $\upsilon_t$ is the stochastic error term.

The short-run forecasting strategy involves utilizing historical data to estimate short-term variations in GDP, with a particular focus on key determinants such as capital formation, labour force dynamics, and the adoption of green technology. Given the economy's tendency to adjust rapidly toward equilibrium, the ECM term is incorporated to capture the speed of adjustment following deviations from the long-run equilibrium. Additionally, short-term forecasts must remain adaptable to economic fluctuations, including external shocks, policy interventions, and market disruptions, ensuring that projections accurately reflect the evolving macroeconomic landscape.

## LONG-RUN GDP FORECASTING MODEL (ARDL-BASED)

For long-term GDP projections, the ARDL model is incorporated, which captures the structural and long-term equilibrium relationships between GDP and its key drivers.

$$GDP_t = \phi_0 + \phi_1 CF_t + \phi_2 LF_t + \phi_3 GT_t + u_t \tag{7}$$

Where:

- $\phi_0$ is the constant term.
- $\phi_1$, $\phi_2$, $\phi_3$ capture the long-run equilibrium effects of capital formation, labour force, and green technology adoption, respectively.
- $u_t$ is the error term.

The long-run forecasting strategy focuses on estimating structural GDP growth by analysing historical relationships between GDP, capital formation, labour force dynamics, and the adoption of green technology. This approach leverages projected trends in these key economic drivers to simulate GDP growth trajectories over the next two decades, providing a forward-looking perspective on economic development. Additionally, the model integrates policy-driven growth factors, such as infrastructure expansion and investments in renewable energy, to refine long-term projections and account for the influence of government interventions and sustainability initiatives on economic performance.

## RESULTS AND DISCUSSION

As economic growth depends on factors like capital investment, labour force growth, and technological progress, analysing their roles assists in understanding how these influence GDP and overall economic performance. By estimating the elasticities (*α, β, γ*), the following analysis quantifies the extent to which changes in capital formation, labour supply, and green technology adoption influence Malaysia's GDP. The following sections present the statistical interpretation and broader economic implications for the country's development trajectory.

## REGRESSION ANALYSIS

The regression analysis in Table 2 presents key insights into the short-term relationships between GDP growth and its determining factors. The $R^2$ value of 0.597 (adjusted $R^2 = 0.562$) indicates that about 59.7 percent of short-term GDP fluctuations can be explained by changes in capital formation, labour force, and green technology proxy. Among the explanatory variables, capital formation elasticity (0.453, $p < 0.01$) remains positive and statistically significant, reinforcing its crucial role in driving Malaysia's economic expansion, where a 1 percent increase in capital formation leads to a 0.45 percent rise in GDP growth. However, the labour force elasticity (-0.872, $p = 0.203$) is negative and statistically insignificant, implying that short-term fluctuations in labour supply do not have a direct impact on GDP.

This suggests that merely increasing the workforce is insufficient for economic growth unless complemented by capital investment, technological advancement, or productivity-enhancing factors. Interestingly, green technology adoption (elasticity = -1.145, $p < 0.01$) is associated with a 1.15 percent decline in GDP growth, highlighting potential short-term economic costs related to structural adjustments, high investment requirements, and shifts away from carbon-intensive industries. While this suggests that Malaysia's transition to a greener economy may have initial economic trade-offs, it does not necessarily contradict the long-term benefits of sustainability-driven growth. Lastly, the constant term (0.0491, $p = 0.066$) is borderline significant, suggesting an underlying annual GDP growth trend of approximately 4.91 percent, even after accounting for variations in capital, labour, and green technology. These findings emphasize the importance of balancing short-term economic growth with long-term structural changes, particularly in capital investment strategies and sustainable technology adoption.

