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Research on the Environmental Effects and Green Development Path of South Korean Foreign Trade

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Abstract

Purpose – This paper aims to examine the environmental effects of South Korean foreign trade, and the changing relationship between industrial "three wastes" emissions and foreign trade.

Design/methodology – Based on time series data of South Korean foreign trade and industrial "three wastes" from 2009 to 2019, a VAR model was used to analyze the long-term internal links and dynamic changes between foreign trade and environmental pollution.

Findings – Variance decomposition analysis shows that for the three types of pollutants, self-impact contributes the most to the variance decomposition. It follows that South Korean foreign trade has a certain negative impact on the environment, and this impact has a certain sustainability.

Originality/value – This paper contributes to the study on the relationship between foreign trade and environmental pollution. It theoretically proposes a coordinated development path for foreign trade development and green development based on the environmental impact of foreign trade, to provide a reference for the development of collaborative promotion.

Keywords: Environmental Effects, Foreign Trade, Green Development, South Korea
JEL Classifications: C22, F18

1. Introduction

International trade, an important economic activity, has affected the ecological environment in varying degrees since its beginning (Zugravu-Soilita, 2018). In the second half of the 20th century, with the increasing awareness of human environmental protection, the relationship between trade and the environment has received increasing attention (Yanase, 2012). The WTO believes that, to a certain extent, foreign trade may deplete natural resources and aggravate the deterioration of the environment. Its growth will not naturally increase the utilization efficiency of natural resources, including energy, nor will it necessarily lead to better environmental quality (Nordström and Vaughan, 1999). For environmentally intensive products, highly industrialized countries and regions import more than export, while developing countries and regions do the opposite. International trade has also accelerated the proliferation of advanced production technologies, thereby benefiting the environment (Archibugi and Michie, 1995).

This research will carry out calculations and analyses on the hidden pollution behind South Korean foreign trade, and theoretically propose a coordinated development path for foreign trade development and green development based on the environmental impact of foreign trade, in order to provide a reference for the development of collaborative promotion.

The relevant indicators of South Korea's economic growth, foreign trade and

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environmental pollution from 2009 to 2019 were selected. Considering the interaction relationship between variables, the vector auto-regression (VAR) model proposed by C.A. Smis (1980) was used for empirical analysis.

The study concluded that there is a long-term positive co-integration relationship between South Korea's foreign trade expansion and industrial pollution emissions. This conclusion has important hints for understanding the environmental effects of Korean trade development, and gives some enlightenment to the path of Korean green trade development.

2. Literature Review

In the study of the relationship between environment and trade, Grossman and Krueger (1993) first classified the environmental effects of trade into scale effects, technological effects, and structural effects. That is, E=E1+E2+E3. Among these, E is the environmental effect of trade, and E1, E2, and E3 represent scale, technological effect, and structural effect, respectively. Based on the above "three environmental effects" theoretical framework, Stevens (1993) attributed the environmental impact of trade to the three aspects of product, scale, and structure, and believed that free trade could provide increased capital investment, improve the technical level, and promote effective resource allocation for environmental protection. Copeland and Taylor (1994) introduced economic models into the study of this problem earlier. Their study found that free trade may increase pollution in northern countries and reduce pollution in southern countries. When studying the environmental effects of trade, Cole and Elliott (2003) constructed a comprehensive empirical analysis model containing four common pollutants, and focused on the structural effects caused by different endowments of factors and the structural effects caused by different environmental regulations. The results showed that both have an impact on the emissions and concentrations of SO2 and CO2. This conclusion was the same as the research results of Antweiler et al. (2001), but the research results of chemical oxygen demand and nitrogen oxides were not the same. Shunsuke Managi, Akira Hibiki, and Tetsuya Tsurumi (2009), based on the revised ACT model, regarded national language, geography, and other factors as instrumental variables for trade opening sing GMM estimation methods, empirical analysis of Organization for Economic Cooperation and Development, OECD, and Africa OECD countries. It turned out that whether trade openness was good for the environment depended on different pollutants and country types. Nakajima (2011) reviewed the estimating methods of the vector auto regression of the stochastic volatility time-varying parameter structure. Taking the data of the significant changes in the structure of the dynamic relationship between macroeconomic variables in Japan as an example, the TVP-VAR model of the stochastic volatility was empirically applied.

