

Dynamic Relationship between Economic Growth, Foreign Trade and Carbon Emissions Based on the VECM Model

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Abstract: Under the dual background of China's "dual carbon" goals and the high-quality development of foreign trade, the dynamic relationship among economic growth, foreign trade, and carbon emissions has become an important research issue. Based on annual national time-series data from 2000 to 2024, this paper incorporates foreign trade into the analytical framework of economic growth and carbon emissions, and comprehensively adopts unit root tests, Johansen cointegration analysis, vector error correction models, Granger causality tests, impulse response functions, and variance decomposition methods to empirically examine the long-term equilibrium relationship, short-term fluctuation characteristics, and dynamic transmission mechanism among the three variables. The study finds that foreign trade, economic growth, and carbon emissions are all first-order integrated sequences, and that there is a unique and stable long-term cointegrating relationship among the variables. Overall, trade and economic growth are the one-way driving factors of carbon emission changes, and there is no reverse transmission effect. Among them, the effect of foreign trade on carbon emissions shows obvious lag and phased structural characteristics: there is a short-term emission-reduction buffer effect, but in the medium and long term it significantly increases carbon emissions. Based on the empirical findings, this paper proposes that China should continue to optimize the structure of goods trade, expand the share of low-carbon service trade, improve the green trade institutional system, increase investment in low-carbon technology research and application, and encourage export industries to decouple economic growth from carbon emissions. This will help maintain a stable foreign trade base and steady economic operation while steadily advancing green and low-carbon transformation, achieving coordinated progress among foreign trade, economic development, and ecological protection.

Keywords: Unit Root Test; Cointegration Analysis; Granger Causality; Impulse Response; Variance Decomposition.

1. Research Background

Since the reform and opening-up, foreign trade and economic growth have been regarded as the two core engines driving the Chinese development miracle. However, with the proposal of the "dual carbon" goals, an unavoidable contradiction has gradually emerged. The export-oriented production system, which relies heavily on a high-carbon energy structure, has driven sustained GDP growth while also causing a rapid rise in carbon emissions. The complex relationship among foreign trade, economic growth, and environmental pressure has raised a key question: what is the dynamic equilibrium relationship among foreign trade, economic growth, and carbon emissions, and what is the direction of causal transmission among them?

Existing studies show that China's foreign trade and carbon emissions are directly related. Many scholars have investigated the relationship between foreign trade and economic growth from the perspectives of imports and exports. For example, Sun Jingshui, Gao Lingfen, and Sun Jinxiu, as well as Leng Mei and Fei Fangyu, have argued that exports, imports, consumption, and investment have long-term cointegration relationships with economic growth, and that exports and consumption significantly promote economic growth.[1][2] Wu Dejin used econometric models to confirm a cointegration relationship among FDI, foreign trade, and economic growth, and found that both imports and exports are drivers of economic growth in the short term.[3] Lü Pin and Mao Qilin found a positive correlation between economic growth and exports, but a negative correlation with imports.

[4] Other studies have focused on the relationship between energy consumption and carbon emissions. Among these, the Environmental Kuznets Curve (EKC) proposed by Grossman and others is the most representative and widely used model in the study of the relationship between carbon emissions and economic growth.[5] In addition, given China's unique national conditions, Chinese scholars have further explored whether carbon emissions should be reduced and whether a low-carbon economic development strategy should be implemented. For instance, Fu Yun et al. analyzed the urgency of developing a low-carbon economy and studied low-carbon development models. [6] Yuan Fuhua and others systematically discussed the direction and development potential of future economic growth under low-carbon conditions. [7] Fang Dachun et al. emphasized the theoretical basis of a low-carbon economy and affirmed its importance. [8] Furthermore, scholars in China have also studied the drivers of carbon emissions. Lin Boqiang et al. proposed energy-saving and low-carbon economic strategies under the influence of energy consumption and carbon intensity on economic growth. [9] Zhou Haiyan et al. analyzed the issues of heterogeneous energy consumption and economic growth and proposed solutions for low-carbon development. [10]

