

Research on the Impact of Low-carbon Economy on the Development of China's Foreign Trade

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Abstract

Focusing on high energy and low emissions, the low-carbon economic revolution in the fields of industry, energy, technology, and commerce has brought barriers such as carbon tariffs and carbon labels to the international trade process. Based on the data from 2006 to 2021, this paper explores the impact of low-carbon economy on China's foreign trade development from five levels: low-carbon production technology level, RMB exchange rate, financing capacity, force majeure trade obstacles, and national system. The results show that the improvement of technological level is positively correlated with the export of goods trade, the level of the RMB exchange rate is negatively correlated with the export of goods trade, the financing ability is positively correlated with the export of goods trade, the trade obstacle of force majeure is negatively correlated with the export of goods, and the promotion effect of the national system is not significant.

Keywords

Low-carbon Economy; Foreign Trade; Least Squares Method; Trade in Goods.

1. Introduction

The concept of low-carbon economy is put forward under the situation of increasing environmental pollution, global environmental warming and environmental deterioration since the industrial revolution. With the continuous increase of China's foreign trade, scholars at home and abroad have also made great achievements in the study of China's low-carbon economic development. Sachs (1995) put forward the hypothesis that the higher the resource utilization rate, the slower the economic development by comparing the relationship between the resource environment and economic development in China and other countries. Through empirical analysis, it is found that manufactured products have a promoting effect on economic development, while primary products have a restraining effect on economic development. David Roland-Holst (2015) studied the impact of China's export trade on energy, and mainly used the input-output table in 2002 to measure the embodied carbon emissions, and the results showed that China's export trade was the main reason for the strong energy demand. However, the irrational export structure leads to the carbon emissions of exported commodities being higher than those of the production process [1]. Michael (2011) used a panel data model to study the industry data of more than 100 countries around the world, and compared it with the import and export trade of the United States, among which the coal industry, the petroleum industry and the chemical industry have a stronger relationship with carbon emissions [2]. Andrea Baranzini (2013) studied the formulation and implementation of carbon tariffs in different countries, and found that the differences in energy tax rates between countries are the main reasons why national tariffs are difficult to reconcile [3]. Weber (2016) used the input-output model and China's 2005 data to study the relationship between China's carbon emissions and export trade carbon emissions, and the studies have shown that about 30% of China's carbon emissions are generated by export trade [4]. Robert C. Harris (2012) studied bilateral trade between China and the United States, and the results showed that 10% of China's

carbon emissions are caused by bilateral trade between China and the United States [5]. Guan D (2008) used a time series method to study the relationship between China's foreign trade and carbon emissions for many years. The results show that the important reason for the rapid growth of China's carbon emissions is the continuous growth of export trade, and in 2015, 30% of China's carbon emissions were caused by export trade.

Chinese scholars Wang Ran, Shen Jun and Xiong weiwei (2015) proposed that the structure of energy use is an important factor affecting environmental pollution, and overload energy utilization has a huge negative impact on the environment [6]. Zhang Tianzhao (2021) pointed out that China's energy structure is generally "rich in coal, poor in oil and gas", and the western and northern regions are the main reserves of coal energy in China, and coal has always accounted for a high proportion of energy consumption in China. By 2019, it still accounts for 58% of total energy consumption, and China's current mineable coal reserves are about 160 million tons [7]. From the perspective of the impact of low-carbon economy on the development of China's trade with China, Chen Yan (2020) explained that with the rapid development of China's low-carbon industry, the proportion of low-carbon product technology in foreign trade has increased rapidly, and the development of low-carbon technology still depends on high-quality talents and continuous technology investment. It also greatly increases the cost pressure of enterprises [8]. Lv Jin and Zhang Song (2019) elaborated on the development of low-carbon economy from the perspective of international trade rules, and while promoting the environmental awareness of the whole society, carbon tariffs and low-carbon labels will also become new trade barriers and hinder the smooth progress of international trade [9].

