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Causal Relationship between China-ASEAN Trade and China's Economic Growth: A Toda-Yamamoto Analysis

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Abstract
Since 2020, ASEAN has consistently been China's largest trading partners, pivotal in driving China's economic growth. Using time series data from 1992 to 2023, this study employs the Toda-Yamamoto causality analysis to examine the causal relationship between China-ASEAN trade and China's economic growth. The results reveal a significant bidirectional causal relationship between China's exports to ASEAN and its economic growth, indicating that exports stimulate and bolster economic growth and vice versa. Moreover, a significant bidirectional causal relationship between exports and imports highlights their strong interaction. The analysis also identifies a unidirectional causal relationship from labor to economic growth and a unidirectional causal relationship from economic growth to capital. Robustness tests further confirm these findings. The results underscore the importance of China-ASEAN trade for economic growth, providing new insights into enhancing bilateral trade cooperation and optimizing trade structures. Moreover, the findings offer empirical support for advancing the Belt and Road Initiative and the implementation of the Regional Comprehensive Economic Partnership.
Keywords: China-ASEAN Trade, Economic Growth, Toda-Yamamoto Analysis, Causal Relationship

Introduction
Since the reform and opening-up policy in the 1970s, China's foreign trade, consumption, and investment have been regarded as one of the main drivers of economic growth, exerting significant influence on China's economic expansion. Trade expansion can increase domestic output and improve total factor productivity (Keller, 2004). In the context of the "dual circulation" development pattern, which aims to balance domestic and international economic activities by fostering internal demand while maintaining openness to the global, the international cycle is an important component, indicating that foreign trade will continue to play a sustained role in China's economic growth for a long time (Yifu Lin, 2021). Therefore,

exploring the relationship between foreign trade and economic growth is significant for China's sustainable development, with ASEAN being China's largest trading partner and, thus, a crucial research subject.

In recent years, China-ASEAN trade relations have emerged as a vital force driving regional economic integration, showcasing robust growth momentum (Wang & Chen, 2024). Since 2020, ASEAN has consistently been China’s largest trading partner, while China has maintained its position as ASEAN’s top trading partner since 2009. This rapid expansion in bilateral trade not only reflects the deepening of cooperation between China and ASEAN but also highlights the institutional dividends of policies such as the ASEAN-China Free Trade Area and the Regional Comprehensive Economic Partnership (RCEP) (Wang et al., 2023).

This study utilizes time series data from 1992 to 2023 and Toda-Yamamoto (T-Y) causality analysis to systematically investigate the causal relationship between China-ASEAN trade and China’s economic growth. Despite the extensive literature on the relationship between international trade and economic growth, there are still gaps in studying China-ASEAN trade. First, while many studies have suggested a long-term equilibrium relationship between China-ASEAN trade and China's economic growth, a minority of these studies argue that this relationship is either insignificant or conditional, indicating the need for further investigations. Second, current research on this topic contains a few limitations in terms of data and methodology. To begin with, most studies examined data before 2010 (Li & Fan, 2006; Gan, 2008; Li & Zhang, 2008), which needs to be updated and may fail to capture the current dynamics of economic relationships. Additionally, many studies employ annual time series data for cointegration analysis, but the sample lengths are typically short, with most studies using datasets spanning less than 20 years, e.g., Zhuang (2010) and Li and Zhang (2008). Furthermore, existing research often limits its scope to trade and economic variables, neglecting critical factors, i.e., labor and capital, which are essential for fully capturing the determinants of economic growth.

Equally important, in cases where variables are of mixed orders of integration (I(1) and I(2)), some studies proceed directly with cointegration and regression analyses (Li & Zhang, 2008), which poses a risk of spurious regression. Although some studies directly differentiate variables to I(0) and conduct impulse response analyses, this weakens the interpretative power regarding the relationships of the original variables (Gan, 2008). These issues collectively hinder a comprehensive understanding of the relationship between China-ASEAN trade and China's economic growth. Therefore, there remains considerable room for improvement in this area of research.

On the contrary, this study addresses these limitations from various perspectives. First, this research tackles the issue of mixed-order variables by utilizing the T-Y causality analysis. Second, this study employs an expanded dataset covering the latest period, extending the sample length and aligning the analysis more closely with the current economic context. Third, by employing an extended Cobb-Douglas production function, this research incorporates labor and capital as control variables, offering a more comprehensive analysis of the impact of China-ASEAN trade on economic growth compared to previous studies. Lastly, the study conducts robustness checks, enhancing the reliability of the results.

Additionally, this research enriches the causality analysis models in the field of international trade and economic growth between China and major ASEAN countries. It also validates the mechanisms of export-driven economic growth. Contextually, the study examines the pivotal role of China-ASEAN trade in regional economic integration, hence providing empirical evidence to justify the necessary of the Belt and Road Initiative and the RCEP framework. Overall, this research deepens the understanding of the interactive mechanisms between bilateral trade and economic growth, offering guidance for optimizing trade policies and fostering regional economic cooperation in the context of China and ASEAN.

