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RESEARCH ARTICLE

The Dynamic Impact of Imports, Exports, and Capital Formation on GDP in Malaysia Using VECM Approach

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ABSTRACT

This research aims to analyze the relationship between imports, exports, capital formation, and GDP in Malaysia using monthly time series data from 2015 to 2023. Based on ADF unit root test and Johansen Juselius cointegration test, this study confirms that there is a long-term stable cointegration relationship between the variables. The Granger causality test results show that there is a bidirectional causal relationship between imports and GDP, while GDP has a unidirectional causal relationship with capital formation. However, no significant Granger causality relationship was found between exports and GDP. In addition, by constructing a Vector Error Correction Model (VECM), the short-term dynamics and long-term equilibrium relationships between variables were further analyzed. Research has found that the error correction term has a significant negative impact on changes in GDP, indicating the existence of an auto correction mechanism in the system to maintain long-term equilibrium. These findings highlight the important role of imports in driving economic growth, not only by reflecting domestic demand but also by bringing in foreign technology and capital goods. Policymakers should consider the productive role of imports when designing strategies to enhance Malaysia's economic development.

INTRODUCTION

Gross Domestic Product (GDP) is one of the most widely used indicators for assessing the overall economic performance and development of a country. It reflects the total value of goods and services produced within a nation over a given period and serves as a key benchmark for evaluating economic health (Hashim et al., 2024). In Malaysia, GDP growth is often used to measure the effectiveness of national policies and to monitor economic trends (Malaysia, B. N., 2020). As Malaysia continues to integrate into the global economy, understanding the key drivers of its GDP growth becomes increasingly important.

Previous research has identified a wide range of microeconomic and macroeconomic factors that influence economic growth, including consumption, government spending, exports, exchange rates, foreign direct investment, imports, and inflation (Kogid et al., 2010). Among these factors, imports and exports play a central role (Romli et al., 2022). Dedeoğlu and Kaya (2013) found that in OECD countries, exports and imports significantly contribute to GDP growth by enabling technology transfer and improving resource allocation. Similarly, Wolla (2018) emphasized that imports can enhance domestic productivity by introducing advanced foreign goods, services, and technology.

Moreover, Ramzan et al. (2019) highlighted that trade openness has a significant impact on GDP growth, with an even stronger effect when total factor productivity (TFP) is taken into account. They demonstrated that trade openness fosters GDP growth by enhancing TFP, emphasizing the critical role TFP plays in the relationship between trade openness and GDP. Similarly, Fatima et al. (2020) found that trade openness not only directly contributes to GDP growth but also indirectly stimulates economic growth by promoting the accumulation of human capital.

Futhermore, Asmare & Haiyun (2019) studied the short-term and long-term relationships between Ethiopia's GDP growth, exports, and imports, as well as their causal relationships. They found through ARDL and ECM models that imports have a significant positive impact on GDP growth in the short term, and there is a bidirectional Granger causality relationship between exports and imports. Karras (2003) employed fixed effects models and OLS estimation techniques to control for both country-specific and time-specific effects, aiming to more accurately assess the impact of trade openness on GDP. The study utilized two datasets: annual data from 56 countries spanning 1951 to 1998, and data from 105 countries covering the period from 1960 to 1997. The empirical findings reveal that trade openness exerts a significant and sustained positive effect on GDP growth. Gries & Redlin (2012) used panel causality analysis to demonstrate a significant causal relationship between trade openness and GDP growth, further supporting the promoting effect of trade openness on GDP growth. Asmare & Haiyun (2019) studied the short-term and long-term relationships between Ethiopia's GDP growth, exports, and imports, as well as their causal relationships. They found through ARDL and ECM models that imports have a significant positive impact on GDP growth in the short term, and there is a bidirectional Granger causality relationship between exports and imports.

In addition, Singh (2010) found that international trade, especially exports, is a key driver of economic growth, though its impact depends on trade policies and economic structure. Michelis and Zestos (2004) showed a bidirectional causal relationship between trade and GDP growth in six EU countries, indicating mutual reinforcement between exports, imports, and GDP. However, imports may also pose challenges by increasing competition for domestic industries, potentially reducing their market share (Romli et al., 2022). Therefore, the impact of imports and exports on GDP is complex and may vary depending on each country's specific economic structure and policy context.