2. The Current Situation of China's Foreign Trade Development under the Low-carbon Economy

2.1. Foreign Trade Import and Export Volume

According to the statistics of the Ministry of Commerce and China Customs, from 2006~2021, the volume of trade in goods and services in China's foreign trade showed an overall upward trend. Among them, in 2008~2009, affected by the global financial crisis, the import and export volume of trade in goods showed a downward trend during this period; In 2014~2016, due to the Sino-US trade friction and the industrial transformation brought about by the low-carbon economy, the output value of some domestic industries declined, especially the high-polluting industries represented by the steel industry; In 2020, due to the impact of the COVID-19, the import and export volume of service trade also declined. However, the import and export trade of goods trade still occupies a comparative advantage compared with service trade.

2.2. Energy Consumption Structure

As shown in table 1, China's energy consumption is gradually optimized under the low-carbon economic model. From 2006 to 2021, with the economic development, China's energy consumption has been gradually increased from 38704.53 million tons of standard coal to 524,000 million tons of standard coal. From 72.4% in 2006 to 56% in 2021. Among them, the consumption of oil is relatively stable, remaining in the range of 16.8%~19%. The proportion of clean energy consumption represented by natural gas increases from 9.1% to 25.5%. Cleaner and more efficient production is gradually replacing the high consumption and high pollution production model. The "energy production and consumption revolution strategy" released by the national development and reform commission and the national energy administration clearly states: "by 2030, China's new energy demand will mainly rely on clean energy."

Table 1. China's energy consumption structure

| Year | Total energy consumption(10,000 tons of standard coal) | Proportion of total energy consumption(%) | | | |
|------|--|---|-----------|-------------|--|
| | | Coal | Petroleum | Natural gas | Primary electricity and other energy sources |
| 2006 | 258676 | 72.4 | 17.5 | 2.7 | 7.4 |
| 2007 | 280508 | 72.5 | 17 | 3 | 7.5 |
| 2008 | 291448 | 71.5 | 16.7 | 3.4 | 8.4 |
| 2009 | 306647 | 71.6 | 16.4 | 3.5 | 8.5 |
| 2010 | 324939 | 69.2 | 17.4 | 4 | 9.4 |
| 2011 | 387043 | 70.2 | 16.8 | 4.6 | 8.4 |
| 2012 | 402138 | 68.5 | 17 | 4.8 | 9.7 |
| 2013 | 416913 | 67.4 | 17.1 | 5.3 | 10.2 |
| 2014 | 428334 | 65.8 | 17.3 | 5.6 | 11.3 |
| 2015 | 434113 | 63.8 | 18.4 | 5.8 | 12 |
| 2016 | 441492 | 62.2 | 18.7 | 6.1 | 13 |
| 2017 | 455827 | 60.6 | 18.9 | 6.9 | 13.6 |
| 2018 | 471925 | 59 | 18.9 | 7.6 | 14.5 |
| 2019 | 487488 | 57.5 | 19 | 8 | 15.3 |
| 2020 | 498314 | 56.9 | 18.8 | 8.4 | 15.9 |
| 2021 | 524000 | 56 | 18.5 | 8.9 | 16.6 |

Source: National Energy Administration and National Bureau of Statistics.

2.3. Problems in China's Foreign Trade in a Low-carbon Economy

2.3.1. The Standard of the System is Not Perfect

Due to the late start of China's low-carbon economy and the imperfection of domestic institutional standards compared with international general standards, China's export products are easily subject to export trade barriers, that is, using a series of measures such as carbon tariffs and carbon standards to raise commodity prices to restrict China's products from entering the markets of other countries. It is estimated that if a carbon tariff of us \$35-60 per ton is imposed on China's exports to Europe and the united states, the tax rate of China's exports will increase by 2.2~4.4 percentage points. The increase in the tax rate will lead to a reduction in the competitiveness of China's export products, and most of the countries that implement carbon tariffs are large countries. The implementation of tariffs are large countries will lower the price of this commodity worldwide, which will lead to a more difficult situation for China's export products. Such as ISO 14064, ISO 14067, PAS 2050 and GHG Protocol, lack uniform macro standards.

