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International trade of PRC and its place in environmental sustainability

Abstract
The sustainable development of trade and the environment is related to the sustainability of a region, a country, and even the global economy. As a major trading country, China has achieved remarkable results in international trade growth in recent years, driven by its continuous deepening of open trade policies. Article identify the key factors that contribute to the changes in environmental sustainability in China's international trade. Research defined the ways of China's growth of international trade volume with promoting sustainable environmental development.
Analysis found the impact and role of the continuous expansion of trade scale on China's sustainable environmental development. By analyzing the data on the scale and structure of China's international trade, research checked the data changes that affect the relationship between international trade and environmentally sustainable development.
In this paper we substantiate the conceptual provisions of the theoretical and methodological model of the international trade and its place in environmental sustainability: system characteristics (international trade development to total GDP; international trade pattern structure analysis; geographic direction of international trade) and the principles of environmental sustainability (total industrial waste gas emissions and treatment; industrial solid waste generation, disposal and comprehensive utilization; industrial wastewater emissions, industrial chemical oxygen demand emissions, and Industrial ammonia nitrogen emissions).

Keywords: Environmental Sustainability; International Trade; Trade Mode; Waste Generation; Waste Utilization
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Міжнародна торгівля КНР та її місце в екологічній стійкості

Анотація. Сталий розвиток торгівлі та навколишнього середовища пов'язаний зі стійкістю регіону, країни і навіть глобальної економіки. Будучи великою торговельною країною, Китай досяг чудових результатів у зростанні міжнародної торгівлі за останні роки завдяки постійному поглибленню політики відкритої торгівлі. Стаття встановила ключові фактори, які сприяли змінам екологічної стійкості в міжнародній торгівлі Китаю. Дослідження визначило шляхи зростання обсягів міжнародної торгівлі Китаю в умовах сприяння сталому екологічному розвитку. Аналіз виявив вплив і роль постійного розширення масштабів торгівлі на сталий екологічний розвиток Китаю. Аналізуючи дані про масштаби та структуру міжнародної торгівлі Китаю, дослідження перевірило зміни даних, які впливають на взаємозв'язок між міжнародною торгівлею та екологічно сталим розвитком. У статті обґрунтовуються концептуальні положення теоретико-методологічної моделі міжнародної торгівлі та її місце в екологічній стійкості, зокрема через: системні характеристики (розвиток міжнародної торгівлі у відношенні до сукупного ВВП; аналіз структури міжнародної торгівлі; географічний напрям міжнародної торгівлі) та принципи екологічної оцінки стійкості (загальні промислові викиди відпрацьованих газів та їх обробка; утворення, видалення та комплексна утилізація твердих промислових відходів; викиди промислових стічних вод, викиди промислового хімічного споживання кисню та промислові викиди аміачного азоту).

Ключові слова: екологічна стійкість; міжнародна торгівля; режим торгівлі; утворення відходів; утилізація відходів.

1. Introduction

The development of international trade and environmental sustainability are two important aspects of social survival and economic development, which are closely related. The rapid growth of international trade can to some extent promote the development of environmental protection. Strengthening environmental protection will encourage businessmen to choose to produce and sell more environmentally friendly products, increasing trade opportunities for more environmentally friendly products; under certain conditions, international trade and the environment will also be contradictory. Environmental protection has put forward new standards and requirements for the development of international trade. Environmental laws and regulations restrict or even prohibit the international trade of many products. Foreign trade not based on sustainable development will have a great negative impact on the local ecological environment. With the increasingly prominent problem of ecological environment pollution and the rise of ecocentrism, as the international community's understanding of ecological civilization continues to improve, a trend of «ecological» has emerged in various industries and fields. This trend attempts to examine all activities in the process of economic and social development from an ecological perspective. The core issue is to achieve harmonious development of the economy, society, population, resources, and an ecological environment. Since the concept of «sustainable development» was explicitly proposed by the World Commission on Environment and Development in 1987, China has been moving towards an «ecological» level: the strategies of «winning by quality», «diversifying the market», and «revitalizing trade through technology» in the 1990s were all directly or indirectly driven by resource reduction, minimizing ecological environmental damage, and stabilizing economic development.

The issues of international trade and its place in environmental sustainability were studied by many scientists. A. Andriamahery and Md. Qamruzzaman (2022) gauged the role of renewable energy consumption, energy innovation, and total trade on environmental sustainability

in selected Middle East and North Africa countries under the assumption of environmental Kuznets curve. Authors suggested implementation the environmentally friendly technologies, the reduction of subsidies on nonrenewable energy, and green trade policies to help advance sustainable development should be implemented. W. Wang, M. Abdur Rehman and Sh. Fahad (2022) securitized the impact of renewable energy, trade openness, industrialization, technology, and economic development on the ecological footprint in G-7 nations with the theoretical support of the STIRPAT model. The empirical estimations reported that clean energy plays its role in mitigating environmental pollution in both the long and short run. More so, production and trade activities utilize more resources that impart their negative influence on the ecological quality. The industrialization has a direct and significant connection with the environment, and, contrarily, technology has a favorable impact on ecological quality. H. Khan, L. Weili and I. Khan (2022) investigated trade openness, innovation and quality institutions in environmental sustainability in 176 countries of the world. By employing OLS regression, fixed effect and generalized method of moments, the results showed that trade openness, renewable energy consumption and foreign direct investment are negatively associated with carbon emission, whereas most of institutional quality indicators significantly contribute to environmental sustainability; however, it is still below the desired level to enhance the quality of environment. The findings suggest promotion of renewable energy sources to cope with environmental sustainability.