In 1989, David Pierce published the Green Economy Blueprint, advocating the establishment of a "sustainable economy". In 2005, the concept of green growth was first proposed by the United Nations Asia-Pacific Economic and Social Committee (UNESCAP). In the Seoul Initiative for Green Growth adopted at the Fifth Asia-Pacific Ministerial Conference on Environment and Development, green growth was defined as environmentally sustainable sustained economic growth. Since then, OECD (2010), the Global Green Growth Institute (GGGI), South Korea, World Bank (WB), and other international organizations and countries have continuously improved the concepts and connotations of green growth. However, in academia, there is no precise and unified definition of the concept of green development (Huberty, Gao and Mandell, 2011). Michio and Katsuya (2007) and Zheng, Bigsten and Hu (2009) studied economic green growth efficiency estimation under the constraints of environment, energy, and ecology.

From the existing literature, most scholars believe that trade has a significant impact on the environment. Most studies use a series of panel data combined with models in an area for analysis. In this study, time series data modeling will be used to study the dynamics of the overall changes of foreign trade development and environmental pollution in South Korea, so as to derive the environmental effects of trade development. The rapid development of foreign trade will have an impact on environmental quality, while the consumption of resources and energy, and the deterioration of environmental quality, will also affect the sustainable development of the economy and trade. Therefore, there may be a long-term stable relationship between foreign trade, economic growth, and environmental pollution. This part examines the long-term equilibrium relationship between foreign trade, economic growth, and environmental pollution from a time series perspective.

3. Method

The rapid development of foreign trade will have an impact on environmental quality, while the consumption of resources and energy, and the deterioration of environmental quality, will also affect the sustainable development of the economy and trade. Therefore, there may be a long-term stable relationship between foreign trade, economic growth, and environmental pollution. This part examines the long-term equilibrium relationship between foreign trade, economic growth, and environmental pollution from a time series perspective.

3.1. VAR Model

At the end of 2009, South Korean President Lee Myung-bak proposed the creation of the Global Green Growth Institute (GGGI) at the Copenhagen Climate Change Conference. So far, South Korea's green development has become an important strategic decision for the country. Affected by the 2008 financial crisis, South Korea's foreign trade dropped significantly in 2009, and has shown rapid growth since 2010. 2009 was an important year for the integration and transition of South Korea's economic and foreign trade development. Therefore, based on this development background and the availability and timeliness of data, the relevant indicators of South Korea's economic growth, foreign trade, and environmental pollution from 2009 to 2019 were selected for research.

The general form of the VAR model (Smis, 1980) is:

$$Y = A_1 Y_{t-1} + A_2 Y_{t-2} + ... + A_3 Y_{t-3} + \varepsilon_t \tag{1}$$

Y is a k-dimensional endogenous variable column vector; A is the corresponding coefficient matrix; p is the order of the endogenous variable lag; t is the number of samples; and ε is the disturbance term.

3.2. Variables and Data Sources

Real GDP is used to measure economic growth; foreign trade is expressed in total import and export trade; and environmental pollution is characterized by the industrial "three wastes" (waste gas, waste water, and industrial residue). The names, units, and symbols of each variable are shown in Table 1.

Table 1. Variables

Indicators	Units	Symbols
GDP	Billion/USD	lnGDP
Total imports and exports	Billion/USD	lnT
Industrial waste water discharge	Billion/ton	lnW
Industrial solid waste generation	Billion/ton	lnS
Industrial exhaust emissions	Trillions/standard cubic meter	lnG

The GDP and trade data come from the statistical yearbook of Korea. The industrial "three wastes" data are taken from the data published by Statistics Korea. In order to eliminate the impact of large fluctuations and heteroscedasticity in the time series, all three types of variable indicators are logarithmic. Such processing will not change the nature and relationship of the original time series. Eviews 10.0 analysis software was used for empirical analysis.