The findings reveal a significant bidirectional causal relationship between China's exports to ASEAN and its economic growth, indicating that exports promote economic growth and are driven by it. However, the causal effect between economic growth and imports is not significant. Furthermore, a significant bidirectional causal relationship exists between exports and imports. The unidirectional causality from labor to economic growth and economic growth to capital are statistically significant. In robustness tests, where gross domestic product (GDP) growth was replaced with per capita GDP growth, the results remained largely consistent. These findings validate the critical role of China-ASEAN trade in driving economic growth in China and highlight the dynamic interplay between the two. The study empirically supports optimizing bilateral trade structures and deepening economic and trade cooperation.

Research Background

Figure 1 illustrates the total trade volume between China and ASEAN from 1992 to 2023, showing a consistent upward trend. Particularly in recent years, the pace of growth has accelerated significantly. Since 2020, ASEAN has remained China's largest trading partner, while China has been ASEAN's largest trading partner for 13 consecutive years since 2009.

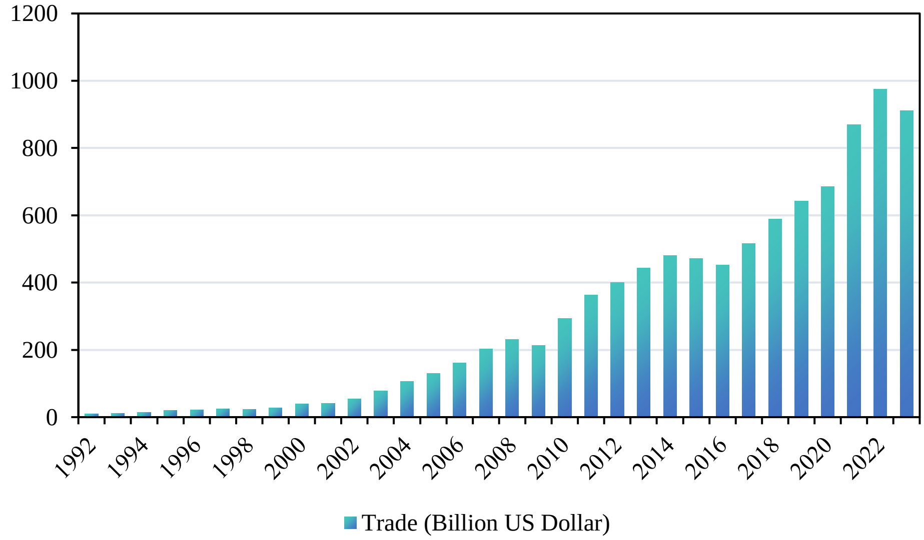

Figure 1. Total Trade Volume Between China and ASEAN, 1992–2023
Source: United Nations Conference on Trade and Development (UNCTAD)

The close trade partnership between China and ASEAN results from a series of economic and trade cooperations. China became a partner in the ASEAN's comprehensive dialogue partner in 1996. In November 2002, both sides signed the Framework Agreement on Comprehensive

Economic Cooperation, with the China-ASEAN Free Trade Area as the main content. On January 1, 2010, the free trade area was formally launched; it accounted for 13% of world trade, creating a huge economic entity covering 11 countries with a population of 1.9 billion and a GDP of $6 trillion (Li, 2016). In November 2020, RCEP, proposed by ASEAN and joined by China, Japan, South Korea, Australia, and New Zealand, was officially signed, marking the formal launch of the world's largest free trade area, which accounted about 30% of the world trade (MFAPRC, 2020), RCEP has further enhanced the trade cooperation between ASEAN and China.

While trade volume between China and ASEAN has rapidly increased, China's economic growth has also significantly expanded. In 2023, China's GDP reached USD17.17 trillion, compared to USD1.47 trillion in 2002, representing an elevenfold increase (World Bank Database, 2024). However, compared to the high growth rate of 14.5% in nominal GDP per year during the first 40 years of reform and opening up, China's average annual growth rate slowed down from 2020 to 2023, with the GDP growth rate at 4.97%. This is still higher than the world average growth rate of 2.5%. The noticeable decline in China's GDP growth is closely related to domestic and international economic situations. Figure 2 illustrates China's GDP total and GDP growth rate annually from 1992 to 2023. As depicted in the Figure, China's economic growth experienced a period of rapid expansion followed by an overall decline since 2008.