H. Arslan, I. Khan and M. Latif (2022) examined the dynamics of China's natural resource rents, environmental sustainability, and sustainable economic growth. Overall, the results of this study indicated that natural resources improve environmental sustainability at the expense of economic growth. In contrast, financial development, merchandise trade, and urban population growth promote environmental degradation. H. Liu, H. Lei and Y. Zhou (2022) focused on the impact of trade in environmentally sound technologies (green trade) on the environment. Using a panel of 277 Chinese cities from 2004 to 2013 and the instrumental variables strategy, authors find that green trade can decrease the pollution level, though total trade openness is far less favorable to the environment. Researchers also find that green imports and green exports are both conducive to the Chinese environment while green ordinary trade performs better than green processing trade.

2. Methodology

Global environmental integration, the natural environment itself and various human activities are affecting each other's environmental changes. This paper is a study of the impact of China's international trade on the environment, only studying various key elements of international trade, including the scale of trade in goods, trade supply, energy consumption, trade pattern structure, trade geographic direction, trade mode etc. Although only China's international trade data are studied, including import and export data, but China's export data will have a greater impact on its own environment, because the development, production, processing and trade of export products are completed within the country, which undoubtedly has a more important impact on its own environment, but for imported products , although the development, production and processing processes are completed abroad, but to a certain extent increases The scale of trade, trade structure, and trade methods in this country have caused an impact, which invariably affects environmental sustainability; at the same time, what constitutes an impact on the environment is not only international trade, but also domestic trade, that is, the total GDP, which is also an important indicator to directly measure environmental sustainability, therefore, the proportion of international trade in GDP can also indicate China's international trade in environmental sustainability (Figure 1).

The scale of trade in goods is expressed in terms of trade volume and gross domestic product. The trade-to-GDP ratio is an indicator of the relative importance of international trade in the economy of a country. It is calculated by dividing the aggregate value of imports and exports over a period by the gross domestic product for the same period:

$$Trade - to - GDP\ ratio = \frac{M+X}{GDP}. \quad (1)$$

Regarding the impact of the scale of trade in goods on ecological composition, scholars have basically reached a consensus that the expansion of trade scale causes the expansion of

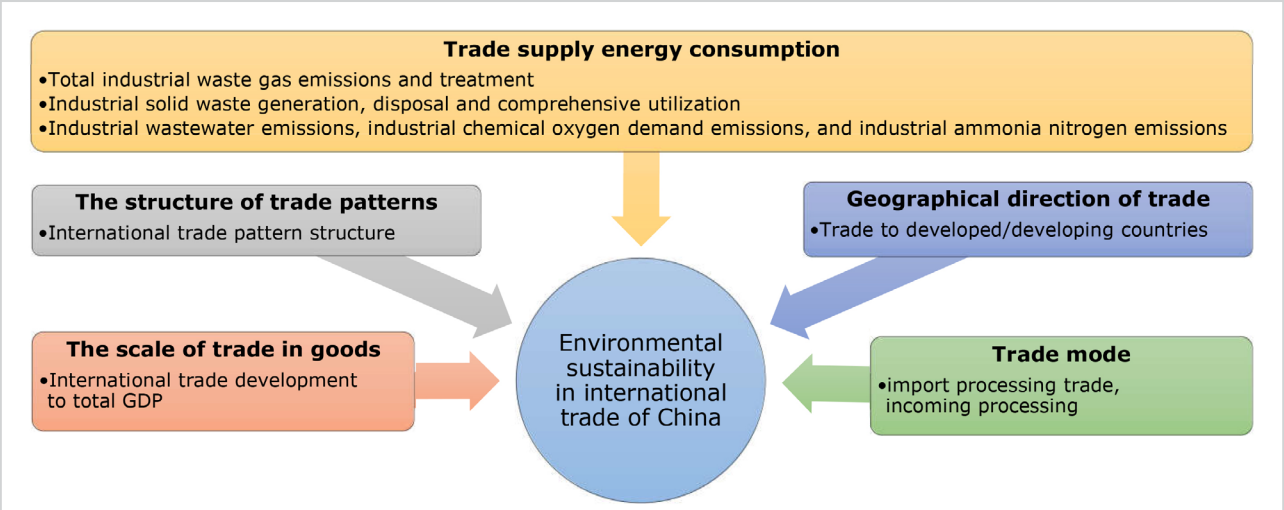

Figure 1:
Data Analysis of the key elements affecting environmental sustainability in international trade of China
Source: Authors' own research

economic scale, the increase of factor inputs, and thus the decrease of ecological resources. According to the criteria of environmental sustainability, this decrease in natural capital is difficult to be replaced by man-made capital. Therefore, this indicator is the inverse one.

The development of international trade has driven the growth of the local economy, and also promoted the progress of local industrial production capacity, but the increase in industrial production capacity has also accelerated the destruction of the environment, and the pollution problems generated by the industrial production process cannot be ignored. Trade supply energy consumption directly influence on: total industrial waste gas emissions and treatment; industrial solid waste generation, disposal and comprehensive utilization; industrial wastewater emissions, industrial chemical oxygen demand emissions, and industrial ammonia nitrogen emissions. Industrial production process will produce a variety of waste gas, waste water, waste residue, these industrial production waste discharged into the natural environment will undoubtedly cause harm to the environment, threatening people's health, and become a key element to restrict the sustainable development of the environment, so how to manage the supply side of the negative impact of industrial production process, increase the investment in governance, improve the level of governance has become a modern industrial production process must This indicator is a positive indicator.