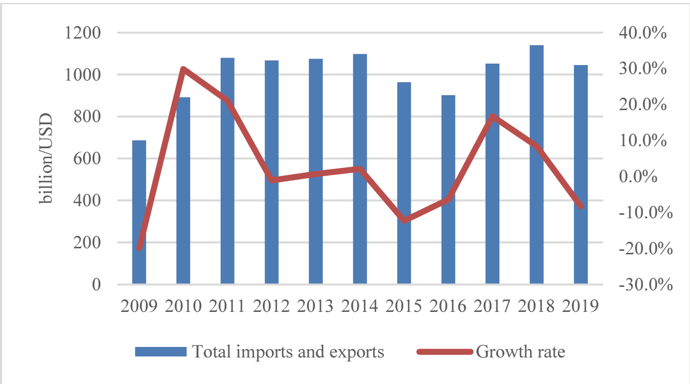
4. Results and Discussions

4.1. Foreign Trade and Environmental Pollution of South Korea

4.1.1. Foreign Trade of South Korea

From 2009 to 2019, the total volume of imports and exports of Korean goods fluctuated. In 2010, South Korea gradually emerged from the impact of the international financial crisis. From 2011 to 2014, South Korean foreign trade volume exceeded US$1 trillion for four consecutive years and remained relatively stable. In 2015 and 2016, due to the slowdown of global economic growth and falling oil prices, South Korea's foreign trade volume fell again below $1 trillion. Since 2017, South Korea's foreign trade volume has begun to pick up again (Lim, 2016). In 2018, the import and export volume continued to increase to 1.14 trillion US dollars, but the growth rate fell by half from the previous year at only 8.4%. In 2019, South Korean foreign imports and exports decreased by 8.3% year-on-year, but the total imports and exports were still as high as 1045.58 billion US dollars, about 63.75% of the total GDP during the same period.

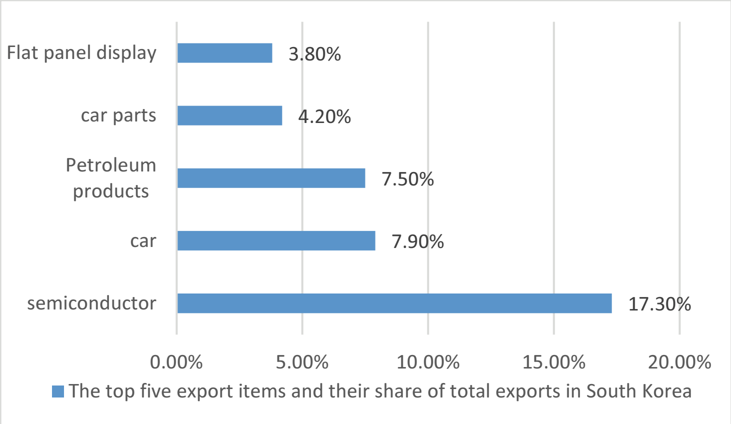
Fig. 1. Total Imports and Exports of Goods and Growth from 2009-2019 in South Korea



Source: Korean Statistical Yearbook (2009-2019).

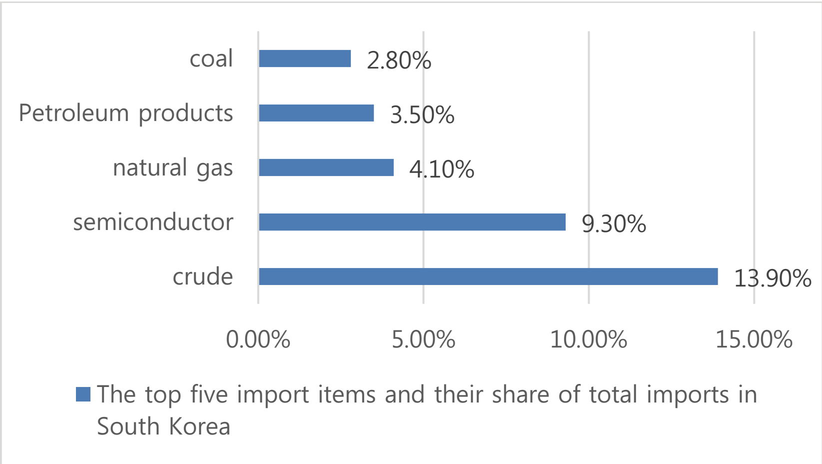
In terms of import and export structure, in 2019, the most exported items were semiconductors, accounting for 17.3% of total exports, and the largest share of imported items was crude oil (13.9%). This is shown in Fig. 2 and Fig. 3.

Fig. 2. The Top Five Export Items and Share of Total Exports in South Korea



Source: Korean Statistical Yearbook (2009-2019).