In addition to trade, capital formation, particularly gross fixed capital formation (GFCF), is widely recognized as a fundamental driver of economic growth. Classical economists such as Adam Smith emphasized that capital accumulation can increase productivity by supporting a more efficient division of labor. Modern economic growth theories, including the Solow-Swan model, also regard capital formation as one of the core determinants of long-term economic development. These theories emphasize that increases in physical and human capital, alongside technological progress, contribute significantly to GDP growth.

Adam Smith (1937) emphasized that capital accumulation promotes economic growth through increasing the proportion of productive labor, refining the division of labor within and across industries, and expanding the number of industries. With the development of neoclassical economics, scholars shifted focus toward the mechanisms linking capital accumulation and growth. Neoclassical growth theory, particularly the Solow-Swan model (Solow, 1956), posits that capital and labor are the primary drivers of growth, with technological progress acting as an exogenous factor. More recently, Dohtani and Matsuyama (2024) highlight the evolution of this framework, incorporating human capital and technology as key components influencing long-run growth.

Ali (2015), using time-series data for Pakistan (1981-2014), found that a 1% increase in gross fixed capital formation (GFCF) leads to a 0.6% increase in GDP growth, highlighting the significance of private investment while questioning the effectiveness of public investment. Similarly, Kononenko and Repin (2016), analyzing data from 35 countries, observed that capital investment tends to rise significantly when GDP growth surpasses a certain threshold, emonstrating a responsive link between output performance and investment behavior.

Beyond physical capital, stock market capitalization has also been identified as a driver of growth. Jalloh (2015), Dökmen, Aysu, and Bayramoğlu (2015), and Osakwe, Ogbonna, and Nwosu (2020) found significant positive relationships between stock market capitalization and GDP in Africa and emerging markets. Churchill, Arhenful, and Agbodohu (2013) emphasized the role of policymakers in strengthening stock markets to foster economic expansion. Further, Iftikhar et al. (2016) and Raza and Jawaid (2014) provided evidence that both domestic capital formation and exports significantly enhance GDP by boosting productivity and foreign earnings. Shahbaz, Rehman, and Muzaffar (2015) also confirmed the positive effect of market capitalization on GDP growth in Bangladesh. Koopman & Wacker (2023) show capital accumulation plays a major role in growth growth, especially in capital-scarce economies. Moreover, a World Bank review (2023) attributes recent global slowdowns in potential output largely to weakened capital formation.

While many studies have examined the individual effects of trade and capital formation on GDP growth, few have focused specifically on Malaysia using a dynamic and integrated approach. In particular, the interaction among imports, exports, capital formation, and GDP has not been sufficiently explored using time series data that captures both short-term fluctuations and long-term relationships. Existing literature often relies on annual or quarterly data, which may miss short-run dynamics or bidirectional relationships between the variables.

To address these gaps, this study investigates the dynamic interrelationships between imports, exports, capital formation, and GDP in Malaysia using the Vector Error Correction Model (VECM). This econometric approach is especially useful when variables are cointegrated, as it can model both short-run adjustments and long-run equilibrium relationships. Using monthly data from 2015 to 2023, this study aims to provide a more detailed understanding of the interaction mechanisms among key macroeconomic indicators in the Malaysian context.

METHODOLOGY

Data Summary

The study used monthly time series data from 2015 to 2023, which were sourced from multiple authoritative institutions including the Malaysian Bureau of Statistics, the World Bank, and the International Monetary Fund. These data ensure the accuracy and reliability of the study, providing a solid foundation for subsequent empirical analysis.