The structure of trade patterns is expressed in terms of trade in services and trade in goods, and refers to the proportion of trade in intangible products (services) and trade in tangible products (goods). Although there are not many studies on the ecological effects of trade in services, there are studies that show that the overall environmental effects of trade in services are not very significant compared with trade in goods, especially the pollution of the local environment by service exports is minimal, so this paper tries to build a trade pattern structure index, the larger the ratio the more favorable to the ecological environment of the region, and the index is a positive indicator.

Geographical direction of trade presents the value of merchandise exports and imports disaggregated according to a country's primary trading partners. Generally speaking, the international trade geographic direction indicator reflects the different shares of countries in the world trade, and the foreign trade geographic direction indicator reflects the source of imported goods or the flow of exported goods of a country and region, and also reflects the degree of connection between it and different countries or regions. However, if understood from the perspective of trade ecology, this indicator has a different meaning. From the perspective of exports, different countries or regions, due to their natural conditions (e.g., contamination of water, soil, etc., spread of plant and animal diseases) or other strategic intentions (ecological dumping, pollution transfer), will intentionally or unintentionally bring some impact on the ecological environment of their trading partners in the process of export trade. From the perspective of imports, goods from different sources also have very different ecological and environmental effects. The

environmental safety effects of harmful elements are evaluated and pointed out that the toxic and harmful elements in iron ores from Australia, Brazil and Venezuela are at acceptable levels, but the ores from India, Iran and other properties contain arsenic, alum, cobalt and nickel in serious excess of the standard, and there is a risk of environmental pollution. Thus, it is clear that the geographical direction of trade does have different impacts on the ecological environment of a country or region.

From the point of view of actual business, the trading methods may involve a variety of forms, such as fixed sale, underwriting, overseas agency, processing trade, consignment, exhibition and sale, compensatory trade, bidding and auction. On the surface, these different forms of trade arrangements do not have much direct connection with the ecological environment, but from the perspective of trade ecology, they may have indirect or significant impact. Take processing trade in China's customs statistics as an example, its typical feature is «two ends»: (1) raw materials or components are «indirectly produced» abroad, and (2) finished products are finished abroad for final consumption. According to the theory of circular economy and ecological footprint theory, this «two-headed» processing trade saves the consumption of domestic production capacity and environmental factors on the one hand, and saves the carrying and absorption capacity of domestic ecological environment for waste on the other hand. So, such ecological effect is more obvious compared with general trade and can be regarded as a good positive indicator.

3. Results

Since 1978 China began to implement the policy of internal reform and opening up to the outside world until 2021. The ratio of China's total import and export trade to China's GDP has been increasing, with GDP figures growing from USD 213.8 billion in 1978 to USD 177,864.65 billion in 2021, an increase of 82.16 times in these 44 years. The international trade import and export trade volume increased from USD 21.086 billion in 1978 to USD 605.148 billion in 2021, an increase of 285.99 times in 44 years. The export data increased from USD 9.955 billion in 1978 to USD 336.359 billion in 2021, an increase of 336.92 times in 44 years (Figure 2).

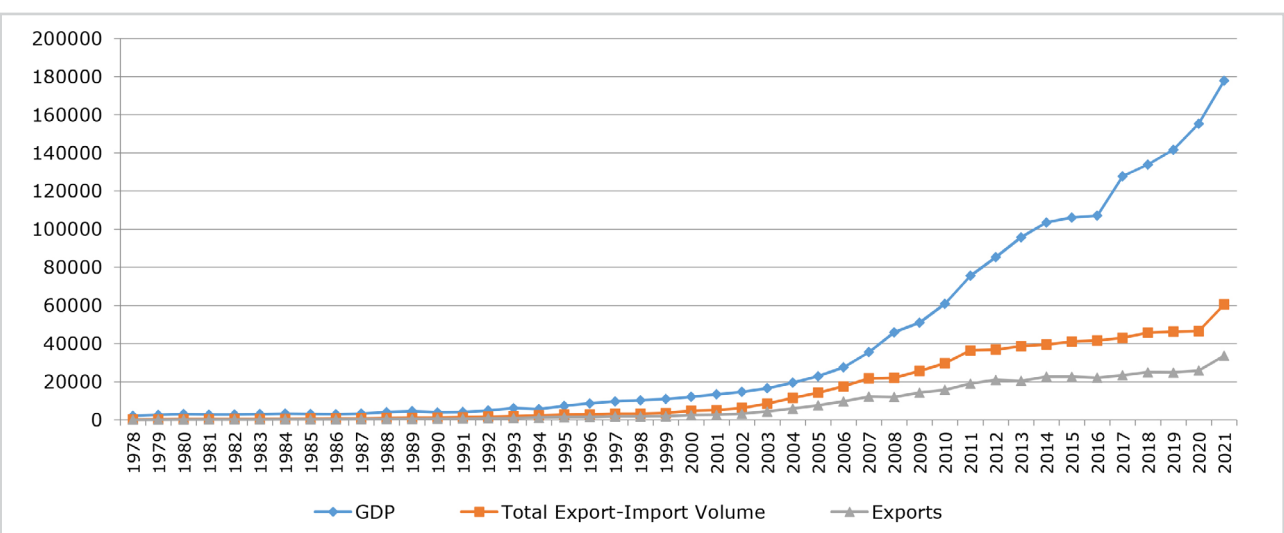

Figure 2:
China's GDP, export/import, export data, USD billion, 1978-2021
Source: China National Bureau of Statistics database

According to the data, the ratio of China's total international trade to China's total GDP declined from 914% in 1978 to 198% in 2021. From the data of China's total GDP and total import/export trade, it is obvious that if to consider the impact on environmental sustainability from the perspective of total economic growth alone, the status of China's international trade on environmental sustainability is declining. Same time it is still not comprehensive enough to measure the degree of impact on environmental sustainability only by such influencing factors as the total GDP and international trade volume. Next, let's analyze the key elements of China's international trade in order to identify the main features of China's international trade on environmental sustainability.