Fig. 3. The Top Five Import Items and Share of Total Imports in South Korea

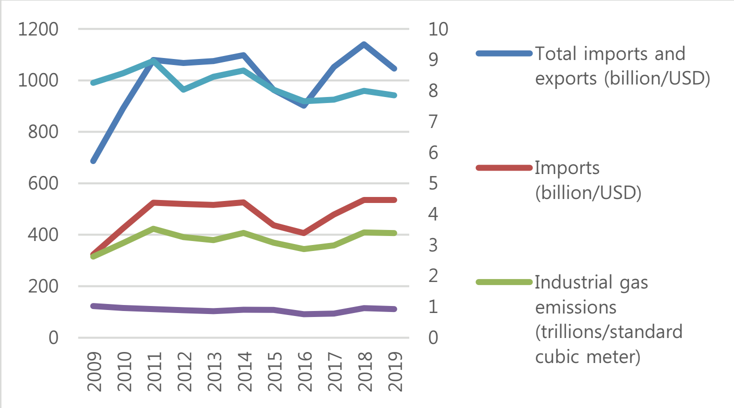


Source: Korean Statistical Yearbook (2009-2019).

4.1.2. Environmental Pollution of South Korea

From Fig. 4, it can be seen that the discharge volume of industrial waste water in South Korea is generally M-shaped. Except for the overall fluctuation of the industrial rosewater data within a certain range, the industrial waste gas and industrial solid waste data and the total import and export volume and total export volume basically show a synchronous change. Therefore, the expansion of foreign trade and the long-term high trade surplus are one of the reasons for the increase in pollution emissions is not ruled out. It is important to note that since the industrial "three wastes" are the total emissions of domestic industrial products, there are both parts that meet domestic production and consumption, and parts that are produced for export (Spedding and Shah, 2012). Therefore, Fig. 4 reflects only an accompanying relationship rather than a direct correspondence. That is, in South Korea, the rapid development of foreign trade is accompanied by a relatively large amount of industrial "three wastes".

Fig. 4. Changes in Total Imports and Exports, Total Exports, and Industrial "Three Wastes" Emissions in South Korea



Source: Statistical Yearbook of Korea (2009-2019); published data by Statistics Korea.

4.2. Empirical Results and Analysis

4.2.1. ADF Test

An Augmented Dickey-Fuller (ADF) Test was used to check whether unit roots exist in the lnGDP, lnT, lnW, lnS, and lnG sequences so as to determine whether the variables meet the preconditions of the next cointegration test.

It can be seen from Table 2 that ln GDP, ln T, ln W, ln S, and ln G are not significant at the significance levels of 10%, 5%, and 1%, so the original hypothesis that these variables exist unit root cannot be rejected, such that the variables are non-stationary. The first-order difference sequences of other variables have passed the stationarity test at the 1% significance level, while the first-order difference terms of ln GDP have not yet passed the stationarity test. Therefore, a second-order difference is made to ln GDP, and the test results show that it is a second-order single-integer variable, while the other variables are all first-order single-integer variables, which do not meet the conditions of cointegration analysis. However, if there are at least two high-order single-integer variables among three or more variables with different single-integer orders, it is possible that the high-order single-integer variables are linearly combined to form a low-order single-integer variable. Therefore, the variable (ln GDP)2 is introduced, and it is found to be a second-order single integer variable, which can be combined with ln GDP to form a first-order single integer variable, and then co-integration analysis is performed with other variables.

Table 2. Results of ADF Test

Variable.s	Form	Augmented ADF Statistic	Prob.*	Critical Values 1%	5%	10%	Result
lnGDP	(C,T,1)	-1.966612	0.5549	-4.194229	-3.465879	-3.115882	I(2)
lnT	(C,T,0)	-1.477633	0.7847	-4.182080	-3.460380	-3.112770	I(1)
lnW	(C,N,0)	-0.973594	0.7192	-3.559161	-2.501610	-2.516660	I(1)
lnS	(C,T,0)	-0.986869	0.9119	-4.182080	-3.460382	-3.112767	I(1)
lnG	(C,T,0)	-1.292143	0.8453	-4.182080	-3.460382	-3.112767	I(1)
(lnGDP)2	(C,T,1)	-2.053000	0.5093	-4.194229	-3.465879	-3.115882	I(2)
ΔlnGDP	(C,N,0)	-2.399365	0.1252	-3.567670	-2.861472	-2.518507	I(1)
ΔlnT	(C,N,0)	-4.299664	0.0090	-3.567670	-2.861472	-2.518507	I(0)
ΔlnW	(N,N,0)	-4.500673	0.0000	-2.541802	-1.849973	-1.507711	I(0)
ΔlnS	(C,N,0)	-4.918387	0.0002	-3.567670	-2.861472	-2.518507	I(0)
ΔlnG	(C,N,0)	-4.208298	0.0021	-3.567670	-2.861470	-2.518510	I(0)
(lnGDP)2	(N,N,0)	-2.479689	0.1066	-3.567670	-2.861472	-2.518507	I(1)
Δ2lnGDP	(N,N,0)	-5.395675	0.0000	-2.544620	-1.850410	-1.507511	I(0)
Δ2 (lnGDP)2	(N,N,0)	-5.375408	0.0000	-2.544620	-1.850410	-1.507511	I(0)