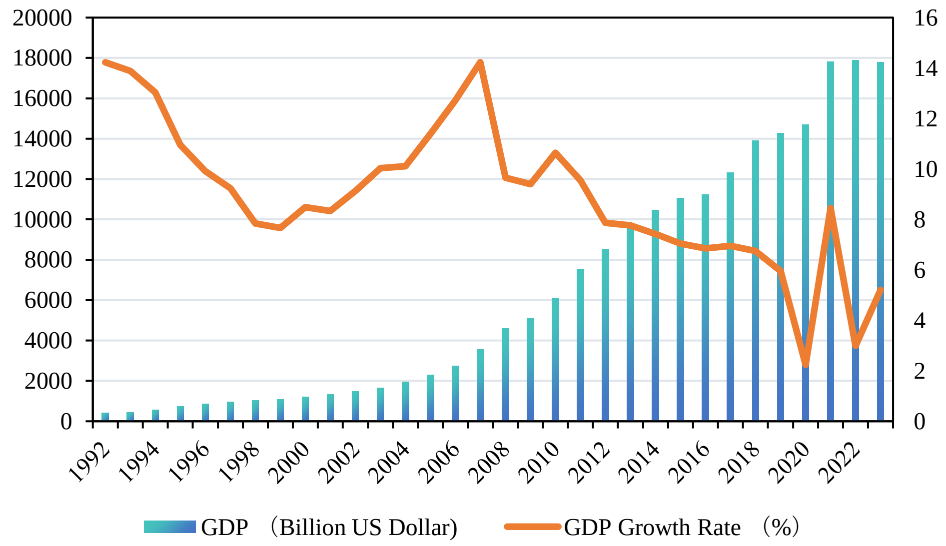

Figure 2. China's GDP Total and GDP Growth Rate, 1992-2023
Source: World Bank Database, 2024

Therefore, the Chinese government proposed a high-quality economic development goal in 2017, emphasizing a transition from high-speed growth to high-quality development. It also formulated supply-side structural reform policies to adjust and upgrade industrial structure, advance the Belt and Road Initiative, and pursue more economic liberalization. This strategy aims to transit from comparative advantage to competitive advantage in the international division of labor, breaking free from the "low-end lock-in" in global value chains and promoting China's position toward the middle and high-end of global value chains (Fangye, 2019). In 2020, the Chinese government proposed building a new development pattern of dual circulation, promoting mutual reinforcement between domestic and international cycles to cope with the unprecedented changes in the world.

Literature Review

The relationship between international trade and economic growth has long been a focal point of academic research. Early studies grounded in classical economics and neoclassical growth theories argued that international trade promotes economic growth by optimizing resource allocation through comparative advantage (Ricardo, 1817). Subsequently, endogenous growth theory further revealed the critical role of trade in driving technological progress, factor accumulation, and market expansion (Romer, 1990; Grossman & Helpman, 1991). Exports enhance firm competitiveness through economies of scale and technology diffusion (Helpman & Krugman, 1985) while also providing foreign exchange reserves and fueling rapid economic growth, particularly in developing countries (Balassa, 1978). Conversely, imports contribute to domestic productivity and technological progress by introducing advanced technologies and capital goods (Eaton & Kortum, 2002). They also facilitate technological spillovers, complement domestic production factors, increase market competition, and improve product quality in open economies (Edwards, 1998; Lawrence & Weinstein, 1999). Furthermore, by absorbing technologically advanced intermediate goods, domestic firms can enhance the overall technological level of the economy (Coe & Helpman, 1995).

While theoretical research affirms a positive relationship between trade and economic growth, empirical studies reveal mixed results, suggesting that the relationship remains inconclusive (Kim & Lin, 2009). Empirical evidence shows that a bidirectional causal relationship often exists between international trade and economic growth, validated across different countries and regions. For instance, Sutbayeva et al. (2024) analyzed data from Kazakhstan spanning 1990 to 2022 and found that trade openness and economic growth exhibit a bidirectional causal relationship in both the short and long term. Kumari & Malhotra (2014) demonstrated that, for China, there is a bidirectional causal relationship between per capita GDP, exports and imports.

Some studies suggest that the causal relationship between trade and economic growth is unidirectional. Chiranga et al. (2024) found unidirectional causality from economic growth to trade openness. Islam et al. (2012) concluded that imports in most high-income countries have a unidirectional long-term causal relationship with economic growth, whereas low-income countries exhibit bidirectional causality.

Other studies deny the existence of causality between trade and economic growth. Aluko & Adeyeye (2020), analyzing data from 41 countries, observed that in over half of these countries, there is no causal relationship between imports and economic growth at both long-term and short-term levels. Similarly, Kumari et al. (2023) found no bidirectional causal relationship between trade openness and economic growth in India. Tang (2006), using long-term data on China, concluded that GDP, exports, and imports show no significant long-term causal relationships. Agudze & Olarewaju (2021), examining data from the U.S. and China from 1985 to 2020, found that trade had no significant short- or long-term effects on U.S. economic growth but positively influenced China’s economic growth.

Similar inconsistencies were found in the relationship between China-ASEAN trade and China's economic growth. Yan & Zhao (2012) applied cointegration and Granger causality analysis to the data from 1998 to 2009 and found no long-term stable relationship between intra-industry trade in manufactured goods and GDP. However, GDP was identified as the Granger cause of intra-industry trade, indicating a unidirectional relationship. Li (2016), analyzing data from 2000 to 2015, concluded that total trade between China and ASEAN significantly promotes China's economic growth. Liu (2016), using panel data, found that China's exports to ASEAN significantly contribute to its economic growth.