2.3.2. The Level of Low-carbon Technology is Not High

The elastic coefficient of energy production = the average annual growth rate of total energy production/ the average annual growth rate of national economy. The elastic coefficient of energy production is greater than 1, under the assumption that other factors are constant, which indicates that the average growth rate of total energy production is higher than that of national economy. It is shown that the average growth rate of total energy production is smaller than that of the national economy, that is, with the development of economy, the track of the change of energy production elasticity coefficient is in the shape of V. As shown in figure 1, China's low-carbon technology is still in the development stage, low-carbon technology level is not high, so that enterprises in the process of transformation and upgrading lack of power, and the high cost of transformation.



Figure 1. Elasticity coefficient of energy production in China from 2006 to2021

Source: National Energy Administration and National Bureau of Statistics

2.3.3. Large Total Energy Consumption Unreasonable Structure and Low Utilization Rate

The growth of carbon emissions depends on the level, structure and utilization efficiency of energy consumption. As the world's largest energy consumer, China's total energy consumption in 2022 was 5.41 billion tons of standard coal, up 2.9% over the previous year. In China, the unit GDP energy cabinet is 14 times the average level of the world and 2.1 times that of developed countries.

In terms of consumption structure, the total energy consumption in 2022 will be 5.41 billion tons of standard coal, an increase of 2.9% year-on-year. Coal accounted for 56.2% of total energy consumption, up 0.3 percentage points year-on year [10]. Compared with the total energy consumption, although the efficiency of China's energy resource utilization has improved in recent years, there is still a big gap compared with the world's advanced level. It can be seen that the total consumption, led by fossil energy consumption, continues to grow. And the energy efficiency is not high, which exacerbates the severe situation of carbon emissions in China.

2.3.4. High Dependence on Foreign Trade, Low-end Products, and Concentration of Export Regions

From the perspective of low-carbon economy, China's foreign trade exports still have problems such as extensive growth mode, high product carrying energy, and high dependence on the market of developed countries. In terms of total trade, the total value of China's import and export of goods in 2022 will be 42.07 trillion yuan, an increase of 7.7% over 2021, and the scale will hit a record high. Among them, exports were 23.97 trillion yuan, and increase of 10.5%; imports were 18.1 trillion yuan, an increase of 4.3%, accounting for 12.6% of the international market share. In terms of product composition, China's current export trade is mainly concentrated on products with low technical content, high energy consumption and high carbon emissions, and such products are the main objects of carbon tariffs. In terms of trade area, China's foreign trade export area is also relatively concentrated, mainly concentrated in the European Union, Japan and the United States, and the environmental standards implemented by such countries are relatively high, and they are the proposers and main promoters of carbon tariffs. It can be seen that due to the large volume of China's foreign export

trade, the high carrying capacity of export areas, once the carbon tariff is levied, China's foreign trade exports will face a huge impact.

2.3.5. The Participation of Financial Institutions is Relatively Low

In developed countries where the carbon trading market is more perfect, all kinds of financial institutions have entered the field of carbon finance in large numbers, they buy carbon trading products from developing countries at low prices, and develop their packaging into higher-priced financial products in the international carbon market for trading, and then obtain high profits. In contrast, China's domestic financial institutions are generally not highly involved in the carbon finance market based on market, policy and other reasons, and there are few ways to participate in the international carbon finance market. The single model and the lack of diversity of carbon financial services cannot meet the practical needs of enterprises in terms of financial integration, intermediary consulting and risk aversion.

3. Analysis of the Factors Affecting the Development of Low-carbon Economy on China's Foreign Trade

3.1. Data Sources

This paper selects the original data of China's total export of goods trade, the level of low-carbon technology, the level of RMB exchange rate and the issuance amount of the securities market from 2006~2021 by consulting the relevant statistical yearbooks and the data from the National Bureau of Statistics.