Notes: 1. The test form is (C, T, K), where C and T respectively indicate that the test contains constant and trend items, N indicates that there are no constant or trend items, and K indicates the lag order, and the value is determined by AIC And SC guidelines.
2. The symbols Δ and Δ2 indicate the first-order and second-order differences of the subsequent variables, respectively.
3. I(0), I(1), and I(2) represent zero-order, first-order, and second-order single integers, respectively.

4.2.2. IRF Analysis

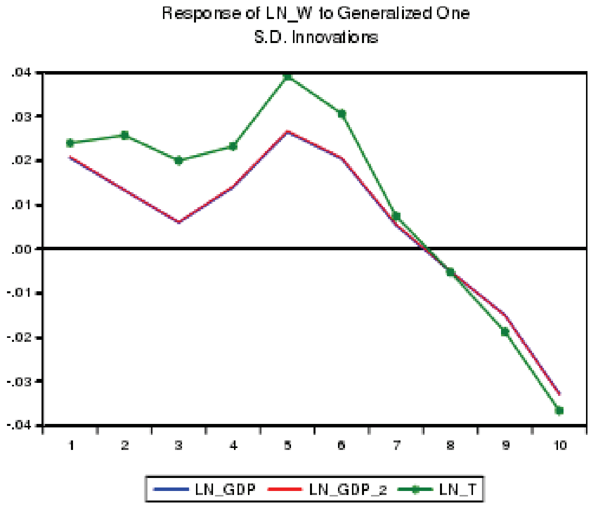
We set the impulse response period to 10 periods, and the resulting impulse response curves are shown in Figures 5, 6, and 7, respectively.

a) Impulse Response Analysis of Industrial Wastewater

It can be seen in Fig. 5 that ln GDP, (ln GDP)2, and ln T have a positive impact on ln W first, and then the effect begins to decline, reaching a staged trough in the third period, but still positive. Afterwards, they both rose and reached a peak in the fifth period. After that, the positive effect gradually decreased, and the effect changed from positive to negative in the 7th to 8th phases, and continued thereafter.

Overall, the response curve of lnW shows certain oscillation characteristics, but it generally shows an inverted U shape. Judging from the cumulative response value in the response period, relative to economic growth, the impact of trade expansion on the discharge of industrial wastewater is greater in both positive and negative effects. This shows that both economic growth and trade expansion will pass respective shocks to industrial wastewater discharge, and will produce positive effects in the early stage and negative effects in the later stage. At the same time, the impact of trade expansion on industrial wastewater discharge is relatively more significant.

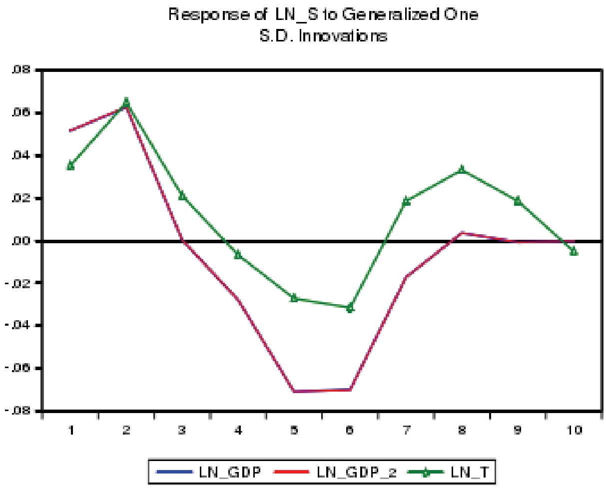
Fig. 5. LNW Impulse Response Curve



b) Impulse Response Analysis of Industrial Solid Waste

It can be seen in Fig. 6 that lnGDP, (lnGDP)2, and lnT have a positive impact on lnS first, and then the effect is enhanced, reaching a staged peak in the second period. Then, it drops all the way, and the effects change from positive to negative in the third to fourth periods. The lowest values of lnGDP and (lnGDP)2 appear in the fifth period, and lnT appears in the sixth period. Afterwards, it started to rise, with a positive effect in the seventh period, reached a staged peak in the eighth period, and then fell again. The impact of lnT was again negative in the 10th period, while the impact of lnGDP and (lnGDP)2 continued near the horizontal axis starting in the 9th period.