In summary, research on the causal relationship between exports, imports, and economic growth presents varying conclusions, even though theoretical and empirical studies generally suggest that trade openness promotes economic growth. Moreover, the specific causal pathways may vary depending on the research methods and contexts. Besides, previous studies on China-ASEAN trade indicate a close dynamic relationship between trade and economic growth. Nonetheless, due to the weaknesses highlighted in Section 1, there is a need to estimate the causal relationship between Chinese economic growth, Chinese exports to ASEAN, and Chinese imports from ASEAN.

Methodology and Data

Model Specification

In studies exploring the relationship between international trade and economic growth, researchers initially employed an extended Cobb-Douglas production function by incorporating exports into the total production function to analyze the causal relationship between exports and GDP growth (Balassa, 1978; Sheehey, 1992). As this study aims to analyze the causal relationship between China-ASEAN trade and China's economic growth, the extended production function proposed by Awokuse (2008) is adopted to examine China's exports to and imports from ASEAN. The extended production function can be expressed as:

$$Y=F\,[K, L, X, M] \qquad (1)$$

where Y represents China's economic growth, K and L denote China's capital and labor inputs, and X and M represent China's exports to and imports from ASEAN, respectively.

Data

This study uses the GDP growth rate as a macroeconomic indicator to represent economic growth. For China-ASEAN trade, China's exports to and imports from ASEAN are selected. The total labor force in China represents labor, and capital is proxied by the share of China's gross fixed capital formation in GDP. Data are sourced from the World Bank and the UNCTAD. The period of the data is from 1992 to 2023, covering 32 years. This period was chosen because the China-ASEAN dialogue began in 1991, and data availability from UNCTAD was limited to this period.

This study focuses on six major ASEAN countries (Singapore, Malaysia, Thailand, Indonesia, the Philippines, and Vietnam). Brunei, Cambodia, Laos, and Myanmar are excluded due to relatively small economic scale differences and the unavailability of specific trade data in UNCTAD's China-ASEAN trade statistics. The detailed data sources are listed in Table 1.

Table 1
Variables descriptions and data sources

Variable	Description	Unit	Data Source
GDPG	China's GDP growth rate	Percentage (%)	World Bank
EX	China's total exports to ASEAN	USD Million	UNCTAD
IM	China's total imports from ASEAN	USD Million	UNCTAD
LF	Total labor force in China	Million	International Labour Organization (ILO)
GFCFG	Gross fixed capital formation as a percentage of GDP in China	Percentage (%)	World Bank

Methodology
The analysis involves three main steps. First, a unit root test is conducted to explore the stationarity of the time series. Second, the cointegration relationship among variables is tested. Third, the T- Granger causality test is performed to identify causal relationships. The detailed analysis is as follows.

Unit Root Test
Since spurious regression often occurs between non-stationary time series in economic models, leading to invalid conclusions (Lin & Xu, 2019), conducting unit root tests on the relevant data before proceeding with the analysis is necessary. This study employs the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. The ADF test, an extended version of the Dickey-Fuller (DF) test (Dickey & Fuller, 1981), examines the null hypothesis of unit root existence. The ADF test can be expressed in the following form:

$$\Delta y_t = \alpha + \beta_t + \delta y_{t-1} + \sum_{i=1}^{m} \lambda_i \Delta y_{t-i} + \mu_t \qquad (2)$$

where α represents the constant term, *t* is the time trend term, and *m*=1,2,3 or is determined empirically. The inclusion of *m* lagged terms in the equation ensures that the residual term μ_t becomes white noise.

Phillips and Perron (1988) proposed an alternative method to control for serial correlation when testing for unit roots. This method modifies the *t*-statistic coefficient by conducting non-parametric estimation so that serial correlation does not affect the asymptotic distribution of the test statistic (Okunlola et al., 2020). An additional advantage of the Phillips-Perron (PP) test is its robustness to general forms of heteroscedasticity in the error term and the lack of necessity to specify lag lengths for the test regression (Denano et al., 2023). This unit root test's null and alternative hypotheses are the same as those of the ADF unit root test.

Cointegration Test
This study employs the Johansen cointegration test, as proposed by Johansen (1988), to determine the cointegrated relationship in a multivariate equation. Let X_t be an $n \times 1$ column vector composed of n variables that meet the first-order stationary *I*(1) condition. Its unrestricted vector autoregressive model is represented as:

$$X_t = \sum_{j=1}^{p} \prod_j X_{t-j} + \mu + \varepsilon_t \qquad t=1, 2, \ldots T \quad (3)$$

Where $\prod_j$ is the coefficient matrix, μ is the intercept term, ε_t is a p-dimensional error vector with independent and identically distributed zero mean, and T is the sample size. By differencing the above equation, we obtain the differenced form of the error correction model:

$$X_t = \sum_{j=1}^{p-1} \Gamma_j \Delta X_{t-j} + \prod X_{t-1} + \mu + \varepsilon_t \qquad (4)$$

Where the coefficient matrix $\prod$ is referred to as the loading matrix, which contains the long-run information among the variables represented in vector form. If the rank of the matrix $\prod$ satisfies $0 < r < n$, it indicates the existence of r cointegration vectors. In this case, the loading matrix $\prod$ can be expressed as:

$$\prod = \alpha\beta' \qquad (5)$$

Where α and β are both $n \times r$ matrices. The cointegration vector β has the following properties: Although X_t is non-stationary, $\beta' X_t$ is stationary; α represents the weights of the error correction terms, reflecting the speed at which the model converges from any non-equilibrium state to a long-term equilibrium state. Johansen and Juselius (1990) derived a likelihood ratio test method for the hypothesis of $\prod = \alpha\beta'$, transforming the problem of maximizing the likelihood function into a problem of maximizing the largest eigenvalue under regular constraints.