Most of the above studies focus either on the relationship between energy consumption and carbon emissions or on the one-sided environmental effects of trade, with relatively few studies placing foreign trade, economic growth, and carbon emissions in the same dynamic system. There is limited analysis of the long-term equilibrium relationship and short-term fluctuation characteristics among the three variables,

especially as China becomes deeply embedded in global value chains. In this context, the scale of embodied carbon in exports and imports is large, but does export growth necessarily lead to a proportional increase in carbon emissions? Can economic growth offset the emissions pressure caused by exports through structural and technological effects? These questions have not yet been systematically tested empirically. Based on this, this paper adopts cointegration tests and Granger causality analysis, using China's total import and export volume, GDP, and carbon emissions data from 2000 to 2024 to systematically examine the long-term equilibrium relationship and short-term causal flow among foreign trade, economic growth, and carbon emissions.

2. The Current Situation of Foreign Trade, Economic Growth, and Carbon Emissions in China

At present, the relationship among China's foreign trade, economic growth, and carbon emissions is undergoing a profound and persistent structural transformation. From the perspective of time, since China joined the WTO in 2001, foreign trade has transitioned from rapid expansion to high-quality upgrading. Export volume increased from approximately 2 trillion yuan in 2000 to 26.99 trillion yuan in 2025, and the share of mechanical and electrical products rose from less than 50% to more than 60%. At the same time, the market structure shifted from dependence on Europe and the United States to broader participation in the Belt and Road region, with the share of trade with Belt and Road countries reaching 51.8%. In terms of economic growth, China's GDP increased from about 10 trillion yuan in 2000 to 140.19 trillion yuan in 2025, achieving an average annual double-digit growth rate. Meanwhile, the growth rate of carbon emissions gradually slowed after around 2010, and carbon intensity per unit of GDP continued to decline, marking China's transition from synchronous growth to weak decoupling and then toward a carbon peak.

The impact of foreign trade on carbon emissions shows notable spatial heterogeneity and transfer characteristics. Over the past two decades, eastern coastal regions achieved export-oriented growth first, while transferring a large number of high-carbon industries to inland and northern regions, resulting in a long-term pattern of “southern consumption and northern emissions.” At the same time, international carbon regulations have become increasingly strict, from the Kyoto Protocol to the formal implementation of the EU Carbon Border Adjustment Mechanism (CBAM) in 2026. Carbon tariffs and carbon footprint rules are gradually replacing traditional tariffs and becoming a new long-term constraint on Chinese exports. Overall, over the past 20 years, the relationship among the three has evolved from early synchronous growth to structural differentiation and

institutional rebalancing, providing a strong empirical foundation for cointegration and causality analysis.

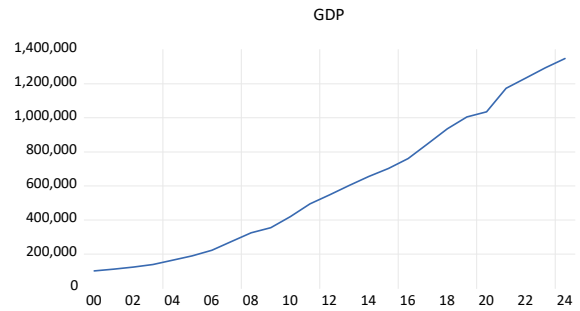


Figure 1. Trend of China's GDP, 2000–2024.

3. Empirical Analysis

3.1. Data and Variable Selection

The data used in this empirical analysis are annual data from 2000 to 2024. The main data sources include the China Statistical Yearbook, China Trade and Foreign Economic Statistical Yearbook, China Energy Statistical Yearbook, and the China Carbon Accounting Database (CEADs). The selected indicators are as follows: GDP represents the level of economic growth, CO₂ represents carbon emissions, and TRA represents the total value of imports and exports, converted into RMB using the average annual exchange rate. To eliminate price effects on each variable and reduce data volatility while avoiding heteroskedasticity and not altering the original economic relationships, all variables are log-transformed. The processed sequences are LnGDP, LnTRA, and LnCO₂, as shown in Figure 2.