Fig. 6. LNW Impulse Response Curve

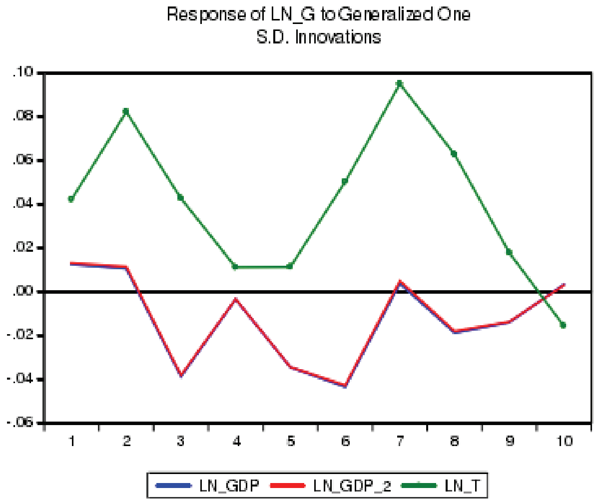


Overall, the response curve of lnS has obvious oscillation characteristics, with two phase peaks, but it is generally U-shaped. Judging from the cumulative response value in the response period, the current effect of economic growth is greater than that of trade expansion, and thereafter, its positive effect is relatively lower, and its negative effect is relatively stronger than trade expansion.

c) Impulse Response Analysis of Industrial Waste Gas

It can be seen from Fig. 7 that lnGDP, (lnGDP)2, and lnT first have a positive impact on lnG. Then, the shock effects of the first two began to decline, were negative in the third period and reached a staged trough, and then fluctuated and oscillated; most periods were negative, and the seventh and tenth periods were positive. The impact effect of lnT on lnG also fluctuated and oscillated, and it was positive for most of the period. It reached a stage trough in periods 4 and 5, and the effect of period 10 turned negative.

Fig. 7. LNW Impulse Response Curve



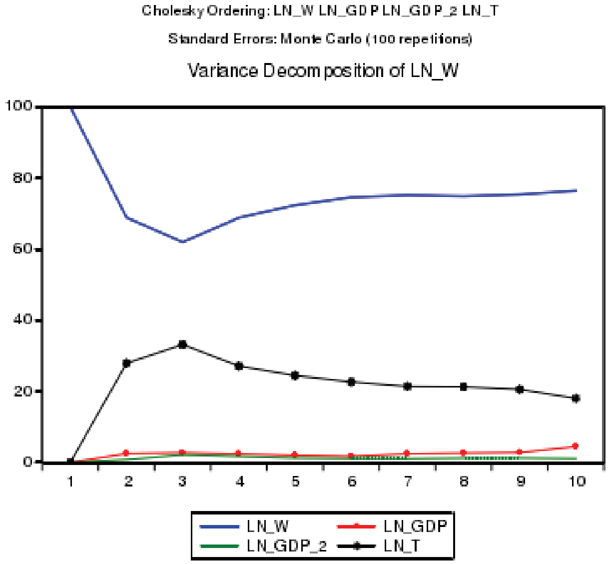
Overall, the oscillation characteristics of lnG's response curve are obvious. The response curves for lnGDP and (lnGDP)2 are roughly W-shaped, with negative effects predominant. The response curve for lnT is roughly inverted W type or M type, and the effect is mainly positive. Judging from the cumulative response value during the response period, relative to economic growth, the impact of trade expansion on industrial emissions is even greater.

4.2.3. Variance Decomposition Analysis

a) Variance Decomposition Results and Analysis of Industrial Wastewater

In Fig. 8, column S.E. gives the forecast standard deviation of lnW for periods 1 to 10. The next four columns represent the proportion of the contribution of changes in the error term corresponding to the forecast period to the forecast standard deviation of lnW. The impact of industrial wastewater itself has the highest contribution rate to its variance decomposition, and the lowest in the third period is still 61.96%. The contribution of trade expansion to the decomposition of variance of industrial wastewater discharge reached 27.91% in the second phase. This shows that 27.91% of the forecast variance of industrial wastewater discharge can be explained by trade expansion, and then reached its highest value of 33.19% in the third period, and then gradually fell back, reaching 17.99% in the tenth period. In contrast, the contribution rate of the variance decomposition of economic growth to industrial wastewater has been relatively low, and both lnGDP and (lnGDP)2 have remained at levels within 5%.