Toda-Yamamoto Granger Causality Test

Cointegration analysis reveals whether a long-term equilibrium relationship exists between variables but does not establish causality. Further testing is required to determine causality. Empirical studies analyzing the causal relationship between international trade and economic growth frequently use the Granger causality test, as shown in Arodoye & Iyoha (2014), Kalai & Zghidi (2019), and Usman (2023). As econometric research highlights, such tests focus on temporal precedence rather than causality in the conventional sense. Kirikkaleli and Darbaz (2021) argue that the Granger causality test does not account for the properties of stationarity and cointegration. If the time series data are non-stationary or incomplete, the *t*-statistics do not follow a chi-square distribution. Furthermore, the Wald test statistic does not follow an asymptotic chi-square distribution, making it unsuitable for robust causality estimation.

Toda and Yamamoto (1995) proposed an alternative method for testing causality to address these limitations. The T-Y modifies the Wald statistic (MWALD) and applies the modified Wald test technique to impose restrictions on VAR models (Rambaldi & Dora, 1996). Unlike the Granger causality tests, this approach incorporates additional lags determined by the maximum integration order of the series under consideration in estimating the vector autoregression (VAR) model. The T-Y method ensures that the Wald Granger non-causality test statistic in the VAR model follows an asymptotic chi-square distribution ($\chi 2$). The T-Y approach avoids pre-testing biases caused by cointegration issues, as it does not require pre-tests for the integration and cointegration properties of the variables (Zapata & Rambaldi, 1997). This is achieved as long as the maximum integration order of the series does not exceed the actual lag length of the VAR model.

Furthermore, Cervantes et al. (2020) highlight that this method outperforms the Granger test because it incorporates data series regardless of potential non-stationarity or cointegration, thereby minimizing risks associated with misidentifying integration orders or cointegration. It

also reduces distortions in test size caused by pre-testing biases (Chowdhury & Mavrotas, 2006). Additionally, the T-Y does not constrain data to specific levels of stationarity, meaning it applies to variables that are *I*(0), *I*(1), or *I*(2) (Toda & Yamamoto, 1995; Cervantes et al., 2020). Finally, the method is robust regardless of the observed variables' integration order or cointegration rank (Sijabat, 2022).
Generally, the T-Y is based on the following VAR(*m+dmax*) model:

$$Y_t = \omega + \sum_{i=1}^{m} \alpha_i Y_{t-i} + \sum_{i=m+1}^{m+d\max} \theta_i Y_{t-i} + \sum_{j=1}^{m} \beta_j X_{t-j} + \sum_{j=m+1}^{m+d\max} \phi_i X_{t-j} + \nu_{1t} \quad (6)$$

$$X_t = \psi + \sum_{i=1}^{m} \delta_i Y_{t-i} + \sum_{i=m+1}^{m+d\max} \varphi_i Y_{i-i} + \sum_{j=1}^{m} \lambda_j X_{t-j} + \sum_{j=m+1}^{m+d\max} \gamma_i X_{t-j} + \nu_{2t} \quad (7)$$

where *X* and *Y* represent the variables in a model. $\omega, \alpha, \beta, \delta, \phi, \gamma, \lambda, \vartheta, \psi$ are the parameters; *m* represents the optimal lag length in the VAR model. The *dmax* denotes the maximum integration order of the variables. $V_{1t} \sim N(0, \Sigma_{v1})$ and $V_{2t} \sim N(0, \Sigma_{v2})$ are the residuals of the model, and Σ_{v1} and Σ_{v2} are the covariance matrices of V_{1t} and V_{2t}, respectively.

The T-Y involves the following stages. The optimal lag length *m* and the maximum order of integration dmax are determined in the first stage. To determine the optimal lag length for the model, several information criteria were employed, including the Final Prediction Error (FPE), Akaike Information Criterion (AIC), Hannan-Quinn Criterion (HQ), and Schwarz Bayesian Information Criterion (SIC) (Niedzwiecki & Ciolek, 2019). Enders (2008) noted that, in practice, SIC tends to select a more parsimonious model compared to AIC or T-tests. Since this study is based on a small sample of 32 years of time series data, a parsimonious model is important to ensure reliable estimation and avoid overfitting. This makes SBC more appropriate for determining the optimal lag length in this context.

