

Article

Impact of Real Effective Exchange Rate of RMB on China's Value Adding in Global Value Chains

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Abstract: The global value chain is a production and supply network that crosses national borders and connects businesses, institutions, and individuals from different countries to create value and produce goods and services. China is an important part of the global value chain, and its position in it has gradually improved. There is a close relationship between the global value chain and currency exchange rates. Studying the impact of RMB exchange rate fluctuations on China's added value of global value chains is of great significance for a deeper understanding of China's internationalization process and competitiveness in the global value chain. Based on the global value chain in trade, a regression analysis is conducted on the added value of China in the global value chain. The real effective exchange rate of RMB is used as the interpretation variable, and foreign direct investment, gross domestic product, and consumer price index are included as the control variables in the analysis. The results show that the rise of China's real effective exchange rate significantly influences the added value in the global value chain even in the global financial crisis of 2008 and the appreciation of the exchange rate improves the production efficiency of China's processing and manufacturing export companies.

Keywords: REER, Added value, Global value chain, Vector autoregressive model, Production efficiency

1. Introduction

Global value chain (GVC) has been used since the 1980s. Value chain refers to the global cross-enterprise network organization that connects production, sales, recycling, and treatment of goods or services, which involves the entire process from the procurement and transportation of raw materials, the production and distribution of semi-finished and finished products, to the final consumption and recycling. This process also includes the organizational activities of all participants such as production, sales, and the distribution of values and profits involved. Companies around the world are in the value chain being engaged in various value-added activities such as design, product development, manufacturing, marketing, delivery, consumption, after-sales service, and recycling. All economic activities are interconnected in creating a mutually influencing and existing production value linkage, and the industrial chain between each value link plays an important role in mutual influence and promotion of market competition in each link. GVC is an important form of organization in today's globalized economy and an important way of international trade.

Value chains are inextricably linked to foreign trade, and exchange rates are one of the important explanatory variables for open economies. Exchange rate fluctuations affect not only the currency and capital accounts but also other overall economic variables. There is a close relationship between global value chains and exchange rates, and GVCs are production and supply chain networks that cross national borders, linking companies, institutions, and individuals in different countries to create value and produce goods and services. In the GVC, a product is sold in the global market through three processes. First, raw materials and required parts are procured from multiple countries, then processed, assembled, and produced in different countries and regions (usually in areas where factory rents are cheap and labor is cheap), and the production technology is provided by the company and finally exported to the global market. Therefore, exchange rate changes affect the cost of raw materials purchased by companies, and the price competitiveness of products in the global market. When a country's currency appreciates, the price of that country's export goods rises with implications for other countries in the GVC. When a country's currency depreciates, the price of that country's export goods decreases, increasing the country's competitiveness in the global market, and also affecting other countries.

In addition, the exchange rate also affects the profitability and cost structure of the company. When companies import raw materials and components from other countries, the appreciation of the national currency reduces procurement costs. When companies export their products to other countries, the appreciation of the national currency leads to higher prices and affects profits. Therefore, companies need to pay close attention to global exchange rate changes and adjust purchasing and sales strategies on time

to cope with the impact of exchange rate changes. In addition to the impact on businesses, exchange rates also have an impact on international trade and the global economy. The appreciation of a country's currency is conducive to imports but not to exports, resulting in an increase in imports and a decrease in exports. Conversely, a country's currency depreciation and lower export commodity prices are beneficial to exports but not to imports. In either case, it is detrimental to the balance of payments in the long run. In addition, global exchange rate fluctuations also impact global financial markets and investment. When the exchange rate fluctuates largely, investors' risk appetite is affected and they choose to transfer funds to other countries or areas, thereby affecting global capital flows and the stability of financial markets.