China's total industrial emissions have risen from 13,814.5 billion cubic meters since 2000 to 6,547.58 billion cubic meters in 2020, an increase of 373.96%, peaking at 7,299.76 billion cubic meters in 2017. At the same time, the cost of industrial emissions treatment in China has risen from USD 1,132 million in 2000 to USD 40,568 million in 2020 reached its peak, rising by 3483.75% in 20 years (Figure 3). The cost of treatment shows a rising trend year by year.

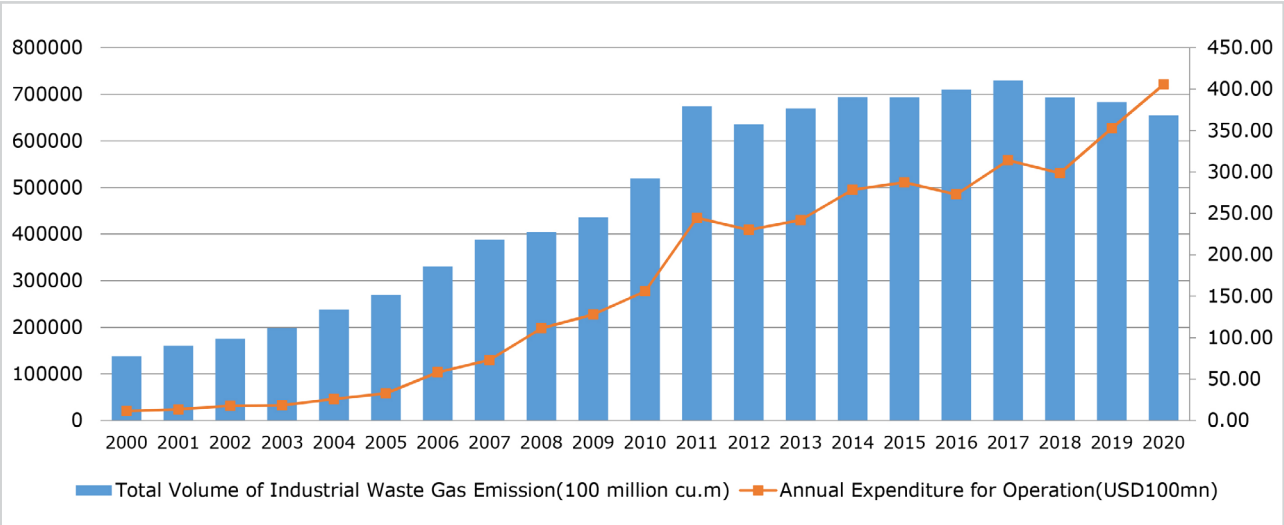

Figure 3:
China's total industrial waste gas emissions and treatment
Source: China National Bureau of Statistics database

Figure shows that since 2000 China's economy stay in the process of continuous growth and this growing has brought a continuous increase in industrial emissions. Since 2013, when the Chinese State Council implemented the Action Plan for the Prevention and Control of Air Pollution, the concentration of respirable particulate matter has decreased by more than 10% compared to 2012 in cities at the prefecture level and above nationwide. Also, the total industrial emissions have decreased year by year since 2018. However, the cost for treatment of exhaust gases has not decreased, but continues to increase year by year.

China's industrial solid waste generation rose year by year, from 816.08 million tons in 2000 to 368.57 million tons in 2020. Industrial solid waste generation has increased of 351.64% over 20 years, peaking at 441.43 million tons in 2019. As industrial solid waste generation rose year by year, the comprehensive utilization and disposal of industrial solid waste also grew year by year. So, it was growing from 3,745,191.52 million tons in 2020 to 20,475,692.56 million tons in 2020, increasing of 445.66% and 911.44% respectively in last 20 years. General, China's comprehensive utilization rate of industrial solid waste rose from 45.9% in 2000 to 56% in 2020 (Figure 4).

From these data, it can be seen that growing of China's economy increased industrial solid waste generation and, same time, stimulated disposal and comprehensive utilization. The Chinese government formulated the «Soil Pollution Prevention and Control Action Plan» and implemented in 2016. China's Action Plan developed in order to prevent and control effectively the soil pollution, and gradually improve the quality of soil environment. This legislation is beginning to show results since 2020.

Also, environmental sustainability analysis should be focused on industrial wastewater emissions, industrial chemical oxygen demand emissions, and industrial ammonia nitrogen emissions in China (Figure 5). China's industrial wastewater emissions have decreased, from 19.42 billion tons in 2000 to 13.76 billion tons in 2020, peaking at 37.8 billion tons in 2018. Industrial chemical oxygen demand emissions and industrial ammonia nitrogen emissions are also decreasing year by year, from 704.5 and 401,000 tons in 2000 to 49.7 and 21,000 tons in 2020 - over the past 20 years, they have decreased by 92.95% and 94.76% respectively.