Then, a VAR model based on the time series data is established. The VAR(*m*) model is then evaluated to ensure it is correctly specified. These tests include residual tests to detect autocorrelation, stability tests to ensure the dynamic stability of the model, heteroscedasticity tests to determine whether the residual variance is constant, and normality tests to verify whether the residuals follow a normal distribution. Next, a causality test is performed using the Wald statistic or a modified Wald test (MWald) to assess the significance of the equations' parameters. The tests are conducted at a lag order of *m+dmax* (Sijabat, 2022).

Empirical Result and Discussion

Unit Root Test and Selection of Optimal Lag Order

This study conducted the ADF and PP tests in Stata 17 to determine the unit root properties of the variables. The results in Table 2 show that the ADF and PP test outcomes are consistent in all cases. At the 5% critical value, the order of integration of LNLF is *I*(0), while the other variables, including GDPG, LNEX, and GFCFG, are *I*(1). This indicates that the maximum order of integration among the variables is 1.

Table 2
Tests Results for Unit Root Tests

Variable	Level		First difference		Decision
	ADF	PP	ADF	PP	
GDPG	-2.381	-2.237	-9.151**	-9.169**	*I*(1)
LNEX	-1.518	-1.540	-4.988**	-5.007**	*I*(1)
LNIM	-2.462	-2.747	-5.677**	-5.670**	*I*(1)
LNLF	-5.291**	-5.070**			*I*(0)
GFCFG	-1.823	-1.824	-6.555**	-6.252**	*I*(1)

Note: ** indicates5% significance levels, respectively. Logarithmic transformations are applied to exports, imports, and labor force data , resulting in the corresponding variables LnEX, LnIM, and LnLF in the estimations.

Table 3 below shows the results of the lag order selection criteria. The maximum lag imposed on the estimation is two, implying that this paper assumes a change in the endogenous variable affects the other variables in two years. The LR, FPE, AIC, and HQ criteria selected a lag order of 2, while the SIC selected a lag order of 1. Given that this study is based on a small sample dataset, the SIC criterion was chosen to determine the optimal lag order, following the recommendation of Enders (2008). Therefore, a lag order of 1 was preliminarily selected as the optimal lag order.

Table 3
Lag Order Selection Criteria

Lag	LL	LR	FPE	AIC	HQ	SIC
0	-81.331	NA	2.000e-4	5.755	5.830	5.989
1	84.655	331.970	1.800e-08	-3.647	-3.195	-2.242*
2	123.911	78.514*	8.300e-09*	-4.594*	-3.772*	-2.025

Note: *Indicates lag order selected by criterion. LR: Likelihood ratio criterion. FPE: Final Prediction Error. AIC: Akaike information criterion. HQ: Hannan-Quinn information criterion. SIC: Schwarz information criterion.

To ensure that residuals from the VAR model with one lag are free from autocorrelation, a Lagrange-Multiplier (LM) test was conducted. The test results are shown in Table 4. At lag 1, the LM test statistic (chi^2) was 64.951 (degrees of freedom df = 25, $p < 0.001$), indicating significant autocorrelation. The opposite conclusion is found when the number of lags increases by a lag order to 2 lags since the LM statistics shows no significant autocorrelation (chi^2=29.82, p=0.231), failing to reject the null hypothesis of no autocorrelation at these lag orders. Therefore, we could conclude the lack of robust evidence to suggest that the VAR at one lag is free from autocorrelation.

Table 4
Lagrange-Multiplier Test for Residual Autocorrelation

Lag	Chi-squared statistics (chi^2)	*p*-value
1	64.951	2.000e-5
2	29.820	0.231

As Scott Hacker and Hatemi-J (2008) suggested, when the sample size is relatively small, priority should be given to selecting a lag order that meets the model assumptions rather than solely relying on information criteria. Therefore, the number of lags increases by a lag order to 2 lags, and the Lagrange Multiplier (LM) test for autocorrelation was conducted. The test results, as shown in Table 5, indicate no significant autocorrelation in the residuals at lag 1 (chi²=25.043, p=0.460) and lag 2 (chi²=34.091, p=0.106), failing to reject the null hypothesis of no autocorrelation at these lag orders. This suggests that the residuals passed the autocorrelation test. Table 5 also presents the results of the normality and heteroscedasticity tests, both of which indicate that the model passed the relevant diagnostic tests. Furthermore, the stability test results, shown in Figure 3, confirm that the model is dynamically stable.