Table 1. Time series data sources

Macroeconomic Variable	Name of Variable in Modelling	Sources of Data
GROSS DOMESTIC PRODUCT	RGDP	Department of Statistics Malaysia
IMPORT	RI	Department of Statistics Malaysia
EXPORT	RE	CEIC DATA
GROSS CAPITAL FORMATION	RCAP	World Bank

Model Specification

This study used regression models to analyze the interrelationships between variables. By constructing an econometric model, (Rambeli et al., 2021) use actual GDP as the dependent variable and actual imports, exports, and capital as independent variables to explore their impact on GDP. This model construction method can clearly reveal the roles of various factors in economic growth.

$$RGDP = f(RI, RE, RCAP) \quad (1)$$

$$RGDP_t = a_0 + a_1 RI_t + a_2 RE_t + a_3 RCAP_t + \varepsilon_t \quad (2)$$

Econometric Approaches

In the application of econometric methods, various statistical tests and techniques were employed to ensure the accuracy and reliability of the analysis results. Firstly, the augmented Dickey Fuller (ADF) unit root test was used to test the stationary of each variable to ensure the effectiveness of the regression model. Secondly, the Johansen Juselius cointegration test was used to verify whether there is a long-term stable equilibrium relationship between variables. In addition, the Vector Error Correction Model (VECM) was used to simulate short-term dynamics and long-term equilibrium relationships between variables, and the direction of causal relationships between variables was determined through the Granger causality test. The Equations are as follows

$$\Delta logGDP_t = \alpha_1 + \sum_{i=1}^{n} \beta_i \Delta logGDP_{t-i} + \sum_{i=1}^{n} \theta_i \Delta logRI_{t-i} + \sum_{i=1}^{n} \rho_i \Delta logRX_{t-i} + \sum_{i=1}^{n} \varphi_i \Delta logCAPITAL_{t-i} + \gamma_1 ECT_{t-1} + \varepsilon_1 \quad (3)$$

$$\Delta logRI_t = \alpha_2 + \sum_{i=1}^{n} \beta_i \Delta logGDP_{t-i} + \sum_{i=1}^{n} \theta_i \Delta logRI_{t-i} + \sum_{i=1}^{n} \rho_i \Delta logRX_{t-i} + \sum_{i=1}^{n} \varphi_i \Delta logCAPITAL_{t-i} + \gamma_1 ECT_{t-1} + \varepsilon_2 \quad (4)$$

$$\Delta logRX_t = \alpha_3 + \sum_{i=1}^{n} \beta_i \Delta logGDP_{t-i} + \sum_{i=1}^{n} \theta_i \Delta logRI_{t-i} + \sum_{i=1}^{n} \rho_i \Delta logRX_{t-i} + \sum_{i=1}^{n} \varphi_i \Delta logCAPITAL_{t-i} + \gamma_1 ECT_{t-1} + \varepsilon_3 \quad (5)$$

$$\Delta logCAPITAL_t = \alpha_4 + \sum_{i=1}^{n} \beta_i \Delta logGDP_{t-i} + \sum_{i=1}^{n} \theta_i \Delta logRI_{t-i} + \sum_{i=1}^{n} \rho_i \Delta logRX_{t-i} + \sum_{i=1}^{n} \varphi_i \Delta logCAPITAL_{t-i} + \gamma_1 ECT_{t-1} + \varepsilon_4 \quad (6)$$

The Augmented Dickey Fuller (ADF) unit root test is mainly used to test the stationarity of time series data. A stationary time series means that its statistical properties (such as mean, variance, and auto covariance) do not change over time ADF test tests whether a variable has a unit root by constructing a regression model that includes lagged differences. If there is a unit root, it means that the sequence is non-stationary, meaning that the mean and variance of the sequence will change over time. ADF test determines whether a sequence is stationary by comparing the coefficients of the regression model with the critical value.

The Johansen Juselius cointegration test is used to test whether there is a long-term stable equilibrium relationship between multiple non-stationary time series variables The cointegration relationship means that although individual variables may be non-stationary, their linear combination may be stationary. Johansen cointegration test constructs a vector auto regression (VAR) model and uses maximum likelihood estimation to test the cointegration rank (i.e. the number of cointegration vectors) between variables.

VECM is an extension of the Vector Autoregressive (VAR) model that introduces error correction terms to capture long-term equilibrium relationships between variables. In the VECM model, the differential variable vector is not only affected by its own lag term, but also adjusted by the long-term equilibrium relationship represented by the cointegration matrix. This model structure enables VECM to more accurately describe the dynamic relationships between economic variables. The VECM model is applicable to non-stationary time series data with cointegration relationships.