Data show that the development of Chinese industry increased the discharge of industrial wastewater, reaching its peak in 2018. Hence, now more than 80% of 500 China's major rivers are polluted for different degrees, which is mainly caused by the discharge of industrial wastewater. Same time, more than 90% of the rivers flowing through 40 China's major cities are polluted,

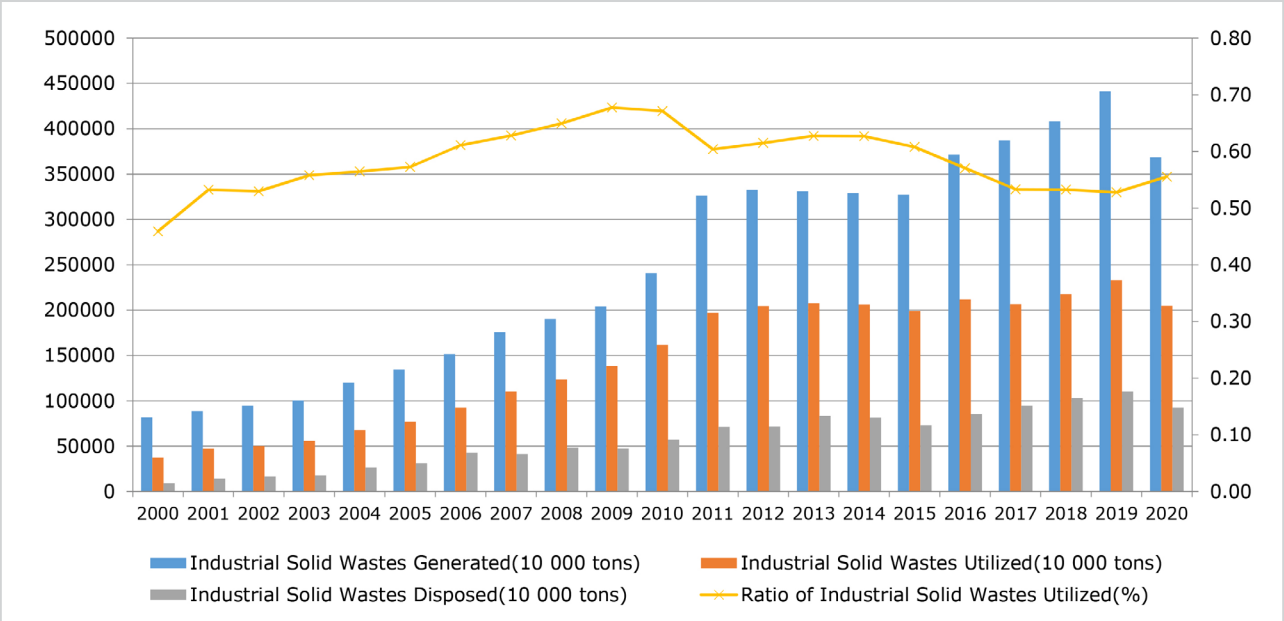

Figure 4:
China's industrial solid waste generation, disposal, comprehensive utilization
Source: China National Bureau of Statistics database

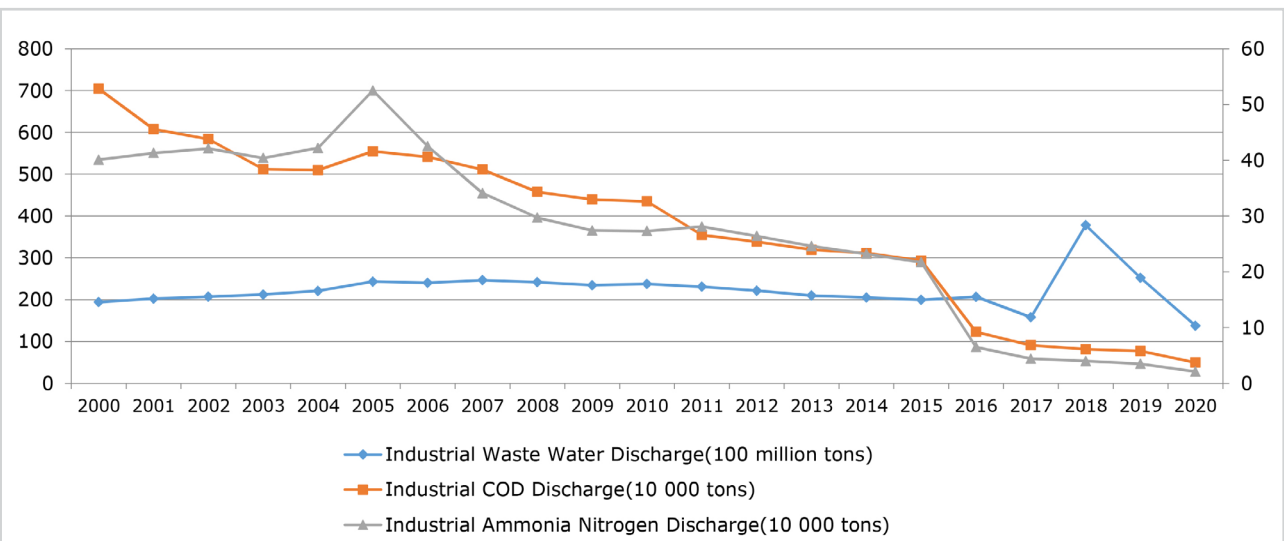

Figure 5:
China's industrial wastewater emissions, industrial chemical oxygen demand emissions, and industrial ammonia nitrogen emissions
Source: China National Bureau of Statistics database

which has a great impact on the environment and the health of residents. In recent years, China has been paying great attention to the treatment of industrial wastewater. China's government has increased the investment in treatment facilities, the intensity of law enforcement, and effectively strengthened the prevention and control of water pollution. In February 2011, the State Council approved the 12th Five-Year Plan for Comprehensive Prevention and Control of Heavy Metal Pollution. In 2015, the Action Plan for Water Pollution Prevention and Control specifically formulated. It formulated the Action Plan for Water Pollution Prevention and Control to solve the difficult problems of industrial wastewater treatment.

