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Cointegration and Dynamic Interactions: A Study on Trade Openness and Economic Growth in China

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Abstract

This research examines the long-term equilibrium relationship between trade openness and China's economic growth, drawing on quarterly data spanning 2002 to 2021. The analysis applies a VAR framework alongside established econometric approaches—Johansen cointegration testing, Granger causality analysis, impulse response functions, and variance decomposition—to systematically assess dynamic interactions among GDP, export-import volumes, and exchange rate fluctuations. Findings empirically confirm three significant cointegration relationships, supporting a stable long-run equilibrium between trade expansion and economic development. The Granger causality tests identify mutual causality between GDP and exchange rate movements, alongside bidirectional effects between exports and the exchange rate. Meanwhile, a unidirectional causal link runs from exports to imports. Variance decomposition further reveals that both exports and imports increasingly account for economic variability over time, with imports demonstrating stronger explanatory power in the extended horizon. These results inform several policy recommendations focused on promoting export growth, refining industrial and trade configurations, and enhancing exchange rate risk frameworks to support sustained economic progress.

Keywords

Trade Openness, Economic Growth, VAR Model, Cointegration Analysis, Impulse Response Function.

1. Introduction

Scholarly literature examining the nexus between international trade and economic growth typically draws upon foundational indicators including exchange rate fluctuations and trade flow data—for econometric investigations. Zhang Shiqing (2007) [1] employed HP filtering, correlation matrices, and cointegration analysis, finding that the combined effect of import and export data more comprehensively reflects the contribution of trade to GDP growth. Zhou Chunying (2007) [2] used Granger cointegration tests and factor analysis to demonstrate that import trade promotes economic growth mainly through two channels: facilitating technological upgrades and expanding export scale. Deng Chuang (2016) [3] constructed a time-varying parameter VAR model and found that the impact of import and export activities on economic growth varies significantly across sectors and exhibits clear seasonal differences. Liu Ali (2014) [4], based on a VAR model, pointed out that RMB appreciation may inhibit economic growth in the short term but helps promote sustainable economic development in the long term. Xu Ke (2012) [5] employed an autoregressive conditional heteroskedasticity (ARCH) model, confirming that RMB exchange rate fluctuations have differentiated effects on China's trade with various trading partners.

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Following international practice, this study selects total import-export volume and the exchange rate as core indicators, using quarterly data from 2002 to 2021 to construct a VAR model. Systematic empirical testing is conducted with impulse response functions and variance decomposition techniques.

2. Model Construction

2.1. Data Sources and Processing

Gross Domestic Product (GDP), as the core indicator for measuring national economic development, is used in this study to represent the level of economic growth. Considering that both exports and imports significantly drive economic development, and the exchange rate is a key variable in the international price system, total import-export volume and the exchange rate are selected as indicators of international trade. This study employs a VAR model to analyze the dynamic relationships among these four variables.

The data are sourced from the Guotai 'a database, covering quarterly observations from 2002 to 2021. To smooth the volatility of the time series, all variables are transformed into natural logarithms, denoted as LNIM (imports), LNEX (exports), LNER (exchange rate), and LNGDP (GDP). The empirical analysis is performed using EViews 9.0 software. To ensure consistency in measurement units, all data are converted to U.S. dollars using the year-end USD/RMB exchange rate published by the National Bureau of Statistics.

2.2. Descriptive Statistics

The descriptive statistics results indicate that the standard deviations of the four indicators remained consistently low from 2002 to 2021, suggesting limited data dispersion and relatively stable fluctuations. Skewness and kurtosis analysis reveals that the exchange rate series exhibits a left-skewed distribution, while the other three variables show right-skewed characteristics. All variables have kurtosis values below 3, indicating that the data distribution is flatter than a normal distribution without pronounced peaks.

2.3. Construction of the VAR Model

To accurately characterize the volatility patterns of global economic growth, this section develops a vector autoregression (VAR) model for analysis. Within this framework, all variables are treated as endogenous, with their respective lagged terms serving as explanatory variables. The general mathematical representation of the VAR model is presented below in formal notation:

2.3.1. General Vector Form

The VAR model can be expressed in vector form as:

$$Y_t = A_i Y_{t-i} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + \varepsilon_t$$

Where:

Y_t is an n×1 vector of all endogenous variables at time t. In your study, this vector may include: LNGDP is economic growth, LNEX is exports, LNIM is imports, and LNER is exchange rate. Formally:

$$Y_t = [\mathrm{LNGDP}_t, \mathrm{LNEX}_t, \mathrm{LNIM}_t, \mathrm{LNER}_t]'$$

P denotes the lag order of the model, which can be determined using likelihood ratio tests, information criteria, or other statistical methods.