Table 2. Raw data

| Year | Total exports of trade in goods(US\$ billion) | Low-carbon technology level (priced at US\$1 per unit direct pricing method) | The level of the RMB exchange rate (100 million RMB/ 10,000 tons of standard coal) | Domestic issuance in the securities market (100 million yuan) |
|------|---|--|--|---|
| 2006 | 9689.78 | 0.836236837 | 6.6810805 | 344.3200603 |
| 2007 | 12200.6 | 0.947603277 | 6.633844611 | 1192.253705 |
| 2008 | 14306.93 | 1.077534929 | 6.543206561 | 625.0456773 |
| 2009 | 12016.12 | 1.11171086 | 6.526641262 | 81.90742728 |
| 2010 | 15777.54 | 1.234699436 | 6.517597415 | 1612.496737 |
| 2011 | 18983.81 | 1.260687314 | 6.470613728 | 1288.264551 |
| 2012 | 20487.14 | 1.339291487 | 6.447701981 | 1060.479684 |
| 2013 | 22090.04 | 1.422270833 | 6.428622102 | 1172.587802 |
| 2014 | 23422.93 | 1.502479607 | 6.42045085 | 1837.519213 |
| 2015 | 22734.68 | 1.586817718 | 6.434289664 | 5507.868101 |
| 2016 | 20976.31 | 1.688354715 | 6.498628475 | 8260.455033 |
| 2017 | 22633.45 | 1.825332637 | 6.514979322 | 7929.278443 |
| 2018 | 24866.96 | 1.947938973 | 6.49487273 | 9897.565326 |
| 2019 | 24994.82 | 2.023670737 | 6.536474183 | 12256.82695 |
| 2020 | 25899.52 | 2.033992623 | 6.536343711 | 14355.58133 |
| 2021 | 33571.4 | 2.182575763 | 6.469482848 | 14787.06824 |

Source: National Energy Administration, National Bureau of Statistics and Ministry of Commerce.

3.2. Model Construction

3.2.1. Data and Variable Description

The data used for the variables in this model are time series data from 2006 to 2021, and the data are from the National Energy Administration, National Bureau of Statistics and Ministry of Commerce.

Table 3. Data and variables

| Explanatory variables | Expression | Meaning | Expected symbols | Theoretical Explanation |
|------------------------------------|-------------|---|------------------|---|
| Technology | $TECH_i$ | National carbon technology level in the i th year | + | The level of national low-carbon technology will increase product supply, and then increase products exit. |
| The level of the RMB exchange rate | ER_i | The level of the RMB exchange rate in the i th year | + | The RMB exchange rate under the direct pricing method, an increase in the level will increase the total export of our country |
| Ability to finance | $FINANCE_i$ | Securities market issuance in the first year | + | An increase in the amount of issuance in the securities market will improve the capital situation of enterprises, which in turn will expand the scale of production and increase exports. |
| State system | NS_i | The dummy variable, the adequacy of national support in the i th year, is in 2006, 2008, 2010, 2011, 2014, 2015. In 2017 and 2021, the value is 1, and in other years, it is 0. | + | The national system and policy support are relatively sufficient, which can increase the effective supply of products, thereby increasing product exports |
| Force majeure trade hindering | TB_i | Dummy variables, force majeure trade hindrance in year 2008, 2009, 2010, 2011, 2014, 2018, 2019, 2020, 2021 the value is 1, and in other years, it is 0. | — | The trade obstacles of force majeure will reduce China's exports. |

3.2.2. Model Construction

In order to avoid absolute differences between variables and enhance the linear relationship, the variables are logarithmic.

$$\ln EX_i = A_1 + A_2 \ln TECH_i + A_3 \ln FINANCE_i + A_4 \ln ER_i + A_5 NS_i + A_6 TB_i + u_i$$

3.2.3. The Parameter Estimation Results of the Model

1) Unit root test

As can be seen from Table 4, the logarithmic form of the raw data is not stationary at the 5% significant level. And its first-order difference data shows stationarity at the 5% significant level. Therefore, we will use first-order difference-in-difference data to study carbon emissions and total export trade, the essence of which is to study the growth rate between the two variables. Among them, $\ln EX_i$ represents the logarithmic form of China's total exports of goods trade in

the i th year; $\ln TECH_i$ represents the logarithmic form of China’s carbon technology level in the i th year; $\ln FINANCE_i$ represents the logarithmic form of the issuance amount of the securities market in the first year; $\ln ER_i$ represents the logarithmic form of the RMB exchange rate level in the i th year; $D(\ln TECH_i)$ is the first-order difference of the $\ln TECH_i$ data; $D(\ln FINANCE_i)$ is the first-order difference of the $\ln FINANCE_i$ data; $D(\ln ER_i)$ is the first-order difference of the $\ln ER_i$ data.