The core idea of Granger causality test is that if the changes in one time series X can be used to predict the changes in another time series Y, and this prediction effect is better than using only Y's own past information, then X can be considered as the Granger cause of Y. Although the VECM model has assumed a long-term equilibrium relationship between variables, further verification is needed to determine whether this relationship has causal properties. Through Granger causality test, it is possible to identify which variables are the causes of changes in other variables, which is of great significance for understanding the operating mechanism of the economic system and formulating relevant policies.

RESULT AND DISCUSSION

In this chapter, we will conduct in-depth and detailed analysis of the data results obtained from the study, including analysis of sample data characteristics, cointegration relationships between variables, etc., in order to calculate the error term. Based on the error term, it is possible to analyze the long-term and short-term relationships between variables.

Trending Analysis

From 2015 to 2023, Malaysia's Real GDP experienced a fluctuating growth process. In 2015, due to the global economic slowdown, reduced domestic demand, and fluctuations in commodity prices.

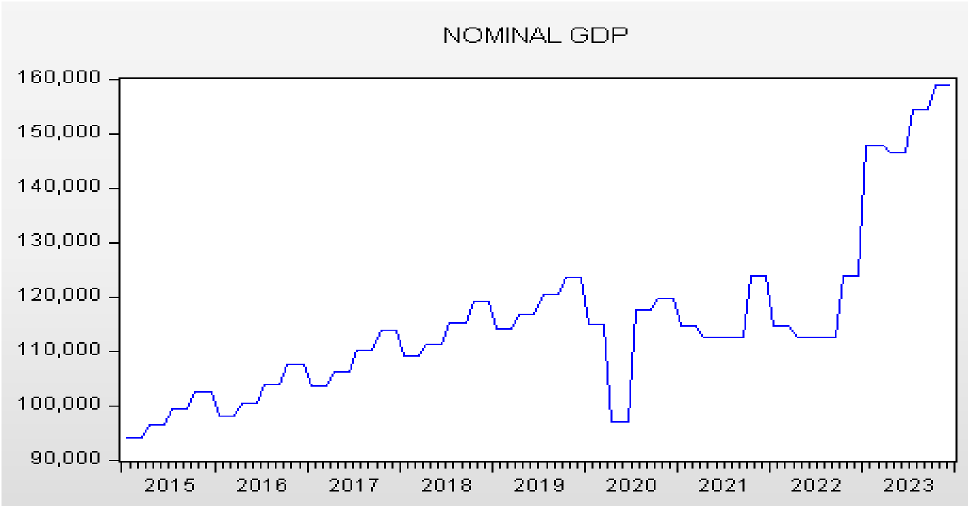

Figure 1 Malaysia Nominal GDP from 2015 to 2023

Malaysian economy faced challenges and GDP growth slowed down. However, in the following years, with the improvement of global economic conditions and support from domestic policies, the Malaysian economy gradually recovered. Especially in 2017 and 2018, the Malaysian economy showed strong signs of recovery, with GDP growth accelerating. However, the global trade tensions in 2019 have had a certain impact on Malaysia's export-oriented economy, resulting in a slowdown in GDP growth. In 2020, the outbreak of COVID-19 had a huge impact on the global economy, and Malaysia was no exception, with a significant decline in GDP. But with the gradual recovery of the global economy and the stimulus measures taken by the Malaysian government, Malaysia's GDP began to rebound from 2021 and gradually returned to pre pandemic levels.

Econometric Empirical Findings

The EVCM model is a time series analysis method that combines cointegration theory and error correction mechanism, particularly suitable for analyzing short-term dynamic adjustment processes between economic variables with long-term equilibrium relationships. In the model, it is necessary to clarify which variables have cointegration relationships and how these relationships are adjusted through error correction terms.

Augmented Dickey Fuller (ADF) Unit Test ADF

Before conducting time series analysis, ADF is applied to test whether time series data such as GDP, imports, exports, and capital formation have stationarity.