With the complexity and diversification of international economic and trade exchanges, the change in the external value of a country's exchange rate is difficult to explain only by the bilateral exchange rate. The real effective exchange rate (REER), as a weighted average of the bilateral exchange rate of the country and its main trading partners and competitors, truly and effectively reflects the overall external value of a country's currency and competitiveness in finance and trade between several economies. The relationship between the added value in the GVC and the REER is interactive, and companies in the GVC need to adjust their purchasing and sales strategies promptly according to the changes in the exchange rates of different countries to maximize the added value. The international community also needs to coordinate and cooperate more to cope with the challenges and risks brought by global exchange rate fluctuations and promote the sustainable development of GVCs.

China has become the world's factory and an important part of GVCs over the past decades. However, with the gradual appreciation of the RMB exchange rate and the intensification of international competition, changes in the RMB exchange rate are becoming more important to China's position and impact on the GVC. Therefore, studying the impact of RMB real exchange rate fluctuations on the added value of China's GVC is of great significance for an in-depth understanding of the internationalization process of China's economy and improving China's competitiveness in the GVC. In addition, with the continuous internationalization and the inclusion of the RMB in the special drawing rights (SDR) basket, the stability of the RMB exchange rate has also impacted the global economy and financial markets. Therefore, studying the impact of RMB real exchange rate fluctuations on the added value of China's GVC provides a useful reference for RMB internationalization to stabilize the global economy and financial market.

2. Literature Review

The relationship between the REER and the added value in GVCs has been an important research topic in international trade and economics. Many studies have shown that changes in exchange rates have an important impact on the position and contribution of companies in GVCs. For example, Gereffi and Freeman (2015) pointed out that REER has an important impact on a company's position and value in the GVC. Cushman and Zhan (2013) showed that exchange rate appreciation helps export companies improve their productivity and thus their position and added value in GVC. However, it was also found that exchange rate appreciation may lead to a decrease in the competitiveness of exporting companies, thereby reducing their position and contribution to GVCs (Baldwin and Yan, 2014). In addition, other factors such as technological innovation, human resources, and market development also have an impact on the position and contribution of companies in GVCs. In recent years, the impact of RMB exchange rate fluctuations on China's GVC status has attracted much attention. In the relevant literature, the impact of changes in the REER of RMB on China's exports, international industrial competitiveness, and position in the GVC was investigated. Zhou and Chen (2019) pointed out that exchange rate appreciation can increase domestic added value but the impact depends on the price elasticity of foreign demand. Tian *et al.* (2019) used the REER measurement method by industry in the GVC and found that the exchange rate is negatively correlated with exports but the export effective exchange rate index has advantages, which solves the problem of "RMB appreciation reduces China's exports". Zhang (2018) empirically studied the impact of asymmetric changes in the exchange rates of major currencies on the trade of major countries around the world and found that the appreciation of the US dollar and the depreciation of the yen have a positive incentive effect on China's trade, while the depreciation of the Euro has a negative inhibitory effect. The research result of Cheng and Cheng (2018) showed that the real exchange rate has a significant impact on the prices, volume, and added value of trade, and the correlation between exchange rate and trade is still large. In addition, exchange rate fluctuations contribute to an increase in the added value of export by adjusting productivity. Therefore, the appreciation of the RMB and the formation of the marketization of the RMB exchange rate do not mean the decline of the status and interests of export. At the same time, the productivity effect transmitted through the exchange rate can maintain China's trade competitiveness. Research by Ren *et al.* (2017) shows that RMB appreciation has a positive impact on the increase in the embedding of companies' GVCs, but the influence weakens after considering intermediary trade. The effect of RMB appreciation on the enhancement of the embedding degree of companies in the GVC varies according to the degree of embedding, enterprise ownership, productivity, and financing constraints. The improvement of product quality is conducive to the improvement of enterprise value chain embedding and has the positive effect of RMB appreciation on the improvement of enterprise value chain embedding degree with higher product quality.