Table 4. ADF stationarity test

| sequence | ADF test results | 5% significant level | conclusion |
|--------------------|------------------|----------------------|------------|
| $\ln EX_i$ | -1.426933 | 0.5411 | unsteady |
| $\ln TECH_i$ | -1.945958 | 0.3042 | unsteady |
| $\ln FINANCE_i$ | -0.147586 | 0.9239 | unsteady |
| $\ln ER_i$ | -2.504162 | 0.1382 | unsteady |
| $D(\ln EX_i)$ | -3.827885 | 0.0137 | smooth |
| $D(\ln TECH_i)$ | -7.148761 | 0.0000 | smooth |
| $D(\ln FINANCE_i)$ | -5.300896 | 0.0010 | smooth |
| $D(\ln ER_i)$ | -4.414979 | 0.0062 | smooth |

2) Co-integration test

In order to verify the stationarity of the first-order difference, the Engle-Granger two-step method was used to test the co-integration of the first-order difference sequence of variables to explore the relationship between the variables. As shown in Table 5, the differential series of the variables $\ln EX_i$, $\ln TECH_i$, $\ln FINANCE_i$ and $\ln ER_i$ are stationary, that is, the original sequence is a first-order single integer sequence rather than a stationary sequence.

Regression model:

$$\ln EX_i = 18.54764 + 0.689186 \ln TECH_i + 0.054942 \ln FINANCE_i - 1.430277 \ln ER_i + 0.051608 NS_i - 0.113946 TB_i \tag{1}$$

$$R^2 = 0.985544, \text{ adjusted } R^2 = 0.978316, \text{ DW} = 1.682535$$

Table 5. ADF test table for co-integration test residuals

| variable | ADF | 5% significant level | Whether it is smooth or not |
|-----------|-----------|----------------------|-----------------------------|
| residuals | -4.277388 | 0.0069 | smooth |

The test results in Table 5 show that the residual series is stationary, indicating that there is a long-term equilibrium relationship between the variables.

3) Establishment of error correction model

The ECM model in this article is as follows:

$$D(\ln EX) = B_1 + B_2 D(\ln TECH_t) + B_3 D(\ln ER_t) + B_4 D(\ln FINANCE_t) + B_5 D(NS_t) + B_6 D(TB_t) + B_7 ECM(-1) \tag{2}$$

$B_i, i = 1,2,3,4,5,6,7$ are all parameters to be estimated.

The analysis of the regression results is shown in Table 6 and Table 7:

Table 6. Regression Analysis

| The name of the variable | numerical | t-Statistic | P |
|--------------------------|-----------|-------------|----------|
| Constant terms | 18.54764 | 11.66013 | 0.0000 |
| $\ln TECH_i$ | 0.689186 | 5.568533 | 0.0002 |
| $\ln ER_i$ | -1.430277 | -5.677046 | 0.0002 |
| $\ln FINANCE_i$ | 0.054942 | 2.621160 | 0.0255 |
| NS_i | 0.051608 | 1.756592 | 0.1095 |
| TB_i | -0.113946 | -3.783778 | 0.0036 |
| F-statistic | 136.3495 | P-value | 0.000000 |

Table 7. Regression results of the error correction model

| The name of the variable | numerical | t-Statistic | P |
|--------------------------|-----------|-------------|--------|
| Constant terms | 0.025434 | 1.092568 | 0.3064 |
| $D(\ln TECH_i)$ | 0.088329 | 0.233778 | 0.8210 |
| $D(\ln ER_i)$ | -2.120413 | -6.461122 | 0.0002 |
| $D(\ln FINANCE_i)$ | 0.065993 | 5.607355 | 0.0005 |
| $D(NS_i)$ | 0.041476 | 3.043480 | 0.0160 |
| $D(TB_i)$ | -0.086053 | -4.583036 | 0.0018 |
| $ECM(-1)$ | -0.836045 | -2.790315 | 0.0235 |
| F-statistic | 24.93956 | | |

Note: The D symbol represents the first order of difference, and ECM (-1) is the residual difference term of the co-integration model.