We used regression analysis as statistical method that allowed us to examine the relationship between environmental sustainability indexes to international trade indexes (Figure 6). At the core it showed the impact of independent variables: export (x_1) and import (x_2) on dependent variables (Y_1 - *Industrial Waste Gas Emission*, Y_2 - *Industrial Solid Waste Generation*, Y_3 - *Industrial Waste Water Discharge*).

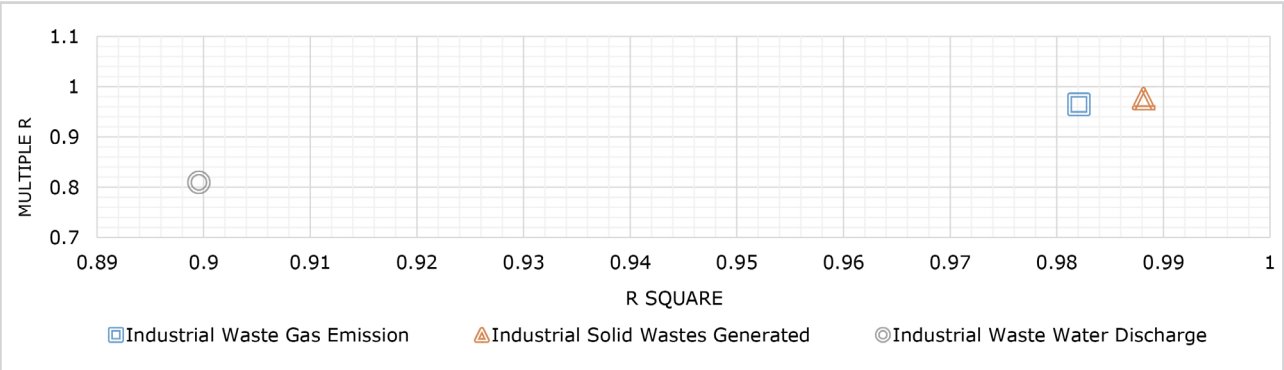

Figure 6:
Regression Analysis of China's Environmental Sustainability Indexes to International Trade Indexes
Source: Authors' own research

By the result of analysis, we got the following regression equations:
Industrial Waste Gas Emission Regression Equation: $Y_1 = -0.25_{x1} + 0.64_{x2}$;
Industrial Solid Waste Generation Regression Equation: $Y_2 = -0.09_{x1} + 0.29_{x2}$;
Industrial Waste Water Discharge Regression Equation: $Y_3 = -0.01_{x1} + 0.01_{x2}$.
In all cases the «Intercept» value means «0». This tells that if there is no «X», then $Y = 0$. So, international trade of China has strong direct linkage with increasing of Industrial Waste Gas Emission, Industrial Solid Waste Generation and Industrial Waste Water Discharge.

The structure of China's international trade pattern described the import and export data of agricultural products, electromechanical products and high-tech products. Since 2005 to 2020, the trade volume of electromechanical products increased from 7,769.48 to 26,332.43 (in hundreds of millions of USD), with a growth rate of 238.92%. The trade volume of high-tech products increased from 4,159.04 to 15,419.25 (in hundreds of millions of USD), with a growth rate of 270.74%. At the same time, the trade volume of agricultural products and high-tech products increased from 486.5 to 2,614.12 (in hundreds of millions of USD), with a growth rate of 437.33%. The trade volume of agricultural products increased from 486.5 to 2,614.12 (in hundreds of millions of USD), with a growth rate of 437.33% (Figure 7).

Last 15 years the growth rate of high-tech products and agricultural products in China is higher than the electromechanical products. The high-tech products and agricultural products have a weaker impact on the environment compared with electromechanical products. The production process of electromechanical products requires more energy and raw materials, which leads to a large volume of pollutants and waste in the production process and will have a greater impact