**Table 2.**

*Regression Analysis*

| Variable | Elasticity | p-value | Interpretation |
|---|---|---|---|
| Constant term | 0.049 | 0.066 | An annual GDP growth trend of approximately 4.91 percent, even after accounting for variations in capital, labour, and green technology. |
| Capital Formation ($\Delta \boldsymbol{lnK}$) | 0.453 | < 0.01 | A 1 percent increase in capital formation leads to a 0.45 percent increase in GDP growth. |
| Labour Force ($\Delta \boldsymbol{lnL}$) | -0.8725 | 0.203 (Not Significant) | A 1 percent increase in the labour force does not significantly affect GDP growth in the short term. |
| Green Technology Proxy ($\Delta \boldsymbol{lnGTech}$) | -1.145 | < 0.01 | A 1 percent increase in green technology adoption (lower emissions) is associated with a 1.15 percent decrease in GDP growth, suggesting short-term economic |

| Variable | Elasticity | p-value | Interpretation |
|---|---|---|---|
| | | | costs. |
| R-squared | 0.597 | - | The model explains 59.7 percent of short-term GDP fluctuations. |

The findings highlight important considerations regarding the short-term *versus* long-term effects of labour force expansion and green technology adoption on GDP. Since these factors may influence economic growth with a time lag, the current model may not fully capture their long-run impacts. Hence, a dynamic model such as ARDL could provide deeper insights by distinguishing between immediate and delayed effects.

Additionally, the negative short-term impact of green technology adoption suggests that transitioning to a more sustainable economy may come with initial economic costs. However, these costs are likely temporary, as higher energy efficiency, technological innovation, and spillover benefits from green investments could enhance productivity and economic performance over time. Similarly, the negative and insignificant labour elasticity implies that simply increasing the workforce is not enough to drive GDP growth. Instead, economic expansion depends on labour productivity improvements, which can be achieved through better education, skill development, and investments in human capital. This underscores the need for policies that not only increase labour supply but also enhance the efficiency and contribution of workers to long-term economic growth.

## UNIT ROOT TESTS

Prior to conducting the dynamic model tests, the Augmented Dickey-Fuller (ADF) and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests were conducted to determine the order of integration for each variable, which helps identify whether they are stationary at the level $I(0)$ or require first-differencing to become stationary $I(1)$.

**Table 3.**

*Unit Root Tests*

| Variables | Order of Integration | Test Statistic | p-value |
|---|---|---|---|
| GDP Growth (log_GDP) | ADF I(0) | -1.14994 | 0.694752 |
| GDP Growth (log_GDP) | KPSS I(0) | 0.878529 | 0.01 |
| GDP Growth (log_GDP) | ADF I(1) | -5.17668 | 9.81E-06 |
| GDP Growth (log_GDP) | KPSS I(1) | 0.12219 | 0.1 |
| Capital Formation (log_Capital) | ADF I(0) | -2.12333 | 0.235239 |
| Capital Formation (log_Capital) | KPSS I(0) | 0.522487 | 0.036602 |
| Capital Formation (log_Capital) | ADF I(1) | -5.50794 | 2.00E-06 |
| Capital Formation (log_Capital) | KPSS I(1) | 0.061517 | 0.1 |
| Labour Force (log_Labour) | ADF I(0) | -1.72901 | 0.416229 |

| Variables | Order of Integration | Test Statistic | p-value |
|---|---|---|---|
| Labour Force (log_Labour) | KPSS I(0) | 0.900111 | 0.01 |
| Labour Force (log_Labour) | ADF I(1) | -5.37573 | 3.81E-06 |
| Labour Force (log_Labour) | KPSS I(1) | 0.281699 | 0.1 |
| Green Technology Proxy (log_GTech) | ADF I(0) | -2.18536 | 0.211601 |
| Green Technology Proxy (log_GTech) | KPSS I(0) | 0.85994 | 0.01 |
| Green Technology Proxy (log_GTech) | ADF I(1) | -1.8344 | 0.363524 |
| Green Technology Proxy (log_GTech) | KPSS I(1) | 0.613954 | 0.021368 |

Based on Table 3, all variables appear to be $I(1)$ (integrated of order one), meaning they are non-stationary at the level but become stationary after first differentiation. Since the variables are $I(1)$, an ARDL model and ECM are appropriate for analysing both short-term and long-term dynamics (Pesaran et al., 2001; Engle & Granger, 1987). While Johansen cointegration test is valid, ARDL is more preferable because it works well with small samples, estimates both short- and long-run relationships in one model, optimizes lag selection, and provides an automatic ECM interpretation (Pesaran et al., 2001).