4. Regression Analysis Results

4.1. Technical Level

The regression coefficient of the low-carbon technology level variant showed a positive value, which was in line with expectations. The coefficient value of 0.69 indicates that for every 1% increase in the level of technology, the export of goods trade increased by 0.68%. And the P-value of the coefficient is less than 0.05, which passes the significance test. This means that the level of low-carbon technology is an extremely important factor in China's trade in goods. Therefore, technological innovation is necessary in order to promote the gradual growth of trade in goods.

4.2. The Level of the RMB Exchange Rate

The regression coefficient of the RMB exchange rate level variable is negative, which is not in line with expectations. The coefficient value is -1.430277, which means that for every 1% increase in the RMB exchange rate, China's exports of goods trade will decrease by 1.4. And the P-value of the coefficient is less than 0.05, which passes the significance test. This means that the level of the RMB exchange rate is the main factor affecting China's trade in goods. The reason for the discrepancy with expectations may be that the data is denominated in US dollars. An increase in the exchange rate level means that the dollar appreciates, and each appreciates of the dollar relative to the RMB is usually accompanied by tensions between China and the United States is one of the main importers of China's trade in goods, so the result will be negative and not in line with expectations.

4.3. Financial Financing Capacity

The regression coefficient of the variable of financial financing capacity is positive, in line with expectations, and the coefficient value is 0.05, indicating that for every 1% increase in financial financing capacity, China's export of trade in goods will increase by 0.05%, and the coefficient

p-value is 0.0255, which shows that the ability of financial financing an investment is the factor affecting China's export of trade in goods. Enhancing the ability of financial financing to provide enterprises with more funds is an important means to increase China's exports of goods.

4.4. National System

The regression coefficient of the national system showed a positive value, which was in line with the expected positive correlation, the coefficient value was 0.05, and the P-value was 0.1095, and the coefficient was not significant. It shows that the support of national institutional policies has no obvious impact on export growth compared with the absence of national institutional policy support. With the in-depth development of global economic integration, the national system and policy have gradually weakened the role of domestic product exports, and the main role is still in the diversified international market and the political game between countries.

4.5. Force Majeure Trade Obstacles

The trade resistance regression coefficient for force majeure was negative, in line with expectations. The coefficient value was -0.11, and the P-value was 0.0036 to pass the significance test. This means that trade obstacles with force majeure have a certain hindrance effect on the export of China's trade in goods compared with trade obstacles without force majeure. This reflects the gradual deepening of the impact of changes in the international situation on China's foreign trade.

According to the results of the error correction model, the ECM(-1) coefficient is -0.836045, P-value is 0.0235, which passes the significance test. It shows that when the relationship between variables deviates from the long-term equilibrium state, the error correction mechanism will reverse the correction with a force of 0.836045 and pull it from the non-equilibrium state to the equilibrium state.

5. Conclusion

With the rise of low-carbon technology, that is, the GDP per unit of energy, China's total import and export of goods has increased overall. On the one hand, due to the transformation dividend of enterprises brought about by the improvement of technological level, the state's subsidies to them reduce production costs, so that enterprises have more production capacity and demand for raw materials to support product production within the cost tolerance; on the other hand, because the products are more in line with international low-carbon standards, it is easier to enter the markets of other countries. The increase in the total volume of exports, the increase in the ability of financial financing, the increase in the available funds of enterprises, the reduction of the pressure on the operation of enterprises, and the increase in the production of products, and thus the increase of exports. Changes in the level of the RMB exchange rate are closely related to the international situation, so the impact on China's foreign trade should be concretely combined with the international situation; the state system has a certain role in promoting the development of China's foreign trade; in recent years, the irresistible trade obstacles suffered by China have mainly been concentrated at one end. For example, the Sino-US trade war mainly affects the export side, which has a strong negative impact on the export of China's trade in goods.

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