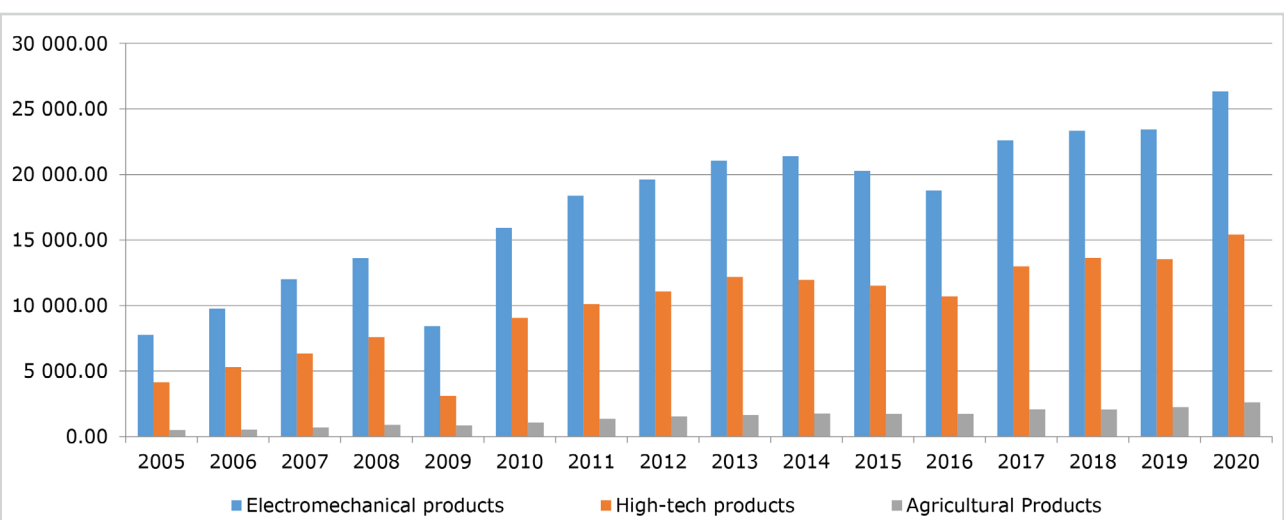

Figure 7:
China's import and export data of electromechanical products, high-tech products and agricultural products
Source: China National Bureau of Statistics database

on the environment. Many of China's high-tech and agricultural products exports are technical services, energy-saving products and environmental protection products. The production and export of these products can help promote the development of environmental protection industry. The export of agricultural products can help improve testing standards, set the green trade barriers, reduce the use of high residue pesticides and fertilizers promoting environmental protection technology. The tendency of the past 15 years argue that the structure of China's international trade pattern is developing environmentally polite (Figure 8).

According to the study, developed economies are benefited in the trade due to natural conditions, strategic intentions, or the degree of economic development, because trade is more conducive to the environmental sustainability of developed countries. It was selected countries that have international trade volume with China more than 20 billion USD during 2008-2022. Such developed economies are: EU, USA, Australia, Japan, and South Korea, and such developing economies are: Association of Southeast Asian Nations, Russia, India, Brazil, and South Africa.

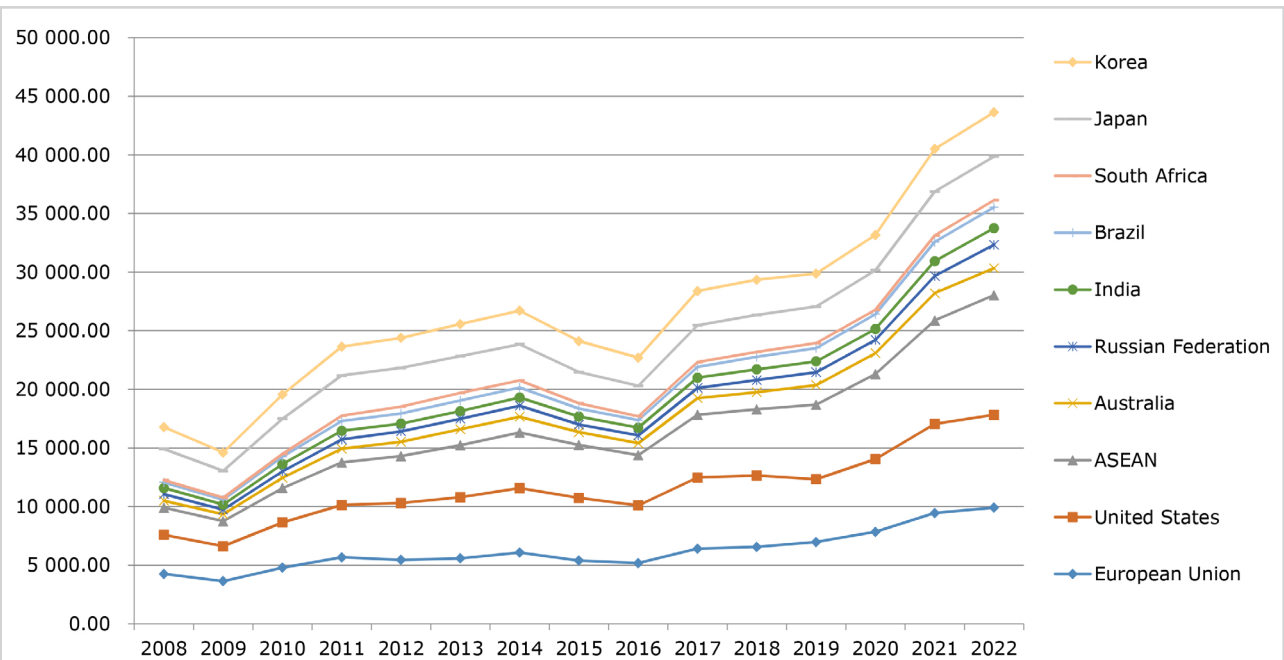

Figure 8:
China's import and export trade data to developed and developing countries
Source: China National Bureau of Statistics database

Data show that the share of developed countries in China's total international trade decreased year by year from 75.8% in 2008 to 63.34% in 2022, and the share of developing countries increased year by year from 24.2% in 2008 to 36.66% in 2022. In general, the share of trade between China and developed countries is large, so data has proved that the geographical direction of international trade has a negative impact on China's environmental sustainability. Same time, the data show that China is reducing the gap between developed and developing countries in terms of trade volume in the last 15 years. Thus, the different impact on the environmental sustainability could have the links of goods and services in the industrial chain, the categories of goods traded, the raw materials used in the processing of goods traded, and the logistics and distribution methods.