## AUTOREGRESSIVE DISTRIBUTED LAG (ARDL) MODEL

The ARDL model results provide significant insights into the relationships between GDP, capital formation, labour force, and green technology adoption in Malaysia (Table 4). With an R-squared value of 0.993 (Adjusted $R^2 = 0.991$), the model explains 99.3 percent of the variation in GDP, indicating a strong fit. The lagged GDP coefficient (0.878, $p < 0.01$) highlights the persistence of economic growth, confirming that Malaysia's GDP follows a dynamic adjustment process. Capital formation has a contrasting impact in the short and long run, with current capital formation (0.483, $p = 0.003$) positively influencing GDP, while lagged capital formation (-0.470, $p = 0.001$) suggests diminishing returns or adjustment effects over time. Interestingly, labour force changes do not significantly affect GDP in the short run, as indicated by both the current (-0.875, $p = 0.282$) and lagged (0.788, $p = 0.280$) coefficients, hinting at possible structural inefficiencies or skill mismatches.

**Table 4**

*ARDL and ECM Results*

| Variable | ARDL Coefficient | ARDL p-value | ECM Coefficient | ECM p-value |
|---|---|---|---|---|
| Lagged GDP (log_GDP_lag1) | 0.8777 | < 0.01 | | |
| Capital Formation (log_Capital) | 0.4834 | 0.003 | 0.446 | < 0.01 |
| Lagged Capital Formation (log_Capital_lag1) | -0.4702 | 0.001 | | |
| Labour Force (log_Labour) | -0.875 | 0.282 | -0.8512 | < 0.01 |
| Lagged Labour Force (log_Labour_lag1) | 0.7878 | 0.28 | | |
| Green Technology Proxy (log_GTech) | -1.025 | 0.014 | -1.1604 | < 0.01 |
| Lagged Green Tech Proxy (log_GTech_lag1) | 0.7759 | 0.094 | | |

| Variable | ARDL Coefficient | ARDL p-value | ECM Coefficient | ECM p-value |
|---|---|---|---|---|
| Error Correction Term (ECM Residual) | | | 1.0136 | < 0.01 |
| Durbin-Watson Statistic | 1.824197 | | 0.290903 | |
| R-Squared | 0.99308142 | | 0.9551727 | |

The impact of green technology adoption is also mixed; in the short run, the green technology proxy (-1.025, p = 0.014) negatively affects GDP, likely due to transition costs, while its lagged effect (0.775, p = 0.094) suggests long-term economic benefits. The Durbin-Watson statistic (1.824) indicates no severe autocorrelation, confirming model stability. These findings highlight the critical role of continuous capital investment in sustaining GDP growth, the need for policies that mitigate the short-term costs of green technology adoption while maximizing long-term gains, and the importance of improving labour productivity rather than relying solely on labour force expansion to drive economic growth.

## THE ERROR CORRECTION MODEL (ECM)

The ECM is estimated to quantify how GDP adjusts back to equilibrium after short-term shocks, following the confirmation of long-run relationships in the ARDL model (Table 3). The ECM effectively captures both short-run GDP dynamics and long-run adjustments, as evidenced by an R-squared value of 0.955 (Adjusted $R^2 = 0.950$), indicating that 95.5 percent of short-term variations in GDP growth are explained by the model. The key component, the Error Correction Term (1.0136, $p < 0.01$), suggests a rapid and strong correction, with deviations from the long-run equilibrium being almost completely adjusted within one period. This confirms the robustness of Malaysia's economic stability mechanisms. In the short run, capital formation plays a crucial role, with a 1 percent increase leading to a 0.45 percent boost in GDP growth ($p < 0.01$), highlighting the immediate benefits of investment. However, labour force expansion has a negative short-run impact, as a 1 percent increase in the labour force reduces GDP growth by 0.85 percent ($p < 0.01$). This suggests that labour market inefficiencies, skill mismatches, or structural unemployment may limit productivity gains.

Similarly, green technology adoption, measured as a reduction in $CO_2$ emissions, decreases GDP growth by 1.16 percent in the short term ($p < 0.01$), reinforcing the notion that transitioning to greener energy sources entails initial economic costs. These may arise from industrial restructuring, new technology investments, or the phase-out of fossil-fuel-dependent sectors. Despite this, the long-run ARDL results indicate that green technology will eventually contribute positively to GDP. The Durbin-Watson statistic (0.291) suggests some autocorrelation in residuals, indicating that further model refinements may be necessary. From a policy perspective, Malaysia’s strong equilibrium adjustment capacity suggests long-term economic stability. However, growth should be driven by continued investment-friendly policies, given the positive short-run impact of capital formation. Although not explicitly measured in this study, labour market inefficiencies can influence the effectiveness of green finance and capital investment in driving economic growth. Hence, ensuring that the workforce is equipped with the necessary skills to complement green technology adoption is crucial for maximizing productivity gains.