In general, the REER influences the added value of the GVC, and its influencing factors involve monetary policy, international trade, industrial organization, and economic development. Therefore, an in-depth study and discussion of the relationship between the REER and the added value of the GVC are important in formulating effective policies and improving the status and contribution of companies in the GVC. For the research on the impact of RMB's REER on the GVC, from the perspective of research methods, previous studies used empirical analysis to quantitatively explore the relationship between the change of RMB's REER and the status of the GVC by econometric model. Among them, most of the literature adopts econometric models such as Vector autoregressive model (VAR) model and automatic relevance determination regression (ARRD) model, which have statistical significance and predictive ability. Several studies adopted the panel data model to provide richer and more detailed data analysis for the study of GVCs. The conclusion of the studies is relatively consistent, that is, the change of the REER of RMB has a significant impact on China's position and international competitiveness in the GVC. The appreciation of the RMB increases the price of export commodities and reduces the international competitiveness of China's export commodities, which weakens China's position in the GVC. At the same time, it is possible to promote China's industrial structure upgrading and technological progress by increasing China's import costs, thereby strengthening China's position in the GVC. From the perspective of the research contribution, the previous studies provided a more in-depth and comprehensive result on the impact of fluctuations of RMB's REER on the added value of China's GVC. They provide an empirical analysis of the impact of changes in RMB's REER on China's GVC status through innovative research methods and data selection, which provides a reference for subsequent research.

In summary, the previous research has objectivity in exploring the impact of fluctuations of RMB's REER on the added value of China's GVC. However, at the same time, it is necessary to further improve research methods, deepen data analysis, and provide more accurate and effective policy suggestions for China's status in the GVC to promote industrial transformation and upgrading. Therefore, it is necessary to select the REER and the added value of the GVC as the main analysis objects. In this study, using EViews software and regression analysis, the impact of the REER on the added value of the GVC is analyzed. The data is processed and analyzed to investigate the REER and the added value of the GVC. The data are obtained from BIS, IMF, UNCTADSTAT, the Ministry of Commerce of China, the China Customs website, and other public data websites. The research process is verified for the unity of theoretical analysis with empirical testing. The analysis results reflect economic theory and provide practical value for the adjustment of international economic policies of various economies.

3. Impact of REER of RMB on China's Added Value in GVC

3.1. Trend and Influencing Factors of REER of RMB

The trend of changes in the REER of RMB is determined by factors such as market supply and demand and policy regulation. Recently, the REER of the RMB has shown volatility, but the overall trend is still appreciating. The factors affecting the changes in the REER of RMB include domestic economic fundamentals, changes in the external environment, and policy regulation. Specifically, the impact of domestic economic fundamentals includes factors such as economic growth rate, inflation rate, interest rate level, and trade structure. Changes in the external environment change demand and supply in international markets, monetary policy in major economies, and geopolitical risks. In terms of policy regulation the monetary policy of the central bank, foreign exchange market intervention, and financial supervision are considered. In general, factors such as the continuous improvement of the overall strength of China's economy, the gradual improvement of the balance of payments, and the increasing openness of the financial market have a positive impact on the REER of the RMB, while factors such as the uncertainty of the external economic environment and the fluctuation of market demand may negatively impact on the REER of the RMB. In addition, the factors of policy regulation and control has an impact on the REER of the RMB, especially the implementation of measures such as the central bank's monetary policy and intervention in the foreign exchange market has a larger impact on the RMB exchange rate.

3.2. Factors Affecting Added Value of GVCs

The added value of GVC refers to the value that a country contributes to through its participation in the GVC. It is used to analyze the position of different industries in the GVC and the degree of internationalization of a country's economy (Borin and Mancini, 2019). The GVC has three mutually influencing and closely connected processes. The first process includes front-end R&D and design, product R&D and design, technology R&D, patent R&D, and technical guidance. The second process consists of the processing and production links, including raw material procurement, factory production, processing and assembly, quality control management and testing, and logistics transportation and management. Finally, the third process includes brand marketing and terminal after-sales, advertising and marketing before the release of products, intermediate wholesaler retail, and product final after-sales service. Each economic activity creates value, and the links are closely connected and mutually undertaken, forming a complete and orderly value chain. Each small link affects the added value of the value chain with high-tech, currency exchange