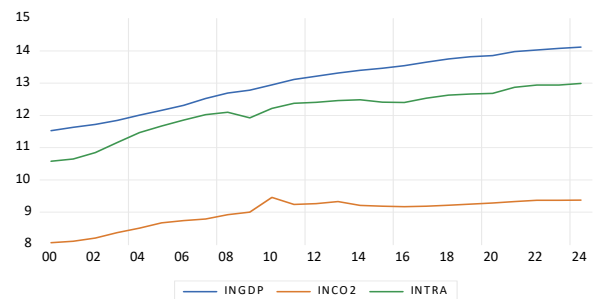


Figure 2. Time-Series Plots of the Variables.

3.2. Unit Root Test

The purpose of the unit root test is to determine whether each series is stationary. If a series is non-stationary, it is necessary to determine its order of integration. In this paper, the ADF test is used for each variable, and the lag order is adjusted so that the DW value is close to 2, thereby ensuring no autocorrelation and reliable test results. The test results are shown in Table 1.

Table 1. Unit Root Test Results of Variables

Variable	Lag Order	ADF Test Statistic	DW Value	P Value	Conclusion
LnGDP	0	0.689125	1.529534	0.9992	Non-stationary
DLnGDP	1	-3.779112	2.167521	0.0378	Stationary
LnTRA	0	-1.878511	1.754380	0.6342	Non-stationary
DLnTRA	0	-4.184652	1.936547	0.0162	Stationary
LnCO ₂	0	-1.506824	2.378886	0.7986	Non-stationary
DLnCO ₂	0	-6.020147	2.048030	0.0003	Stationary

Note: D denotes the first difference.

According to the unit root test results, the ADF test values of the level sequences LnGDP, LnTRA, and LnCO2 are all greater than the critical value at the 5% significance level, and their P-values are greater than 0.05. Therefore, the null hypothesis of a unit root cannot be rejected, indicating that the original series are non-stationary. In contrast, the ADF test values of the first-difference series DLnGDP, DLnTRA, and DLnCO2 are all below the critical value and their P-values are less than 0.05, indicating that they become stationary after first differencing. Thus, LnGDP, LnTRA, and LnCO2 are all first-order integrated sequences, i.e., I(1) processes. Because the three variables are integrated at the same order, direct regression using non-stationary raw sequences may generate spurious regression. Therefore, it is necessary to further test

whether a cointegration relationship exists among them.

3.3. Cointegration Test

The Johansen cointegration test is adopted. The premise of this test is first to estimate a VAR model and determine the optimal lag order based on LR, FPE, AIC, SC, and HQ criteria. As shown in Table 2, the optimal lag order of the model is 3. The VAR (3) model fits well. Then a test is conducted for whether a trend term exists in the cointegrating equation. The results show that the trend term in the cointegrating equation is significant; therefore, adding the trend term improves the equation fit. Finally, the cointegration test is performed, and the results are shown in Table 3.

Table 2. Selection of Lag Order

Lag	LogL	LR	FPE	AIC	SC	HQ
0	10.83838	NA	9.84e-05	-0.712580	-0.563802	-0.677533
1	99.71612	145.4363	6.99e-08	-7.974192	-7.379078	-7.834001
2	115.8580	22.01161*	3.87e-08	-8.623451	-7.582002*	-8.378117
3	129.5724	14.96123	2.92e-08*	-9.052039*	-7.564254	-8.701561*

Note: * indicates the optimal lag order according to the corresponding criterion.