The short-term costs of green technology adoption, on the other hand, suggest that it should be managed through incentives such as R&D subsidies, tax breaks, and phased transition strategies to mitigate economic disruptions. These measures help offset the initial financial burden on businesses, encourage investment in clean technologies, and prevent sudden economic shocks, particularly in industries reliant on carbon-intensive processes (Popp, 2019; Acemoglu et al., 2012). R&D subsidies stimulate innovation, accelerating the development of cost-effective green solutions, while tax breaks lower operational costs, making sustainable practices more financially viable (Johnstone et al., 2010; Noailly & Ryfisch, 2015). A phased transition strategy ensures that businesses and workers have adequate time to adapt, reducing risks of job losses and industrial slowdowns (Fankhauser et al., 2008). Thus, enabling economies to transition towards sustainability without compromising short-term economic stability. In conclusion, while the ARDL model confirms the long-run influence of capital formation and green technology on GDP, the ECM demonstrates rapid economic adjustment after short-term shocks. Capital investment remains the strongest short-run driver of growth, while labour expansion without productivity improvements may be detrimental. Therefore, the economic costs of green transition must be strategically addressed to ensure long-term benefits without hampering short-term stability.

## DIAGNOSTIC TESTS

Before proceeding with forecasting, it is important to assess whether the model is robust and reliable for predictive purposes. Table 5 indicates statistical assumptions for reliability.

**Table 5**

*Diagnostic Test*

| Tests | Test Statistic | p-value | Interpretation |
|---|---|---|---|
| Jarque-Bera (ARDL) | 0.225 | 0.893 | The ARDL model is normally distributed. |
| Jarque-Bera (ECM) | 3.134 | 0.208 | The ECM model is approximately normal. |
| Breusch-Godfrey (ARDL) | 2.691 | 0.260 | The ARDL model does not exhibit significant autocorrelation. |
| Breusch-Godfrey (ECM) | 27.893 | 8.77E-07 | The ECM model suffers from autocorrelation. |
| Breusch-Pagan (ARDL) | 6.4031 | 0.493 | The ARDL model does not suffer from heteroskedasticity. |
| Breusch-Pagan (ECM) | 4.113 | 0.390 | The ECM model does not suffer from heteroskedasticity. |

The diagnostic tests evaluate whether the ARDL and ECM models satisfy key statistical assumptions for reliability. The normality test (Jarque-Bera Test) confirms that the residuals of both models are approximately normally distributed, with the ARDL model showing better adherence (Test Statistic = 0.225, p-value = 0.893) compared to the ECM model (Test Statistic = 3.134, p-value = 0.209). Since both p-values are greater than 0.05, the null hypothesis is accepted, indicating no major concerns with normality. In the autocorrelation test (Breusch-Godfrey LM Test), the ARDL model does not exhibit significant autocorrelation (Test Statistic = 2.691, p-value = 0.260), making it suitable for reliable inference. However, the ECM model fails this test (Test Statistic = 27.894, p-value = 0.0000008768), indicating strong autocorrelation, which can bias forecasting results. This suggests the ECM model requires corrective measures such as Newey-West standard errors, adding autoregressive terms, or using an ARDL-based ECM (Chandio et al., 2019).

The heteroskedasticity test (Breusch-Pagan Test) shows that the ARDL and ECM models maintain homoskedasticity, confirming that their residuals have constant variance and enhancing model reliability. Based on these diagnostics, the ARDL model is suitable for forecasting, as it passes all key tests, while the ECM model requires correction before it can be used for forecasting due to the presence of autocorrelation. Following that, Table 6 shows the corrected ECM model for autocorrelation using Newey-West heteroskedasticity and autocorrelation-consistent (HAC) standard errors.