Table 2 Summary of ADF test results

Vairables	At Level		At First Difference	
	Intercept	Trends and Intercept	Intercept	Trends and intercept
log_GDP	-1.376108	-2.355196	-10.5809	-10.56579
	-0.5914	-0.4007	(0.0000)***	(0.0000)***
log_IMPORT	-0.970655	-3.100399	-11.58049	-11.53012
	-0.7615	-0.1116	(0.0000)***	(0.0000)***
log_EXPORT	-2.02259	-2.868265	-11.29519	11.53012
	-0.2769	-0.177	(0.0000)***	(0.0000)***
log_CAP	-3.08589	-3.069189	-8.140009	-8.095034
	(0.0306)**	-0.1191	(0.0000)***	(0.0000)***
Note: The () are numbers of prob.* of Augmented Dickey Fuller Test Statistics. The sign '***', '**', and '*' specify significance at 99%, 95%, and 90% significance levels respectively.				

Table 3 reports the results of ADF unit root test, including level and initial deviation. Log_GDP, log_iMPORT, log_dePORT, and log_CP are all non-stationary at the level. After the first differencing of all variables, the results were significantly stable, indicating that these variables are all first-order uniinteger (I (1)) time series. For example, after the first differencing, the GDP series is stationary, indicating that log_GDP is a first-order monointeger (I (1)).

Vector Auto Regression

AIC and SC play an important role in the construction process of VAR models, as they help researchers choose the optimal lag order of the model, balance the complexity and fit of the model.

Table 3 AIC and SC of the Vector Auto Regression (VAR) Model

Lag	AIC	SIC
0	-10.74747	-10.63486
1	-15.50947	-14.94644*
	…	…
18	-17.24997	-9.029721
19	-18.14128	-9.470605
20	-20.46479*	-11.34368
* indicates lag order selected by the criterion		
AIC: Akaike information criterion		
SC: Schwarz information criterion		

The Akaike Information Criterion (AIC) value reaches its minimum value (-20.46479) at a lag order of 20. This indicates that the AIC criterion tends to choose a lag of 20 orders. The Schwarz Information Criterion (SC) value reaches its minimum value (-14.94644) when the lag order is 1, and the SC criterion is marked with an asterisk (*) here, indicating that the SC criterion selects lag order 1 as the optimal order. In order to analyze the dynamic impact of independent variables on GDP, we chose AIC, which tends to have a longer lag order because it is more sensitive to the fit of the model and usually tends to reduce the size of residuals. In order to obtain a stable first difference, I (1), it must subtract the optimal lag 5 (lag 20-5=15) to obtain the best result.

Granger Causality

Granger causality test is used to determine whether the historical information of one variable can be used to predict the future changes of another variable. This study uses Granger causality test to analyze whether variables influence each other during the lag period (lag=15).

Table 4 Granger Causality Test Result Summary

Null Hypothesis:	Obs	F-Statistic	Prob.	Decision
Capital Formation does not Granger Cause GDP		1.21207	0.2874	Accept
GDP does not Granger Cause Capital Formation	93	2.12972	0.0197**	Reject
Import does not Granger Cause GDP		2.14723	0.0186**	Reject
GDP does not Granger Cause Import	93	0.76733	0.7071	Accept
Export does not Granger Cause GDP		0.22036	0.9989	Accept
GDP does not Granger Cause Export	93	0.3803	0.9795	Accept
Import does not Granger Cause Capital Formation		0.73295	0.7422	Accept
Capital Formation does not Granger Cause Import	93	2.13095	0.0196**	Reject
Export does not Granger Cause Capital Formation		0.34226	0.9878	Accept
Capital Formation does not Granger Cause Export	93	0.33211	0.9895	Accept
Export does not Granger Cause Import		0.74923	0.7257	Accept
Import does not Granger Cause Export	93	1.11475	0.3628	Accept
Note: Asterisks (****), (**) and (*) indicates statistically significant at 1%, 10% and 30% level, respectively.				