Fig. 8. Variance Decomposition Curve of Industrial Wastewater



b) Variance Decomposition Results and V Analysis of Industrial Solid Waste

It can be seen in Fig. 9 that in the decomposition of variance of industrial solid wastes, the impact contribution rate received by itself is the highest. Although the contribution rate decreases gradually, the lowest value in the tenth period is still as high as 66.71%. The variance decomposition contribution rate from trade expansion is second, reaching 7.29% in the second period, and then slightly fluctuating in each period; the overall trend is rising, reaching a peak of 22.16% in the tenth period. The variance decomposition contribution rate from economic growth changes also fluctuated slightly, but remained stable overall since the second period.

c) Variance Decomposition Results and Analysis of Industrial Waste Gas

From Fig. 10, we can note that the forecast standard deviation of industrial waste gas in each period is most affected by its own new information, and the lowest value in the sixth period still reaches 59.62%. Unlike industrial waste water and industrial solid waste, in terms of economic growth, the contribution rate of lnGDP changes to the decomposition of variance in industrial exhaust gas emissions ranks second, reaching a maximum value of 33.18% in the sixth period. The variance decomposition contribution rate from trade expansion changes has been relatively stable from the second period, with a slight change between the lowest value of the fourth period of 4.61% and the highest value of the fifth period of 6.23%.

Fig. 9. Variance Decomposition Curve of Industrial Solid Waste

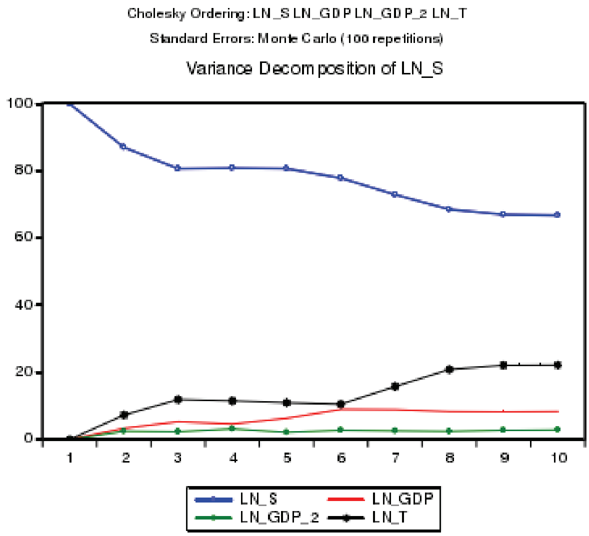
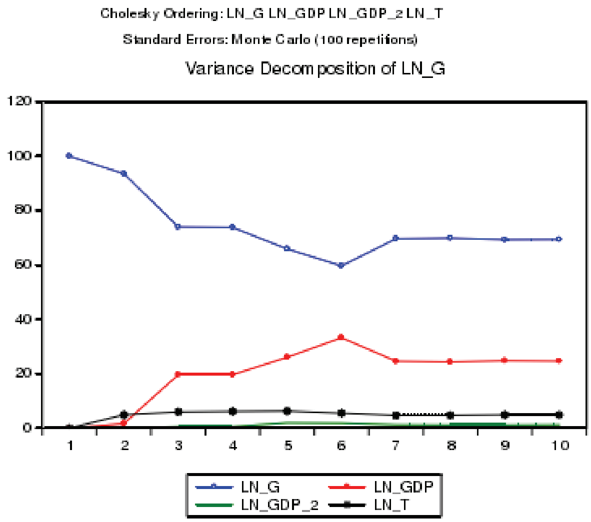


Fig. 10. Variance Decomposition Curve of Industrial Waste Gas



First, from the analysis of changes in South Korea's foreign trade and environmental pollution, with the growth trend of South Korea's foreign trade development, the emissions of industrial "three wastes" show the same change trend.

Second, the impulse response analysis shows that for industrial wastewater, the impulse response curve generally presents an inverted U shape. Trade expansion will transfer its own impact to industrial wastewater discharge, and produce positive effects in the early stage and negative effects in the later stage. For industrial solid waste, the impulse response curve is roughly U-shaped. The current effect of economic growth is greater than that of trade expansion, its positive effect is relatively lower, and its negative effect is relatively stronger than trade expansion. For industrial waste gas, the impulse response curve to economic growth is roughly W-shaped and dominated by negative effects. The response curve to trade expansion is roughly M-shaped and dominated by a positive effect.