Table 3. Johansen Cointegration Test

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.765666	31.92219	25.82321	0.0069
At most 1	0.499884	15.24412	19.38704	0.1807
At most 2	0.430133	12.37176	12.51798	0.0529

The Johansen maximum likelihood eigenvalue test results show that there is a unique long-term stable equilibrium relationship among the variables. The cointegrating equation obtained from Johansen test is as follows:

$$\begin{aligned} \text{LnCO}_2_t = & -12.4288 + 1.7594\text{LnTra}_t + 0.1239\text{LnGDP}_t - 0.12232\text{TREND}_t + \text{EC}_t \\ & (0.21267) \quad (0.33892) \quad (0.02898) \\ & (-8.27285) \quad (-0.36557) \quad (4.25099) \end{aligned}$$

The results indicate that there is a unique long-term stable equilibrium relationship among carbon emissions, economic growth, and foreign trade. Specifically, a 1% increase in foreign trade leads to a 1.7594% increase in carbon emissions, while a 1% increase in GDP leads only to a 0.1239% increase in carbon emissions, and this effect is not statistically significant in the long term. After controlling for economic and trade factors, each additional year lowers the equilibrium level of carbon emissions by 0.1232 on average. In the long run, foreign trade has a particularly strong pull effect on carbon emissions, while economic growth does not exert a stable and significant long-term effect. The time trend factor, reflecting technological upgrading and energy-saving policies, significantly suppresses carbon emissions. Therefore, optimizing the structure of foreign trade and reducing the share of high-energy-consuming processing trade is beneficial for long-term carbon reduction. The error correction term indicates that carbon emissions, economic growth, and foreign trade have a dynamic adjustment relationship toward long-term equilibrium. Carbon emissions and foreign trade possess significant error-correction convergence ability. When the system deviates from the long-term equilibrium, the two will adjust automatically back to the equilibrium level, while GDP does not have a significant equilibrium correction effect. Carbon emissions deviating

from equilibrium will not reverse-drive economic scale adjustment.

3.4. Error Correction Mechanism

Johansen cointegration tests can describe the long-term equilibrium relationship among variables, but they cannot capture short-term dynamic fluctuations and adjustment processes. Engle and Granger combined cointegration models with error correction models to establish a vector error correction mechanism. As long as there is a cointegration relationship among variables, an error correction model can be established to describe short-term fluctuations. In the short term, after a variable is shocked, it deviates from its original equilibrium. However, if a cointegration relationship exists among variables, this deviation will gradually be corrected after short-term adjustment, and the variables will return to long-term equilibrium.

Based on the above cointegration relationship, a VEC error-correction model is constructed to characterize the short-term dynamic relationship among carbon emissions LnCO2, foreign trade LnTRA, and economic growth LnGDP. The model is estimated using EViews software, with carbon emissions as the dependent variable.

$$\begin{aligned} \text{DLnCO}_2_t = & -0.308928 - 1.202703\text{DLnTra}_{t-1} + 1.059292\text{DLnTra}_{t-2} \\ & + 3.542899\text{DLnGDP}_{t-1} - 0.154310\text{DLnGDP}_{t-2} \\ & + 0.113422\text{DLnCO}_2_{t-1} - 0.151091\text{DLnCO}_2_{t-2} - 1.108059\text{EC}_{t-1} \end{aligned}$$

The VEC model results show that the long-term cointegration relationship exists among carbon emissions, foreign trade, and economic growth. The error-correction coefficient is negative (-1.108), which is consistent with the expected reverse correction. In the short term, economic

growth has a significant positive impact on carbon emissions, particularly with a lag of one period. The impact of trade on carbon emissions alternates between positive and negative, indicating a complex environmental effect of trade. Overall, the system can automatically correct short-term deviations, but carbon emissions still exhibit a strong short-term dependence on economic expansion.

3.5. Granger Causality Analysis

To further identify the short-term predictive transmission relationship among variables, a Block Exogeneity Wald Granger causality test is conducted based on the VEC model. The results are shown in Table 4.