According to the results of the Granger causality test (Table 5), only three hypotheses can be rejected at the 5% singularity level GDP Granger leads to capital formation, indicating that changes in GDP can help predict capital formation. Capital formation Granger leads to imports, indicating that changes in capital formation can help predict changes in imports. Importing Granger leads to GDP, indicating that changes in imports can help predict changes in GDP. There is no significant Granger causality relationship between imports and exports.

In comparison, Asmare & Haiyun (2019) found that exports and imports have a unidirectional Granger causality relationship with GDP growth, and there is a bidirectional Granger causality relationship between exports and imports. However, in this study, there is a bidirectional Granger causality relationship between imports and GDP, and a unidirectional Granger causality relationship between GDP and capital formation, but there is no significant Granger causality relationship between exports and GDP.

Johansen Juselius Cointegration

Johansen cointegration test can justify whether there is a cointegration relationship between variables, achieve the number of cointegration relationships, and provide specific cointegration vectors.

Table 5 Summary of Johansen co-integration test result

Hypothesis		Co-integrating System			
$H0$	$H1$	Trace Statistics	5% Critical Value	Max Eigenvalue	5% Critical Value
r = 0	r > 0	97.35127***	47.86	42.90685***	27.58
r < 1	r > 1	40.62284***	29.80	30.9235 ***	21.13
r < 2	r> 2	9.699307	15.49	8.597594	14.26
r< 3	r> 3	1.101713	3.84	1.101713	3.84
Note: Critical values are obtained from *Osterwald-Lenum* (1992). Sign (**) indicates rejected critical values at significant level of 5% and (*) at 1%.					

The Johansen Juselius cointegration test aims to analyze whether there is a long-term equilibrium relationship between multiple time series variables. When r=0, the trace statistic (97.35127) far exceeds the 5% critical value (47.86), thus rejecting H0, indicating the existence of at least one cointegration relationship. When r=1, the trace statistic (40.62284) is greater than the critical value (29.80), rejecting the hypothesis of r ≤ 1, but accepting the hypothesis of r=1 implies the existence of at least one of two cointegration relationships. When r=2, the trace statistic (9.699307) is less than the critical value (15.49), which cannot reject the hypothesis of r ≤ 2, indicating that there is insufficient evidence to support the existence of two of the three cointegration relationships.

Thus, this study conducted Johansen Juselius cointegration tests on four variables: GDP, imports, exports, and capital formation, and found at least one cointegration relationship between the variables. Rambeli et al. (2021) conducted cointegration tests on five variables: industrial production index, capital formation, employment, government education expenditure, and broad money supply, and determined the existence of at least two cointegration relationships in the system.

Error Correction Term

In the error correction model, the error correction term (ECT), as a concrete manifestation of cointegration, can capture the long-term equilibrium relationship between variables. ECT represents the difference between the actual observed values and long-term equilibrium values of variables.

Table 6 cointegration equation from Johansen Juselius Cointegration test

Cointegrating Eq:	CointEq1
LOGGDP(-1)	1
LOGRI(-1)	-1.049945
	-0.23531
	[-4.46192]
LOGRX(-1)	0.128322
	-0.06248
	[2.05396]
LOGCAPITAL(-1)	1.740636
	-0.30451
	[5.71619]
C	-4.516919

$$ECT = -4.516919 + loggdp(-1) - 1.049945 * logri(-1) + 0.128322 * logrx(-1) + 1.740636 * logcapital(-1)$$