rates, raw material costs, labor prices, the development of freight methods, the innovation of marketing means and other factors. For example, when the REER of a country's currency rises, the cost of purchasing raw materials, that is, the cost of input products, decreases. At the same time, its price increases relatively and the competitiveness of product exports weakens. These cause the change of added value in the value chain but the specific increase or decrease depends on which factor is more significant. In addition, changes in the added value of GVC may also be affected by the global economic environment. For example, under the influence of the epidemic in 2019–2022, the production of many countries was paralyzed, the global economic environment was upturned, and the export of various countries decreased, which reduced the added value of their GVCs. However, during the epidemic, China's production recovered rapidly, and when countries were unable to produce medical supplies and daily necessities, China exported a large number of products, and the added value of the value chain increased. Therefore, it is important to consider the impact of various factors on the added value to GVCs.

3.3. Value of GVCs and Current Situation of China's Import and Export

Import and export are important links in the GVC because they involve the exchange of goods and services between different countries and regions. From the perspective of the added value of the GVC, trade has a significant impact on it. Specifically, import increases added value in value chains because it can provide more materials, components, and technologies, making products more value-added. On the other hand, export can also increase the added value of the value chain, because it can promote industrial upgrading and technological innovation, thereby making export products more high-end and higher added value (Li, 2022). Import-export can thus affect the added value of GVC by influencing REER. In practice, the impact of trade on the added value of GVC is also constrained by many factors. For example, factors such as the size of the domestic market, the level of technology, and human resources affect the quality and scale of imports, thereby affecting the increase in the added value of the GVC. In addition, the demand and competitive environment of export markets will also have an impact on the quality and scale of export, thereby affecting the increase in the added value of GVC. Therefore, to achieve the improvement of the added value of the GVC, it is necessary to continuously optimize the structure of trade, improve the quality and scale, and increase the added value of products through industrial upgrading and technological innovation to improve the added value level of the GVC.

Since the reform and opening up, China's trade pattern and industrial patterns have undergone considerable changes, and foreign trade has become one of the "troikas" driving China's economic growth, playing a vital role in the stable and sustained growth of China's economy. In recent years, the development of import has expanded China's consumer demand, while export has played an important role in optimizing resource allocation. Trade has a positive impact on promoting the rapid development of related industries, improving people's employment problems, and increasing fiscal taxation. As a developing country, China has used its demographic advantages to participate in the international division of labor in economic globalization and has emerged as a global processing plant in the decades of reform and opening up, and its huge population base has also made China destined to become a large importer.

As shown in Fig. 1, in 1995, China's export volume was 5,120.70 billion USD, and its imports were 5,184.32 million USD. After 27 years of economic development, China's trade exports in 2021 reached 21,139.88 million USD, and imports reached 22,348.85 million USD. From 1997 to 2007, it showed a moderate and then steep growth rate, which decreased in 2008 and showed a tortuous increase from 2008 to 2021, and the overall growth rate was smaller than that in 1997–2007. From 1995 to 2021, the export value increased by 17.02 billion USD, and the import value increased by 171.6452 trillion USD. Trade increased rapidly, the development tended to be in the same direction and almost synchronized. The overall export value is slightly lower than the import value, the import and export balance in 1995 was 0.6361 billion USD. The import and export balance in 2021 was 2.0896. The overall trade balance was relatively small, but the gap has gradually increased in the past 27 years, and the import value was greater than the export value.