Table 4. Granger Causality Test

Explained Variable	Excluded Variable	Chi-sq	Degrees of Freedom	P-value
$D(\text{LnTRA})$	$D(\text{LnGDP})$	1.85	2	0.396
	$D(\text{LnCO}_2)$	1.06	2	0.589
	All	5.14	4	0.273
$D(\text{LnGDP})$	$D(\text{LnTRA})$	0.04	2	0.978
	$D(\text{LnCO}_2)$	1.83	2	0.400
	All	2.09	4	0.719
$D(\text{LnCO}_2)$	$D(\text{LnTRA})$	14.29	2	0.001
	$D(\text{LnGDP})$	10.81	2	0.005
	All	28.03	4	0.000

The test results show that when the increment of carbon emissions $D(\text{LnCO}_2)$ is the dependent variable, the P-values corresponding to $D(\text{LnTRA})$ and $D(\text{LnGDP})$ are 0.001 and 0.005 respectively, both rejecting the null hypothesis at the 1% significance level. This confirms that foreign trade and economic growth are Granger causes of carbon emissions. When $D(\text{LnTRA})$ and $D(\text{LnGDP})$ are used as dependent variables, the P-values associated with the remaining variables are all greater than 0.05, so the null hypothesis cannot be rejected. This indicates that carbon emissions cannot reverse-drive trade or economic growth, and that there is no mutual predictive causal relationship between trade and economic growth. Overall, only a one-way Granger causal

relationship exists from LnTRA and LnGDP to LnCO_2 . In the short term, trade expansion and economic upturn are the precursor driving factors of rising carbon emissions.

3.6. Impulse Response

To characterize the dynamic evolution path of the variable system after receiving a one-standard-deviation positive shock, this paper uses the VEC model and the Hall bootstrap percentile method to generate a 95% confidence interval impulse response graph (see Figure 3), selecting a 10-period horizon to focus on the dynamic shock effects of foreign trade and economic growth on carbon emissions, while also checking the significance of causal transmission in reverse.

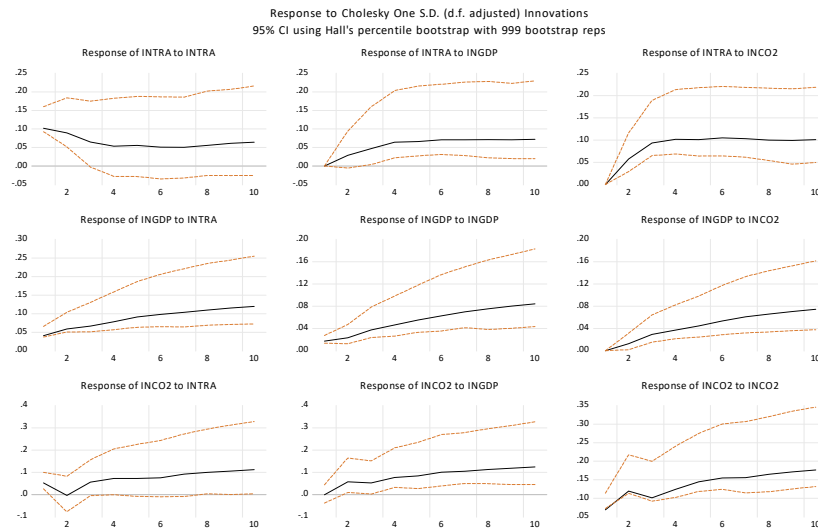


Figure 3. Responses of Each Variable to Shocks in the Other Variables

When a positive shock is applied to foreign trade LnTRA , carbon emissions show a short-term slight decline and reach a trough in period 2; after period 3, the effect turns from negative to positive and continues to rise, showing a stable positive long-term impact. This indicates that trade expansion initially has a temporary emission-reduction buffer, while in the medium and long term the increase in production and transportation energy consumption will raise carbon emissions. This is consistent with the conclusion that LnTRA is a one-way Granger cause of LnCO_2 .

When a positive shock is applied to economic growth LnGDP , carbon emissions decline slightly in the short term but then rise steadily. Economic expansion drives higher industrial production and energy consumption, which continues to increase carbon emissions, demonstrating that economic growth is a precursor driver of carbon emission fluctuations.

Carbon emissions themselves show a short-term slight decline after a positive shock, but in the long run they remain positive, reflecting strong path dependence; past emission

levels continue to influence current scale. In contrast, the reverse transmission paths—carbon emissions to trade, carbon emissions to economic growth, and trade to economic growth—have confidence intervals that cross the zero axis many times, and the shock effects are not statistically significant. This indicates that carbon emissions cannot reverse-drive trade and economic growth, and there is no significant two-way transmission relationship between trade and economic growth.