Table 5
VAR Diagnostic Test Summary

Test Type	Chi-squared statistics (chi²)	*p*-value
LM autocorrelation test (lag1)	25.043	0.460
LM autocorrelation test (lag2)	34.091	0.106
Normality Test (Jarque-Bera)	3.674	0.961
Heteroscedasticity Test (White's Test)	20.380	0.434

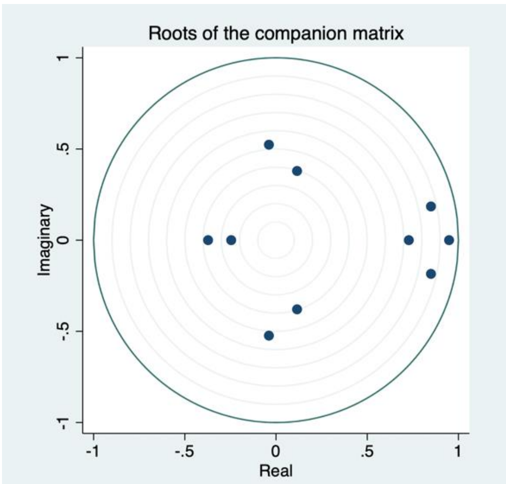

Figure 3. Stability Check of the VAR Model Using the Roots of the Companion Matrix

In conclusion, the results above indicate that the VAR model with a lag order of 2 satisfies the necessary conditions of model assumptions, demonstrating that lag two effectively balances model complexity and the ability to capture dynamic information.

Cointegration Analysis

Since not all variables are stationary at the level, it is also necessary to perform a cointegration test before constructing the initial VAR model. The Johansen cointegration test was conducted in this study, and the results are presented in Table 6. The estimation is done on a VECM model with one lag since the VAR model contains two lags. The results indicate a cointegration relationship among the variables, reflecting a long-term equilibrium relationship. Based on the Johansen test results, the level form of the variables can be directly used for the next estimation without differencing the data. This approach avoids potential information loss caused by differencing (Johansen, 1991; Lütkepohl, 2013).

Table 6
Johansen Cointegration test

Hypothesized No. of CE(s)	Eigenvalue	Trace statistic	Critical value 5%
None	NA	50.248	47.210
At most 1	0.481	29.946	29.680
At most 2	0.411	13.541*	15.410
At most 3	0.246	4.807	3.760
At most 4	0.144	NA	NA

Note: * indicates the failure to reject the null hypothesis of no cointegration at 5% significance level.

Toda-Yamamoto Causality Analysis

The results of the cointegration test provide preliminary evidence of a long-term equilibrium relationship among the variables, suggesting the existence of causality. Consequently, based on the argument in Section 4.2.3, the T-Y was conducted. Based on the analysis, the optimal lag length was determined to be two, while the maximum order of integration among all variables was one. Therefore, an additional lag (*dmax*=1) was added to each equation, resulting in a T-Y with a lag length of three. The specific results are shown in Table 7.

Table 7
Result of Toda-Yamamoto Causality Test

Null hypothesis	Chi-Square	Probability	Decision on the null hypothesis
Export does not Granger cause economic growth	13.431*	0.001	Reject
Economic growth does not Granger cause Export	11.873*	0.003	Reject
Import does not Granger cause economic growth	3.514	0.173	Accept
Economic growth does not Granger cause Import	5.954	0.051	Accept
Export does not Granger cause Import	7.111*	0.029	Reject
Import does not Granger cause Export	23.008*	0.000	Reject
Labour does not Granger cause economic growth	9.885*	0.007	Reject
Economic growth does not Granger cause Labour	0.434	0.805	Accept
Capital does not Granger cause economic growth	2.708	0.258	Accept
Economic growth does not Granger cause Capital	31.968*	0.000	Reject

Note: * Indicates significance at 5% critical values.

At the 5% significance level, the results revealed the following relationships.First, China’s exports to ASEAN have a significant causal relationship with China’s economic growth, rejecting the null hypothesis that exports do not cause economic growth. The significant positive impact of exports on Chinese economic growth indicates that China’s exports to ASEAN are crucial in promoting domestic economic development. This finding implies the impact of the export-oriented development model, especially under the context of the establishment of CAFTA, where the structure of China’s export commodities has gradually shifted toward high value-added products (Chiang, 2019). Moreover, the results align with the assumption that ASEAN provides a large and diversified market for China’s manufacturing industry, including machinery, electrical products, and high-tech goods, significantly contributing to China’s GDP growth (Lee, 2024).

At the same time, the Chinese economic growth also shows a significant causal effect on the exports to ASEAN countries. As China’s economy expands, industrial upgrading and technological innovations have made export products increasingly competitive internationally (Xu et al., 2024). This enhanced competitiveness enables Chinese exports to better meet the growing and diversifying demands of the ASEAN market. In sum, this bidirectional causal relationship demonstrates a high level of interdependence between China’s exports to ASEAN and its economic growth, forming a robust interactive mechanism.

Otherwise, the results indicate no significant bidirectional causal relationship between China’s economic growth and imports from ASEAN. This suggests that resource-based imports from ASEAN, such as agricultural products, mineral resources, and rubber, have a limited direct impact on China's economic growth. This may be because these imports are primarily used in intermediate production processes, and their effect on overall economic growth tends to be more indirect and long-term, making it difficult to detect significant short-term causality effects. Similarly, China’s economic growth does not exhibit a significant driving effect on imports from ASEAN. One possible explanation is China’s high resource utilization efficiency and robust domestic production capacity, which reduce its dependency on imports for economic growth.