**Table 6**

*Corrected ECM Model*

| Variable | ECM Coefficient (Corrected) | ECM p-value (Corrected) |
|---|---|---|
| Constant | 0.048 | < 0.01 |
| Capital Formation (d_log_Capital) | 0.446 | < 0.01 |
| Labour Force (d_log_Labour) | -0.851 | < 0.01 |
| Green Technology Proxy (d_log_GTech) | -1.160 | < 0.01 |
| Error Correction Term (ECM Residual) | 1.013 | < 0.01 |
| R-Squared | 0.955 | |
| Durbin-Watson Statistic | 0.290 | |

The ECM model has been corrected for autocorrelation using Newey-West heteroskedasticity and autocorrelation-consistent (HAC) standard errors, enhancing the reliability of coefficient estimates. After correction, the standard errors are more robust, ensuring that the statistical inferences are more accurate. The model retains its strong explanatory power, with an R-squared value of 0.955 (Adjusted $R^2 = 0.950$), confirming that it explains 95.5 percent of the variation in short-term GDP growth. The short-run impact of capital formation remains positive and significant (0.4460, $p < 0.01$), reaffirming that a 1 percent increase in capital formation leads to a 0.45 percent rise in GDP growth. Similarly, the negative short-run impact of labour force expansion (-0.851, $p < 0.01$) remains significant, indicating that increasing the labour force without productivity improvements can hinder growth. The negative effect of green technology adoption (-1.160, $p < 0.01$) is also reinforced, suggesting that while green transitions impose short-term economic costs, the long-term benefits remain promising.

Importantly, the error correction term (1.013, $p < 0.01$) remains highly significant, confirming that GDP growth rapidly adjusts back to its long-run equilibrium, with a speed of adjustment close to instantaneous correction. These corrected results strengthen the credibility of the ECM model and confirm its robustness after addressing autocorrelation concerns.

## SHORT-RUN AND LONG-RUN FORECASTING ANALYSIS

The following forecast results provide insights into short-term and long-term GDP trajectories (in USD) for Malaysia from 2024 to 2044, using the refined ECM and ARDL models (Table 7).

**Table 7**

*ARDL and ECM Forecasting*

| Year | ARDL Forecasted GDP (billion USD) | ECM Forecasted GDP (billion USD) |
|---|---|---|
| 2024 | 408.65 | 405 |
| 2025 | 416.20 | 411 |
| 2026 | 419.88 | 416 |
| 2027 | 421.13 | 422 |
| 2028 | 421.37 | 427 |
| 2029 | 421.33 | 433 |
| 2030 | 421.26 | 439 |
| 2031 | 421.22 | 445 |
| 2032 | 421.20 | 451 |
| 2033 | 421.20 | 457 |
| 2034 | 421.20 | 463 |
| 2035 | 421.20 | 469 |
| 2036 | 421.20 | 475 |
| 2037 | 421.20 | 482 |
| 2038 | 421.20 | 488 |
| 2039 | 421.20 | 495 |
| 2040 | 421.20 | 501 |
| 2041 | 421.20 | 508 |
| 2042 | 421.20 | 515 |
| 2043 | 421.20 | 522 |
| 2044 | 421.20 | 529 |

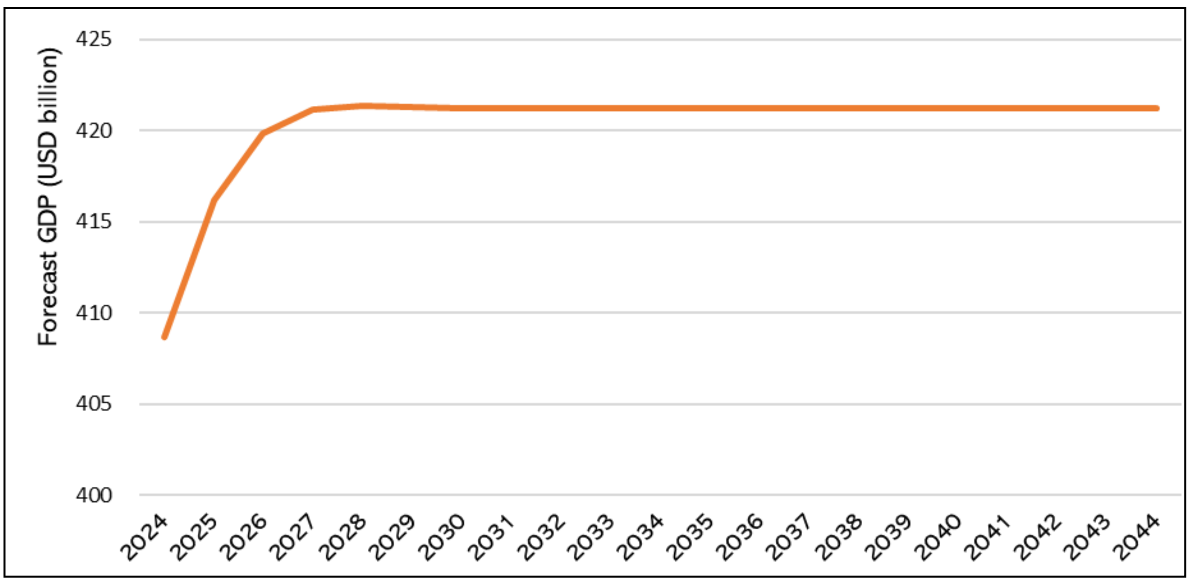
The GDP forecasts for Malaysia from 2024 to 2044, based on the ECM and ARDL models, provide key insights into the country's short-term and long-term economic trajectory. In the short term, the ECM model predicts steady GDP growth, reflecting economic stability and resilience through a highly significant error correction term (1.013, $p < 0.01$) (Table 6). This is expected since ECM estimates short-term deviations and adjusts back to equilibrium. However, the ECM forecast does not capture the structural changes, productivity growth, and technological advancements, making it impractical for long-term forecasting. To counter this, the ARDL model projects a more sustainable GDP growth path, capturing structural relationships between GDP, capital formation, labour force, and green technology adoption, integrating structural growth models for a more realistic trajectory in the long run. The ARDL forecast suggests gradual economic expansion following an initial adjustment phase, confirming that Malaysia's long-term fundamentals remain strong. However, the forecasted values remain constant from