3.7. Variance Decomposition

To further quantify the contribution structure of the dynamic relationship among foreign trade, economic growth, and carbon emissions, and to clarify the differences in the explanatory power of each variable for carbon emission fluctuations, the variance decomposition model is used to break down the sources of system fluctuations and identify the main and secondary drivers. The results of variance decomposition are as follows.

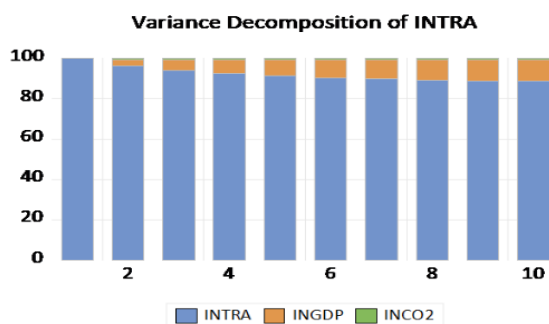


Figure 4. Variance Decomposition of Foreign Trade

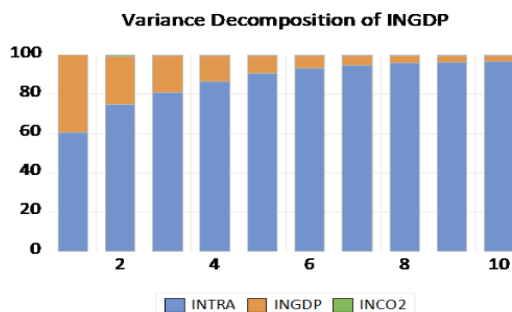


Figure 5. Variance Decomposition of GDP.

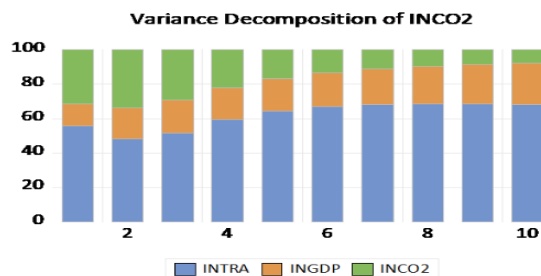


Figure 6. Variance Decomposition of Carbon Emissions.

From the perspective of foreign trade, its long-term volatility is dominated by its own shocks; economic growth has only a weak explanatory role, while carbon emissions contribute almost nothing. From the perspective of economic growth, foreign trade is the core explanatory variable for long-term volatility, while carbon emissions do not have explanatory power for economic growth fluctuations. Regarding carbon emissions as the core variable, short-term

fluctuations depend heavily on their own lagged effects, showing clear path dependence. As the lag order increases, the explanatory power of foreign trade and economic growth continues to rise steadily. In the medium to long term, foreign trade becomes the most important external driver of carbon emission fluctuations, followed by economic growth. The two jointly dominate changes in carbon emissions. Overall, the decomposition results confirm the one-way asymmetrical transmission pattern in the system: only foreign trade and economic growth affect carbon emissions in one direction, while carbon emissions cannot act in reverse on trade and economic growth. At the same time, trade can significantly explain economic growth fluctuations, and there is no significant two-way transmission relationship. This conclusion is consistent with the empirical results of impulse response and Granger causality tests.

4. Conclusion and Policy Recommendations

4.1. Main Conclusion

This paper uses annual time-series data from 2000 to 2024 and combines unit root tests, Johansen cointegration tests, vector error correction models, Granger causality tests, impulse response functions, and variance decomposition to systematically explore the long-term and short-term dynamic relationship and transmission mechanism among China's foreign trade, economic growth, and carbon emissions. The main conclusions are as follows: First, unit root test results show that the original sequences of foreign trade, economic growth, and carbon emissions are non-stationary, but their first-difference sequences are stationary, indicating that they are all first-order integrated sequences, satisfying the prerequisite for cointegration analysis.