A_i (for= 1, 2, ..., p) is an n×n coefficient matrix, where each element (e.g., a_{11}, a_{12}) measures the effect of one variable's lagged value on another variable.

Y_{t-i} is the lagged vector of Y at time $t - i$.

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ε_t is an n×1 vector of stochastic disturbances, representing unexplained components in the model. It is typically assumed to have a mean of zero and to be serially uncorrelated.

2.3.2. Explicit System of Equations Form

To better illustrate the relationships among variables, the vector form can be expanded into a system of n equations. For a system with four variables (LNGDP, LNEX, LNIM, LNER), the first equation (for LNGDP) can be written as:

$$\begin{aligned}\mathrm{LNGDP_t} = {} & \beta_{11}\mathrm{LNGDP_{t-1}} + \beta_{12}\mathrm{LNEX_{t-1}} + \beta_{13}\mathrm{LNIM_{t-1}} + \beta_{14}\mathrm{LNER_{t-1}} + \cdots \\ & + \beta_{1(p+3)}\mathrm{LNER_{t-p}} + \varepsilon_t\end{aligned}$$

Each equation includes Lagged values of all variables up to order as regressors. Corresponding coefficients β, which are estimated from the data. A stochastic error term. This setup clearly shows that each current endogenous variable is modeled as a function of the past values of all variables (including itself), capturing the dynamic interactions within the system.

3. Empirical Analysis

3.1. Stationarity Test and Johansen Cointegration Test

To ensure the reliability of the empirical results, this study first conducted stationarity tests on the selected variables. The results indicate that, at the 5% significance level, all variable series are integrated of order one, i.e., I (1) processes. Based on this, we further employed the Johansen cointegration test to examine whether there exists a long-term stable equilibrium relationship among these variables. The test results confirm that, at the 5% significance level, there are three significant cointegration relationships among the variables. This finding aligns with the conclusions of Chu et al. (2020), indicating a long-term stable equilibrium relationship between international trade and economic growth.

3.2. Granger Causality Test

To further explore the causal relationships among the variables, a Granger causality test was performed. The results show a significant bidirectional Granger causality between GDP and the exchange rate (ER), with both p-values below 0.05. This suggests that economic growth and exchange rate fluctuations mutually influence each other. Similarly, exports (EX) and the exchange rate (ER) also exhibit a significant bidirectional relationship, passing the significance test at the 10% level. Further examination of the relationship between imports (IM) and exports (EX) shows that the null hypothesis “IM does not Granger-cause EX” has a p-value greater than 0.1, while “EX does not Granger-cause IM” has a p-value below 0.05. This indicates a unidirectional causal relationship: exports significantly affect imports, whereas imports do not drive changes in exports.

3.3. Lag Order Selection and Model Stability Test

When constructing a VAR model, selecting the lag order requires balancing information completeness and model degrees of freedom. After comparing multiple information criteria, most criteria suggest a lag order of 4 as optimal. Therefore, a VAR (4) model was established for subsequent analysis. Unit root tests on the VAR (4) model show that all characteristic roots have moduli less than 1 and lie within the unit circle. This result demonstrates that the constructed VAR (4) model is stable, satisfying the prerequisites for impulse response and variance decomposition analyses.

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3.4. Impulse Response Function Analysis

This study uses impulse response functions to examine the dynamic interactions among variables, setting the observation horizon to 10 periods to capture short- and medium-term interactions.

Observing a one-standard-deviation shock in exports (EX), economic growth (GDP) initially exhibits a volatile response but generally trends positive. The response peaks in the second period and gradually diminishes, indicating that exports have the most pronounced short- to medium-term impact on economic growth. Conversely, when GDP receives a one-standard-deviation shock, EX's initial response is relatively muted, followed by similar cyclical fluctuations with smaller amplitudes.

Shocks in the exchange rate (ER) show an initial decline followed by a rise in GDP, indicating that ER fluctuations have a noticeable short-term impact on economic activity, which diminishes over time as market participants gradually adjust expectations and behaviors. Correspondingly, GDP shocks also produce similar cyclical patterns in ER, with gradually decreasing influence. For the interaction between imports (IM) and GDP, import shocks affect GDP significantly in the short term but gradually weaken over time. In contrast, GDP's effect on imports shows persistent cyclical fluctuations, with negative effects generally outweighing positive effects.