2032 onwards due to the long-run equilibrium constraint inherent in the model, which assumes that the economy eventually stabilizes at a steady-state level. Since the ARDL long-run equation defines this equilibrium, the ECM, which captures short-term deviations, cannot drive GDP beyond this limit once the equilibrium is reached.

A comparison of both models highlights key insights: while ECM forecasts short-term GDP fluctuations and rapid corrections, ARDL provides a stable long-term growth trajectory. The ARDL model now projects a more realistic outlook, correcting previous underestimations due to incorrect lag selection (Figure 2). Importantly, the progression captured by ECM does not significantly impact long-term ARDL projections, reinforcing Malaysia's economic resilience and the importance of structural policies.

**Figure 2**

*Long-Term GDP Forecast*




To ensure sustainable growth, Malaysia should consider investment in infrastructure and technology-driven sectors, as higher capital formation enhances productivity and economic expansion. Increased investment facilitates technological adoption, improving efficiency and competitiveness, which in turn drives GDP growth. However, while green technology adoption supports long-term sustainability, it entails initial costs due to industry restructuring and high capital investment. Without adequate support, these disruptions may slow economic growth. To mitigate this, strategic incentives such as tax breaks and R&D subsidies can lower investment barriers, facilitating a smooth transition to clean energy and ultimately enhancing energy efficiency, reducing environmental costs, and attracting green investments.
Since labour force expansion alone does not significantly drive GDP growth, emphasis should shift to upskilling, automation, and productivity enhancements. A highly skilled and automated workforce improves output per worker, leading to higher wages, increased efficiency, and greater labour market resilience. Without these interventions, merely expanding the workforce may result in diminishing returns and inefficiencies, constraining long-term economic gains.

Additionally, macroeconomic stability is critical for maintaining economic adjustments and long-term growth momentum. Flexible fiscal and monetary policies help stabilize inflation, interest rates, and government spending, which in turn enhances business confidence, investment growth, and financial stability. If policies are not adaptive, economic volatility could undermine capital investments and slow GDP expansion. By integrating these strategies, Malaysia can achieve higher productivity, a seamless green transition, improved labour efficiency, and economic stability. These measures function synergistically, where investment drives technological progress, green finance supports sustainable expansion, workforce development enhances economic output, and macroeconomic stability fosters resilience, reinforcing Malaysia's global competitiveness.

## POLICY RECOMMENDATIONS AND MALAYSIA'S CURRENT GOVERNMENT ACTIONS

Malaysia has made significant strides in green financing and economic growth policies, aligning with key recommendations from GDP forecast analyses. However, challenges persist in policy execution, structural reforms, and long-term sustainability. Table 8 presents key policy insights derived from the ARDL and ECM analyses, highlighting current government actions, policy recommendations, and their expected economic impact. These findings offer evidence-based strategies to enhance investment effectiveness, green technology adoption, labour market productivity, and macroeconomic stability for Malaysia's sustainable economic growth.