Furthermore, thehe results reveal a significant bidirectional causal relationship between China’s exports to and imports from ASEAN. Export growth directly drives the demand for intermediate goods and raw materials from ASEAN. For instance, China’s exports to ASEAN require substantial inputs of rubber, timber, and electronic components, which hold significant shares in ASEAN trade (Tongzon, 2005). Conversely, imports from ASEAN create competitive advantages for China’s exports. The advantages are created by sourcing high-quality raw materials and intermediate products from ASEAN countries, reducing production costs, and enhancing the international competitiveness of Chinese export goods (Athukorala & Kohpaiboon, 2014).

This bidirectional causality highlights the dynamic interaction between China-ASEAN trade. ASEAN is an important trading partner for China and a key node in its supply chain. This relationship forms a mutually reinforcing and cyclic mechanism, laying a solid foundation for bilateral trade's long-term and stable development. When combining the findings involving export, import and economic growth, we could further summarise that while export can promote economic growth directly, import indirectly affects economic growth in China via its causal relationship with the Chinese exports to ASEAN.

Furthermore, a significant unidirectional causal relationship is observed between labor and economic growth, indicating that labor growth significantly promotes economic growth. This highlights the crucial role of labor in driving China's economic growth. Meanwhile, economic growth has a significant causal effect on capital accumulation, reflecting the strong impetus of economic expansion on capital formation. This aligns with the expectation that economic growth leads to increased investment demand, capital expansion, and enhanced production capacity.

Robustness Test

To ensure the robustness of the findings, this study replaces GDP growth with per capita GDP growth as the economic growth variable and conducts the T-Y causality test. As shown in Table 8, the results indicate a bidirectional causal relationship between China's exports to ASEAN and economic growth. Similarly, a significant bidirectional causal relationship is observed between China's exports to and imports from ASEAN. At the same time, a significant unidirectional causal relationship is observed between labor and economic growth, as well as between economic growth and capital accumulation. These findings are consistent with the results obtained using GDP growth as the economic growth variable. However, this analysis also shows that economic growth exhibits a significant causal relationship with imports, which differs from the baseline model results above. Overall, both baseline and robustness analyses results show high consistency, demonstrating that the causality relationships identified in this study are robust.

Table 8
Robustness test for Toda-Yamamoto causality test

Null hypothesis	**Chi-Square**	**Probability**	**Decision on the null hypothesis**
Export does not Granger cause economic growth	13.454*	0.001	Reject
Economic growth does not Granger cause Export	12.531*	0.002	Reject
Import does not Granger cause economic growth	4.089	0.129	Accept
Economic growth does not Granger cause Import	7.291*	0.026	Reject
Export does not Granger cause Import	8.459*	0.015	Reject
Import does not Granger cause Export	23.492*	0.000	Reject
Labour does not Granger cause economic growth	9.769*	0.008	Reject
Economic growth does not Granger cause Labour	0.438	0.803	Accept
Capital does not Granger cause economic growth	2.038	0.361	Accept
Economic growth does not Granger cause Capital	33.711*	0.000	Reject

Conclusion

Based on annual data from 1992 to 2023, this study employs the TY causality framework to systematically investigate the causal relationships between China's exports to ASEAN, imports from ASEAN, and China's economic growth, yielding the following main conclusions. First, there is a significant bidirectional causal relationship between China's exports to ASEAN and its economic growth, indicating that exports drive economic growth by increasing output, creating employment and, therefore, benefiting economic growth. This reverse causality occurs when economic growth enhances production capacity through industrial upgrading and technological innovations. This growth-driven improvement in competitiveness enables Chinese exports to better meet the growing and diversifying demands of the ASEAN market, thereby supporting the continued expansion of exports. Second, the causality relationship between China's economic growth and imports from ASEAN was insignificant in the baseline model. Additionally, a significant bidirectional causal relationship between exports and imports indicates that their interaction is crucial in promoting bilateral trade and economic growth.

Based on these findings,the following policy recommendations are proposed. First, efforts should focus on enhancing export products' added value and technological content, thereby differentiating Chinese products from global competitors. Eventually, it boosts their international competitiveness and maximizes the contribution of exports to economic growth. The indirect effect of exports on economic growth via imports also suggests that improving exports to ASEAN countries also increases the contribution of imports to economic growth. Second, the significant bidirectional causal relationship between exports and imports underscores the importance of their interaction in driving trade growth and economic development. Therefore, further strengthening bilateral trade cooperation mechanisms between China and ASEAN is crucial. Within the framework of the RCEP, measures should be taken to advance higher levels of trade liberalization and facilitation, reduce trade barriers, and enhance regional economic integration.

Future research can focus on the specific roles of different export commodity structures in economic growth, such as classifying export commodities into resource-based, labor-intensive, and high-tech products, to explore the differentiated impacts of various categories of goods on economic growth. Such an analysis can help identify which export sectors contribute the most to economic growth, providing targeted guidance for optimizing export policies and enhancing the added value of export commodities. Additionally, the studies could be extended to cover the issue from the perspective of ASEAN countries.

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