Third, the analysis of variance decomposition shows that for the three types of pollutants, self-impact has the greatest contribution to the variance decomposition. For industrial wastewater and industrial solid waste, the contribution rate of trade expansion is second. Specifically, in terms of industrial wastewater discharge, the contribution of trade expansion first increased, and then decreased. In terms of industrial solid waste emissions, the contribution of trade expansion increased first, and then continued to rise after a slight decline. For industrial waste gas, the contribution rate of changes in economic growth is second.

4.3. Green Development Path of South Korean Foreign Trade

Green development is regarded as the “fourth industrial revolution”, and is believed to be an inevitable choice for mankind to get out of the predicament of resources and environmental degradation. Through the above comparative analysis, we can see that trade is not the opposite of the environment. Optimizing trade structure, reducing transportation pollution, and increasing government’ investment in environmental protection technology can achieve the purpose of trade growth and environmental optimization. Accordingly, this paper proposes the following suggestions for the green development path of South Korean foreign trade.

4.3.1. Short-Term Solution

Green development often contradicts short-term profit goals. However, short-term economic benefits must be considered, which are related to confidence in green development. From a short-term perspective, the green development of South Korea's foreign trade first needs to expand the scale of foreign trade. With reference to the experiences of the green development of international trade, appropriately raise the green barriers to foreign trade when expanding imports to ensure a steady growth in the total volume of export trade, while gradually improving the quality of foreign trade. Raising green tariffs and market access standards is one such measure. South Korea can impose additional taxes on products that may cause environmental threats and damages by designating a series of environmental standards that restrict imports. In the name of protecting the environment and human beings, health, safety and health of animals and plants, and setting higher levels of pest indicators improve the level of market access. Second, establish and implement a green sanitation and quarantine system based on the protection of the environment and ecological resources, to ensure that humans, animals and plants are protected from pollutants, toxins, microorganisms, and additives.

4.3.2. Medium and Long Term Solution

Green development is a long-term process. The green development of South Korea’s foreign trade should require a medium- and long-term target strategy as a guide. First, South Korea needs a sustainable foreign trade development strategy to guide the green transformation of foreign trade. The research in this paper shows that, whether it is exports or imports, the scale effect is the main cause of the increase in South Korea’s pollution emissions, while the structural effect still has room for further improvement. Therefore, South Korea needs to formulate and improve the green trade list, guide the adjustment and upgrading of the import and export product structure based on the intensity of pollution emissions, comprehensively use differentiated tariffs, export tax rebates, and other policy measures to guide the optimization and upgrading of the export structure, and shift to high additional value, low pollution intensity and environment-friendly products (Ameli, Mansour & Ahmadi-Javid, 2017). Second, they should work through legislative means to formulate strict mandatory environmental technical standards to restrict foreign commodity imports. In addition, South Korea also needs to actively participate in international cooperation related to green development, such as participating in the formulation of international environmental and trade standards, and the United Nations Framework Convention on Climate Change negotiations.

5. Conclusion

By adopting the VAR model, using the time series data of South Korea from 2009 to 2019 as samples, this paper empirically tests the environmental effects of foreign trade.

First, with the growth trend of South Korea's foreign trade development, the emissions of the industrial "three wastes" show the same change trend.

Second, the impulse response analysis shows that for industrial wastewater, the impulse response curve generally presents an inverted U shape. For industrial solid waste, the impulse response curve is roughly U-shaped. For industrial waste gas, the impulse response curve to economic growth is roughly W-shaped and dominated by negative effects. The response curve to trade expansion is roughly M-shaped and dominated by a positive effect.

Third, the analysis of variance decomposition shows that for the three types of pollutants, self-impact has the greatest contribution to the variance decomposition. For industrial wastewater and industrial solid waste, the contribution rate of trade expansion is second.

The study concludes that there is a long-term positive co-integration relationship between the expansion of Korean foreign trade and industrial pollution emissions. That is, South Korean foreign trade has a certain negative impact on the environment, and this impact has a certain sustainability. Therefore, when developing foreign trade, South Korea must give more attention to environmental pollution and ensure the coordinated development of foreign trade growth and environmental improvement. This requires South Korea to follow the path of green development when developing foreign trade.

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