To date, Malaysia has introduced several investment and infrastructure initiatives to boost economic growth, including the Green Technology Financing Scheme (GTFS), which has mobilized RM6.26 billion in green projects, creating over 5,500 jobs (Malaysian Green Technology Corporation and Climate Change Centre, 2020), and tax incentives such as the Green Investment Tax Allowance (GITA) & Green Income Tax Exemption (GITE), attracting RM9 billion in green investments since 2016, benefiting over 1,000 projects in renewable energy, energy efficiency, electric vehicles, and green buildings (MGTC, 2024). Additionally, the Johor-Singapore Special Economic Zone (SEZ) is set to attract high-value industries such as AI, renewable energy, and smart logistics (Yahoo, 2025).

While these initiatives align with recommendations to enhance capital formation, the ECM result indicates that a 1 percent increase in capital investment raises GDP by 0.45 percent, suggesting that current investment levels may not be enough for long-term transformation. ECM findings further reveal that Malaysia's economy corrects short-term imbalances quickly, but capital-intensive sectors require strategic planning to ensure sustained growth. To overcome this, over-reliance on tax incentives rather than structural reforms could limit long-term economic stability (OECD, 2022). Therefore, public sector investment in green infrastructure (e.g., green transport, smart cities) should be expanded to complement private sector efforts, and policy continuity beyond election cycles must be ensured to maintain investor confidence (UNEP, 2024). On the broader side, Malaysia's commitment to a Net-Zero economy by 2050 through the National Renewable Energy Roadmap (NETR) and National Energy Policy (2022-2040) provides a strong framework for its green transition (Ministry of Economy, 2021; 2023). For instance, Malaysia demonstrates its commitment to expanding renewable energy through the Renewable Energy Policy and Action Plan, aiming to achieve a 24 percent share of renewable energy in the national energy mix by 2050.

**Table 8.**

*Current Government Actions versus Policy Recommendations*

| **Policy Area** | **Current Government Actions** | **Policy Recommendation** | **ARDL & ECM Insights** | **Key Recommendations** |
|---|---|---|---|---|
| *Source of Insights* | *Derived from Malaysia's current initiatives and masterplans* | *Derived from content analysis of policy documents* | *Empirical results from ARDL and ECM model estimations* | *Policy implications drawn from research findings* |
| Investment & Infrastructure | GTFS mobilized RM6.26 billion in green projects, tax incentives attracted RM9 billion in investments, Johor-Singapore SEZ. | Enhance investment-friendly policies, prioritize public-private partnerships (PPPs) and FDI. | Capital formation increases GDP by 0.45 percent, but the scale of investment is insufficient for long-term transformation. | Increase public sector investment in green infrastructure and ensure policy continuity beyond election cycles. |
| Green Technology Transition | National Renewable Energy Roadmap (NETR), SAF production by 2027, net-zero commitment by 2050. | Implement a phased green transition, minimize economic disruptions, and introduce sector-specific incentives. | Green technology adoption initially reduces GDP (-1.16 % per 1 percent $CO_2$, reduction), though ARDL suggests long-term recovery. | Accelerate renewable energy adoption, introduce transition funds, and reduce reliance on foreign green technology. |
| Labour Market Productivity | Semiconductor industry expansion, Johor-Singapore SEZ to create 20,000 high-skill jobs. | Focus on workforce upskilling, prioritize high-productivity industries (AI, semiconductors, automation). | Labour force expansion alone does not significantly impact GDP (-0.87 % per 1 percent increase); productivity is key. | Launch national AI and digital skills programs, offer automation tax incentives, address brain drains. |
| Macroeconomic Stability | Energy surplus management, data center investments, but concerns over fossil fuel dependence remain. | Maintain flexible fiscal and monetary policies to ensure economic stability while enabling green growth. | Malaysia's economy corrects short-term imbalances rapidly, but structural inefficiencies still exist. | Phase out coal dependency faster, balance data centre expansion with sustainable energy policies. |

Complementing this effort, the Renewable Energy Act 2011 establishes a feed-in tariff (FIT) system, ensuring fixed rates for energy producers and fostering investment in the sector (IEA, 2025). While these efforts align with recommendations for a phased green transition, ECM results indicate that green technology adoption initially lowers GDP by 1.16 percent per 1 percent reduction in $CO_2$ emissions, reflecting transition costs such as industry restructuring and investment risks.