According to the theory of circular economy and ecological footprint theory, this research has compared and analysed the China's data of general trade, incoming processing trade and assembly trade. The share of general trade is increasing year by year, from USD 1,488.711 billion in 2010 to USD 4,196.808 billion in 2022, with a growth rate of 181.91%. The amount of incoming processing and assembly trade raised from USD 11,577.768 billion in 2010 to USD 1,323.09 billion in 2022, with a growth rate of 14.29%. Such growth rate was significantly lower than the amount of general trade.

Data shows, that China's international trade mode is dominated by general trade import and export mainly based on natural resource endowment as the basis for the growth of international trade (Figure 9). Also, China has focused on the export of labour-intensive products and resource-intensive products as the main growth point, and the trade growth mode is relatively

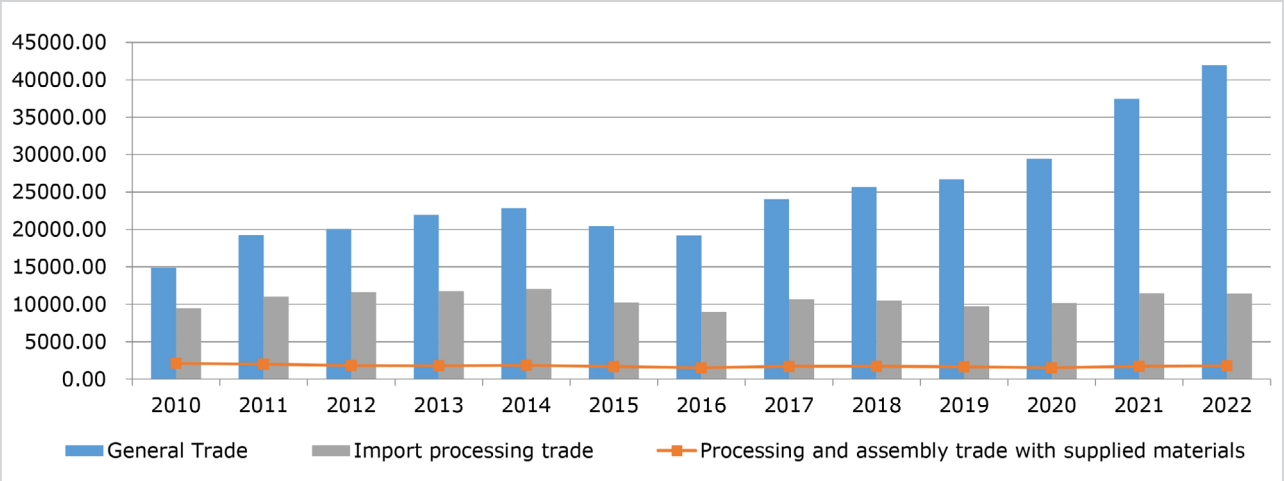

Figure 9:
China's international trade in general trade, import processing trade, incoming processing and assembly trade data
Source: China National Bureau of Statistics database

crude. Through the data in recent years, it can be concluded that China's international trade pattern has consumed China's domestic production capacity and environmental factors on the one hand, and aggravated the domestic ecological environment's bearing and absorption capacity for waste on the other hand. Hence, China's international trade pattern has a more obvious impact on China's environmentally sustainable development. It means that China must adjust its foreign trade strategy, change its trade growth pattern, accelerate the cultivation of knowledge industries, force the independent innovation and technological transformation, upgrade industrially the traditional industries. The traditional industries could be transformed into technology-intensive and knowledge-intensive industries, thus raising the level of China's participation in the international division of labour. In such point of view, the China's international trade approach is still a negative case, because such approach is not conducive to environmentally sustainable development.

4. Conclusion

The research shows complex, multi-level, multi-faceted relationship problem of relationship between international trade and environmental sustainability in China. China's international trade accounts for 34.19% of the total Chinese economy and influence on environmental sustainability since 1978. The Kuznets «U» curve shows the relationship between China's economic growth and the environment since 2000 on the data of industrial emissions, industrial solid waste generation, industrial wastewater emissions, industrial chemical oxygen demand emissions, and industrial ammonia nitrogen emissions. The curve shows deterioration of environmental conditions on early stages of industrialization and its gradually improve on growing the GDP per capita till USD 5,000-10,000. The tendency showed the increasing of GDP per capita up USD 12,700 by 2022 and improvement the environmental conditions due to decreasing the emissions per capita.

The Chinese government has taken a series of environmental protection measures: system of source protection, compensation for damages, accountability, system of environmental treatment and ecological restoration. The Chinese government enacted a series of laws and regulations for increasing the continuous investment in circular economy technology and treatment funds. Same time government promotes policy for low consumption, low pollution, green, environmentally friendly production and consumption.

This paper analysis shows that the overall impact of China's international trade on environmental sustainability is relatively large and unfavourable to China's environmental sustainability. To achieve the goal of carbon peaking and carbon neutrality, the Chinese government needs to further accelerate the change of production, lifestyle and consumption patterns. Also, it should resolutely implement various pollution prevention and control action plans; adhere to ecological priority and green development; maintain the stability of the ecosystem; improve the ecological environment; promote the sustainable and healthy development of the green economy.

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