3.5. Variance Decomposition Analysis

To better understand each variable's contribution to economic fluctuations, variance decomposition was performed. The results reveal the explanatory power of each variable for GDP volatility. GDP explains 88% of its own variation initially, reflecting the inertia characteristic of the economic system. Exports account for 12%, indicating that exports are a key external driver of economic growth. Imports initially have no impact, while the exchange rate contributes approximately 0.5%. Over time, the explanatory power of external variables changes significantly. Exports' contribution to GDP variation increases, peaking at 18%, confirming their important role in driving economic growth. Imports' explanatory power rises gradually, reaching a maximum of 6%, and the exchange rate eventually explains 10%, highlighting its non-negligible influence on medium- to long-term economic performance. Notably, in the long run, imports' explanatory power on GDP fluctuations surpasses that of exports and the exchange rate. This finding aligns with Zhou (2007), who concluded that China's import trade mainly contributes to economic growth by promoting technological development and export expansion.

4. Research Conclusions and Policy Implications

4.1. Main Research Conclusions

By constructing a VAR (4) model and employing cointegration tests, Granger causality tests, impulse response functions, and variance decomposition, this study systematically examines the long-term equilibrium relationship between trade openness and economic growth, leading to the following key conclusions. 1. Total imports and the exchange rate show significant predictive power for future economic growth, providing a basis for formulating scientific export development plans. Granger causality tests further confirm a significant bidirectional causal relationship between the exchange rate and GDP, as well as mutual influence between the exchange rate and exports. 2. From a trade structure perspective, imports and the exchange rate have good predictive value for GDP, while imports have limited predictive power for exports. This complements Deng (2016), who found that import and export transactions have seasonal effects on economic growth. 3. The rising share of equipment manufacturing exports reflects an optimization of export structure. Equipment manufacturing accounts for 58.3% of

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total exports and contributes 73% to overall export growth. Private enterprises account for 57.1% of total foreign trade, becoming the main driver of trade development. These structural changes provide new insights into the relationship between trade openness and economic growth. 4. Foreign trade plays a crucial role in promoting economic development. By stimulating trade, it broadens channels for economic growth and supports sustainable development, consistent with Zhang (2007), who found that imports and exports jointly contribute to GDP growth.

4.2. Policy Recommendations

4.2.1. Promote Export Expansion and Structural Upgrading

This study confirms that economic growth and foreign trade maintain a long-term equilibrium, with exports significantly promoting economic development. It is recommended to continue deepening free trade zone construction, coordinate post-pandemic economic development, and strengthen multilateral trade cooperation. Empirical results show regional differences in the elasticity of export fluctuations on macroeconomic volatility: the western region (0.601) is higher than the eastern (0.302) and central (0.546) regions. This suggests that regional differences should be considered in export promotion policies. Regarding export structure, efforts should focus on increasing the share of high-tech product exports. In the first five months of 2025, industrial robot exports grew by 55.4%, electric vehicle exports by 19%, and integrated circuit exports by 18.9%. Promoting high-end manufacturing and innovative industries can effectively optimize export structure and foster new competitive advantages in foreign trade.

4.2.2. Optimize Industrial Structure and Trade Patterns

Targeted policies should align with domestic trade development, actively introducing advanced foreign technologies to promote domestic technological progress. The long-term equilibrium effect of trade openness on economic growth suggests that trade drives growth indirectly through capital formation, technological progress, and increased factor productivity. Optimizing the import-export trade structure is an effective way to cultivate new export advantages and economic growth momentum. The central region leads national import-export growth, rising 11.1% year-on-year, 8.6 percentage points higher than the national average. This indicates that the central region can serve as a demonstration for optimizing trade structure and promoting coordinated national trade development. Market diversification should also continue, expanding trade with emerging markets. In the first five months, China's exports to ASEAN, Africa, and five Central Asian countries increased by 16.9%, 35.3%, and 8.8%, respectively, with ASEAN remaining China's largest trade partner. Market diversification enhances foreign trade resilience and promotes stable trade development.

4.2.3. Improve Exchange Rate Risk Management and Financial Security Mechanisms

Although the direct impact of the exchange rate on the economy is limited, long-term risks cannot be ignored. A sound risk response mechanism is needed to prevent economic shocks from large exchange rate fluctuations. Studies on financial openness suggest that as domestic institutional conditions improve, its impact on macroeconomic resilience shifts from inhibitory to supportive. The relationship between trade openness and economic risk indicates that higher openness steepens the aggregate supply curve, flattens the aggregate demand curve, increases the output-inflation substitution ratio, and reduces economic downturn and deflation risks. This provides theoretical support for maintaining economic security while promoting trade openness. Regarding financial openness, strategies should be chosen based on domestic institutional conditions. Research shows that institutional financial openness has higher thresholds and stronger positive effects than factor-based financial openness, indicating that

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China should continue deepening financial system reform to create conditions for steadily advancing institutional financial openness.

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