Furthermore, it is also shown that while short-term economic disruptions occur, the economy rapidly adjusts back to equilibrium, meaning long-term benefits will likely outweigh short-term costs. The slow pace of renewable energy adoption (currently below 25 %) remains a key challenge, given the government's aims to increase the share for 31 percent renewable energy capacity by 2025 (SEDA, 2025). To accelerate green growth, Malaysia must strengthen its implementation of green industrial policy, combining innovation, technology transfer, market creation, and robust governance to achieve sustainable economic growth and decarbonization (United Nations Department of Economic and Social Affairs, 2023).

Malaysia has been investing in high-tech industries, but labour productivity remains a challenge. The country still relies on low-cost production and foreign workers, which slows productivity growth and wage increases. To address this, the government is promoting high-tech industries and skilled labour to reduce dependence on foreign workers. Malaysia is also positioning itself as a semiconductor and AI hub, with projects like the Johor-Singapore SEZ expected to create 20,000 high-skill jobs (MIDA, 2021; WSJ, 2025). Nonetheless, ARDL results indicate that labour force expansion alone does not significantly drive GDP growth (-0.87 percent per 1 percent increase in labour force), highlighting that Malaysia's economic growth is more dependent on productivity improvements rather than workforce expansion. These findings reinforce that automation, upskilling, and workforce efficiency, rather than labour quantity, are critical for long-term economic gains. Skills mismatches and brain drain remain major obstacles, as many high-skilled workers seek better opportunities abroad (OECD, 2022). To address these issues, Malaysia should launch national AI and digital skills programs to future-proof the workforce, offer fiscal incentives for companies investing in automation, and increase salaries in high-tech sectors to retain talent and attract R&D investment (ILO, 2018).

## CONCLUSION

As Malaysia navigates an evolving economic landscape, the country has made notable strides in green financing, economic restructuring, and energy transition. These efforts reflect a commitment to sustainable development and long-term economic resilience. However, the road ahead is marked by challenges in policy execution, workforce transformation, and structural reforms. Addressing these gaps is crucial to ensuring that Malaysia's economic policies translate into tangible growth and long-term stability. By leveraging robust economic models and strategic policy interventions, Malaysia has the potential to strengthen its economic fundamentals, enhance sustainability, and position itself as a regional leader in green growth.

The findings show that Malaysia's economic policies are progressing in the right direction, particularly in green financing, economic restructuring, and energy transition. However, significant challenges persist in execution, workforce transformation, and structural reforms. To sustain long-term growth, the government must scale up public sector investments in green infrastructure, accelerate renewable energy adoption, and prioritize workforce upskilling.

While ARDL and ECM models confirm Malaysia's short and long-term economic fundamentals, the success of these policies hinges on effective execution, forward-looking planning, and strategic alignment between green initiatives and economic growth objectives. The country's economy is expected to remain stable in the short term and grow steadily over the next two decades, but achieving long-term success will require targeted structural adjustments, particularly in the labour market and green technology sectors.

To sum up, Malaysia's positive economic outlook is reinforced by a strong equilibrium adjustment mechanism, sustainable growth fundamentals, and policy-driven capital investments. To unlock its full economic potential, the country must adopt strategic policies that drive capital formation, technological innovation, and a sustainable energy transition, ensuring resilient and inclusive long-term growth in the future.

## ACKNOWLEDGEMENTS

This research was supported by the Fundamental Research Grant Scheme provided by the Ministry of Higher Education of Malaysia: FRGS/1/2021/ICT06/UMT/02/1, vot 59675.

## DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work, the authors used Gemini, Bing Copilot and Perplexity.ai to augment the effectiveness of the written content, thereby enhancing its overall impact. Nonetheless, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

## DISCLOSURE STATEMENT

The authors declare that they have no conflicts of interest related to the publication of this article. No financial or personal relationships with third parties that could influence the work have affected the content of this manuscript. This includes but is not limited to, employment, consultancies, honoraria, and ownership of stocks or shares. The authors have also ensured that any potential conflicts related to project funding or other forms of support are disclosed.

## DATA AVAILABILITY STATEMENT

The datasets generated and analysed during the current study are not publicly available but are available from the corresponding author on reasonable request.

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