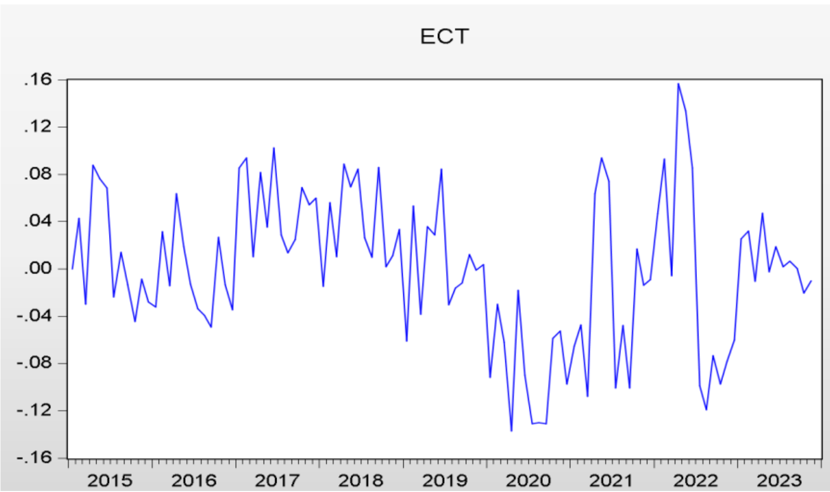

Figure 2. The graph of ECT

After incorporating the error correction term into the EVCM model, classical regression methods can be used for estimation. By estimating the model parameters, the degree to which the error correction term affects the relationship between variables can be obtained.

Error Correction Model

Granger causality was performed in the VECM framework of Table 7, revealing short-term and long-term causal relationships or temporal connections between variables. There is an error correction term (ECT), which measures the speed at which any short-term imbalance adjusts to long-term equilibrium in the long run. The results in Table 7 indicate the existence of long-term equilibrium among variables in the equation system, which is consistent with the findings of Asmare & Haiyun (2019) and Rambeli et al. (2021). For example, according to the economic growth model, the ECT amplitude value is -0.055049. This means that short-term imbalances take less than a month to recover to long-term equilibrium, which is different from the conclusion of Rambeli et al. (2021), possibly due to significant differences in the variables selected in the two studies.

Table 7 The Results of Granger Causality in Vector Error Correction Model (VECM) Framework

Dependent Variables	Independent Variables					Diagnostic Tests					
	$\Delta loggdp_t$	$\Delta logri_t$	$\Delta logrx_t$	$\Delta logcapital_t$	Ect(t-1)	R2	F-stat	DW	ARCH	BG-LM	JB
$\Delta loggdp_t$		0.049584 0.2615	-0.000757 0.9638	-0.14598 0.0185***	-0.055049 0.0585*	0.0068348	1.870743	2.111560	0.6966 0.6901	0.8074 0.7957	602.3534 0.0000
$\Delta logri_t$	0.249011 0.2615		0.122649 0.0007***	0.183486 0.1907	0.257869 0.0000***	0.246573	8.345345	2.658121	4.099412 0.0450	13.19575 0.0000	2.681166 0.261693
$\Delta logrx_t$	-0.026821 0.9638	0.864967 0.0007***		-0.25455 0.4956	-0.101479 0.5610	0.115588	3.332708	2.142415	0.0027751 0.8665	0.276409 0.7491	7259.665 0.0000
$\Delta logcapital_t$	-0.364161 0.0185**	0.091143 0.1907	-0.017929 0.4956		-0.167548 0.0002***	0.160507	4.875486	1.715118	0.624886 0.4262	3.815637 0.0253	97.06754 0.0000

Note: All variables in each data set are in first difference (denoted Δ) with the exception of the lagged error correction term (ECTt-1). All equations for all data set passed the diagnostic tests. Also, the superscript '***','**', and '*' specify significant at 99%, 95%, and 90% significance levels

Discussion and Conclusion

The results are consistent with Dedeoğlu and Kaya (2013), who found that imports and exports contribute significantly to GDP by enabling technology transfer and improving resource allocation. In the Malaysian context, the bidirectional Granger causality between imports and GDP affirms that imports are both a reflection of domestic demand and a channel through which foreign technology and capital goods enter the economy, boosting productivity. Similarly, rhe findings align with Wolla (2018), who emphasized that advanced foreign goods and technologies brought through imports can raise domestic efficiency. This supports the view that imports are not merely consumption-related but play a key developmental role.

The findings also support Asmare & Haiyun (2019), who observed that imports had a significant short-term positive effect on GDP in Ethiopia and found a bidirectional causality between imports and exports. While the research did not find significant causality between exports and GDP, the import-GDP nexus in Malaysia mirrors the productivity-enhancing role of imports they emphasized. In line with Karras (2003), who used panel data from over 100 countries to confirm a positive and lasting impact of trade openness on GDP, the results suggest that trade openness, especially via imports, remains a potent tool for driving long-run growth in Malaysia.