Second, the Johansen maximum eigenvalue cointegration test shows that there is a unique set of long-term stable cointegration equilibrium relationships among the three variables. In the long run, both foreign trade and economic growth exert positive pulling effects on carbon emissions. Among them, the carbon emission elasticity of foreign trade (1.7594) is far greater than that of economic growth (0.1239), making foreign trade the core factor driving carbon emissions. The coefficient on the time trend is negative, indicating that after controlling for economic and trade factors, the sample period shows a gradual decarbonization trend.

Third, the vector error correction model results confirm that the system has an effective reverse correction mechanism. When carbon emissions deviate from the long-term equilibrium level, the system can gradually return to the equilibrium state through short-term adjustments. In the short term, economic growth has a significant positive impact on carbon emissions, while the effect of foreign trade on carbon emissions is mixed and complex, reflecting the phased nature of trade's environmental effects.

Fourth, the results of Granger causality, impulse response, and variance decomposition mutually confirm each other: the three variables show a one-way asymmetric transmission pattern. Foreign trade and economic growth are Granger causes of carbon emissions and can significantly influence carbon emission trends, but carbon emissions cannot reverse-drive foreign trade and economic growth. There is also no significant two-way causal relationship between trade and economic growth. Impulse response further shows that there is a temporary emission-reduction buffer during the early

stage of trade expansion, but the increase in production and transportation energy consumption in the medium and long term will continue to push carbon emissions higher. Carbon emissions exhibit obvious path dependence, and past emission levels continue to influence current levels. Variance decomposition quantifies the contribution structure: short-term carbon emission fluctuations are mainly driven by their own inertia, while foreign trade becomes the primary external driver of carbon emission fluctuations in the medium and long term, followed by economic growth.

Overall, China currently exhibits a development pattern in which foreign trade and economic growth drive carbon emissions in one direction. The high-carbon consumption caused by trade activities is a key issue in carbon control. How to achieve coordinated progress among foreign trade growth, economic development, and carbon reduction has become the core task of green development at the current stage.

4.2. Policy Recommendations

Based on the empirical conclusions, and in line with the goals of “dual carbon” and high-quality foreign trade development, while balancing the three objectives of steady economic growth, trade quality upgrading, and carbon reduction, the following targeted policy recommendations are proposed:

1. Optimize foreign trade structure and reduce the carbon emissions of the entire trade chain. Empirical evidence shows that foreign trade is the main long-term driver of carbon emissions. It is necessary to promote green transformation of foreign trade across product structure, trade modes, and logistics links. On the one hand, adjust the import and export product structure, strictly control the scale of exports of high-energy-consuming and high-emission products, and increase support for low-carbon products such as new energy equipment, energy-saving environmental protection equipment, and green materials, thereby increasing the share of green products in exports. Appropriately expand the import of recycled resources, advanced low-carbon technologies, and energy-saving equipment to leverage imported technology for domestic carbon reduction. On the other hand, promote the upgrading of trade models by vigorously developing service trade and digital trade, reducing dependence on goods trade, and using new business forms such as cross-border e-commerce to promote green goods and reduce the high-carbon pressure caused by traditional goods trade. At the same time, advance the greening of foreign trade logistics by guiding long-distance freight from road to rail or water transport and promoting environmentally friendly packaging and green logistics equipment to reduce energy consumption and carbon emissions in cross-border transportation.

2. Promote green transformation of the economy and weaken the carbon emission increment effect of economic growth. Economic growth continues to raise carbon emissions, so it is essential to shift away from a crude growth model and build a low-carbon economic growth system. First, accelerate industrial structure upgrading, phase out backward high-energy-consuming capacity, and promote energy-saving transformation and process upgrading in traditional industries to reduce carbon emissions per unit of output. Vigorously cultivate low-carbon industries such as renewable energy, high-end manufacturing, and modern services, gradually achieving weak decoupling between economic growth and

carbon emissions. Second, optimize the energy consumption structure by continuously increasing the share of renewable energy such as wind, solar, and hydropower in industrial production and commercial activities and reducing dependence on fossil fuels to reduce carbon emissions from the source. Third, establish a regional coordinated emission reduction mechanism to address regional emission differences caused by industrial transfer, coordinate the industrial layout across eastern, central, and western regions, and avoid disorderly transfer of high-carbon industries, thereby achieving coordinated development of economic growth and carbon reduction.