In contrast to prior studies that Singh (2010), Michelis and Zestos (2004), and Gries and Redlin (2012) stated, who found strong bidirectional relationships between exports and GDP in other regions, this study found no significant Granger causality between exports and GDP in Malaysia. This divergence may reflect recent global trade tensions, the restructuring of global value chains, and Malaysia's increasing automation and outsourcing in export-oriented sectors, which could have weakened domestic value-added and employment linkages.

This result also diverges from Ramzan et al. (2019) and Fatima et al. (2020), who found that trade openness (including exports) has a strong direct and indirect impact on GDP via total factor productivity and human capital. While this study supports the importance of trade openness via imports, the export-GDP linkage appears weaker, possibly due to Malaysia's relatively low domestic value capture in some export sectors such as electronics.

Nonetheless, the findings do not invalidate export-led growth theories but rather suggest that contextual factors, such as the composition of exports and the degree of domestic participation in global supply chains, matter significantly.

The results are consistent with the classical economic view (e.g., Adam Smith, 1937) and the Solow-Swan model (Solow, 1956), which regard capital accumulation as a central pillar of economic growth. The unidirectional causality from GDP to capital formation indicates that as Malaysia's economy expands, investment follows in response to increased economic opportunities, supporting the acceleration principle.

This finding pairs well with Ali (2015), who demonstrated that GFCF contributes significantly to GDP in Pakistan, although the results suggest reverse causality, GDP growth predicting investment, consistent with Kononenko and Repin (2016), who observed increased capital investment following high output growth in 35 countries.

The findings also complement Koopman & Wacker (2023) and the World Bank (2023), who stress that weakened capital formation explains slowdowns in potential growth. Malaysia's sustained investment in physical capital in the post-COVID era may help mitigate such risks.

In addition, the study repeated the insights of Dohtani and Matsuyama (2024), who updated the neoclassical growth framework by including human capital and technology factors implicitly linked to capital formation. While the data did not directly model human capital, future work could expand in this direction.

Although not directly tested in this model, the results resonate with findings from Jalloh (2015), Dökmen et al. (2015), and Osakwe et al. (2020), who emphasized the role of capital market development in fostering growth. As GDP growth drives capital formation, Malaysia's ongoing efforts to strengthen its financial markets may further accelerate this link.

The results also indirectly support the conclusions of Churchill et al. (2013) and Shahbaz et al. (2015), who observed that effective stock market development policies are essential for mobilizing capital, improving investment, and thus boosting GDP growth. Although stock market variables were not included in our model, the capital formation proxy captures a part of this financial depth indirectly.

The presence of a long-term cointegration relationship among all four variables (GDP, imports, exports, capital formation) indicates that despite short-run fluctuations caused by global crises or policy changes, the Malaysian economy exhibits a stable underlying equilibrium. This reinforces the findings of Gries and Redlin (2012) and Karras (2003) regarding the long-run positive effects of trade openness on growth.

The VECM results confirm that the error correction term for GDP is negative and statistically significant, suggesting that short-term deviations are gradually corrected. This aligns with theoretical expectations from the Solow-Swan model and provides reassurance about the structural resilience of Malaysia's macroeconomic system.

A limitation of this study is the reliance on monthly time-series data, which, while allowing finer analysis of short-term dynamics, may suffer from data volatility, missing observations, and seasonal effects. Another limitation is the exclusion of other macroeconomic variables such as exchange rates, inflation, interest rates, and government expenditure, which may influence or moderate the GDP-growth relationship.

Future studies may incorporate structural break analysis, especially to capture the effects of the COVID-19 pandemic and global supply chain shifts. Moreover, using sectoral data (e.g., manufacturing vs. services) could yield more granular insights into the heterogeneous impacts of trade and capital formation. Cross-country comparative research with ASEAN neighbors would also help contextualize Malaysia' performance and policy effectiveness.

Authors' Contributions

Zhang Jiangxia contributed to the design and implementation of the research, and Norimah Rambeli, Asmawi Hashim, Norasibah Abdul Jalil, Emilda Hashim, Laximee Abimannan & Keerthana Balan contributed to data analysis.

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