3. Distinguish long-term and short-term regulation logic and strengthen dynamic management based on the error correction mechanism. Differential management should be implemented according to the short-term and long-term fluctuation characteristics. In the short term, it is necessary to acknowledge the complexity of trade effects and introduce short-term incentive policies to guide foreign trade enterprises to seize the window of opportunity for low-carbon transformation. At the same time, closely monitor the short-term upward pressure on carbon emissions caused by economic expansion and implement dynamic energy consumption controls on high-carbon industries to smooth short-term carbon emission fluctuations. In the long term, it is crucial to grasp the long-term equilibrium relationship among the three variables, incorporate carbon constraints on trade and economic growth into long-term planning, and use the system's reverse correction mechanism to monitor deviations of carbon emissions from the equilibrium level on a regular basis, issuing timely policy adjustments to prevent carbon emissions from drifting outside a reasonable range and consolidate the long-term emission reduction trend.

4. Improve the green trade institutional system and respond to international green barriers. Current international carbon tariffs and carbon footprint certification rules are becoming increasingly strict, and combined with the high-carbon characteristics of China's foreign trade, it is necessary to accelerate the improvement of a green trade support system. First, establish a product carbon footprint accounting, verification, and certification system to require foreign trade enterprises to conduct life-cycle carbon emission statistics, establish product carbon records, and actively align with international green rules to avoid additional costs caused by trade barriers such as the EU Carbon Border Adjustment Mechanism. Second, improve green trade standards and regulatory rules by establishing unified standards for green products, green packaging, and green exhibitions, and promote domestic green certification and international mutual recognition to enhance the international compliance capabilities of foreign trade enterprises. Third, leverage leading foreign trade enterprises to drive upstream and downstream small and medium-sized enterprises in the supply chain toward green transformation, creating a full-value-chain green supply chain and achieving scale-based emission reductions.

5. Improve coordinated supervision and incentive mechanisms to consolidate emission reduction outcomes under one-way transmission. Since carbon emissions cannot reverse-drive trade and economic growth, relying solely on market self-regulation is insufficient to achieve emission reduction goals. It is necessary to strengthen policy guidance and regulatory constraints. On the one hand, establish cross-departmental coordinated supervision mechanisms involving

commerce, development and reform, ecology and environment, and customs, integrating carbon emission indicators into the evaluation systems of foreign trade enterprises and industrial enterprises, and setting access thresholds for high-carbon foreign trade projects and high-energy-consuming investment projects. On the other hand, introduce fiscal, tax, and financial incentive policies to provide tax reductions, low-interest loans, and subsidies to foreign trade enterprises engaged in low-carbon retrofits and green production, and set up a special green trade fund to support enterprises in introducing low-carbon technology and developing green products. At the same time, strengthen green and low-carbon publicity and training to enhance the awareness of low-carbon development among foreign trade enterprises and market participants and create a favorable atmosphere for coordinated development among trade, the economy, and ecological protection.

6. Continue the long-term emission reduction trend and consolidate the foundation of low-carbon development. The cointegration equation shows that there is a natural long-term emission reduction trend during the sample period, which must be sustained and amplified. China should adhere to the green development strategy, continue increasing investment in low-carbon technology research and development, and promote the transformation and application of energy-saving and carbon-reduction technologies. It should continue to advance the construction of the national carbon market and improve the carbon emissions trading mechanism so that market-based tools can force various market participants to reduce emissions. By relying on the Belt and Road Initiative and other external cooperation platforms, China can deepen international green economic and technical cooperation, expand foreign trade while introducing advanced international low-carbon development experiences, and further amplify the long-term emission reduction effect. In the end, China can achieve the multiple goals of improving the quality of foreign trade, maintaining stable economic growth, and steadily reducing carbon emissions.

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