The import turnover in this study refers to the total import volume of raw materials in several categories, the classification by the Standard international trade classification (SITC). Commodities consisting of SITC 0+1+2+3+4+68+667+971 represent unprocessed raw materials, where SITC 0 represents food and live animals, SITC 1 represents tobacco and beverage commodities, SITC 2 represents non-edible raw materials other than fuels, SITC 3 represents mineral fuels, lubricants, and related substances, SITC 4 represents unspecified chemicals and related products, SITC 68 represents non-ferrous metals, and SITC 667+971 represents pearls, precious gemstones, and non-monetary gold. The export volume refers to the total export volume of high-tech finished products in several categories, including SITC 5+6+7+8 commodities and high-tech finished products, of which SITC 5 represents chemical and related products, SITC 6 represents finished products classified by material, SITC 7 represents machinery and transportation equipment, and SITC 8 represents miscellaneous manufactured products.

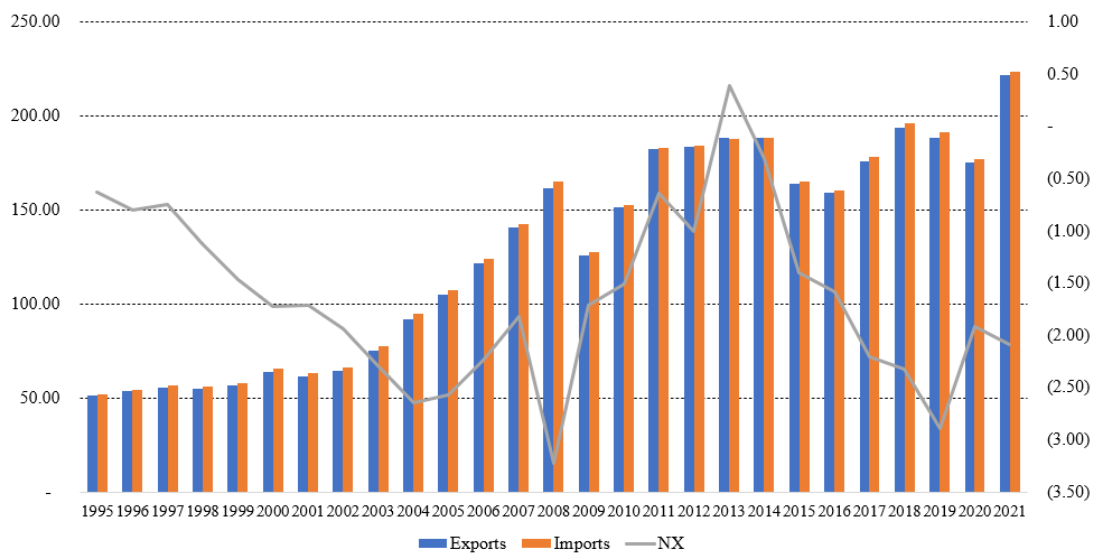


Fig. 1. Growth trend of China’s trade from 1995 to 2021 (unit: 100 billion USD). Source: China Customs.

As shown in Fig. 2, in 1995, China’s exports of finished products were 43,043.47 million USD, raw material imports were 27,334.04 million USD, and under the rapid development of China’s economy, China’s exports of manufactured goods reached 2,007,178.22 million USD in 2021, 41 times larger than that of 1995, and raw material imports reached 1,120,961.77 million USD, 42.67 times larger than that of 1995. The increase in the past 27 years has been large the same as the trade volume. The difference between the value of exports of produced goods and imports of raw materials was 19,709.42 million USD in 1995 and 886,216.45 million USD in 2021 with a significant increase between 1995 and 2021 and an increase of 866,507.02 million USD. In 2008, there was no significant decline in the export value of finished products and imports of raw materials, indicating that even under the influence of the global economic crisis in 2008, the added value of export was considerable and was not greatly affected. During the severe outbreak of the global epidemic in 2020–2021 when the manufacturing industry of many countries stagnated and daily necessities relied on imports, China’s foreign export volume was still increasing, and even the increase was greater than that in the previous two years, and the added value was higher. It means that China’s manufacturing export was relatively mature with an ability to resist risks, which reflected China’s advantages as a global processing plant in the economic environment.

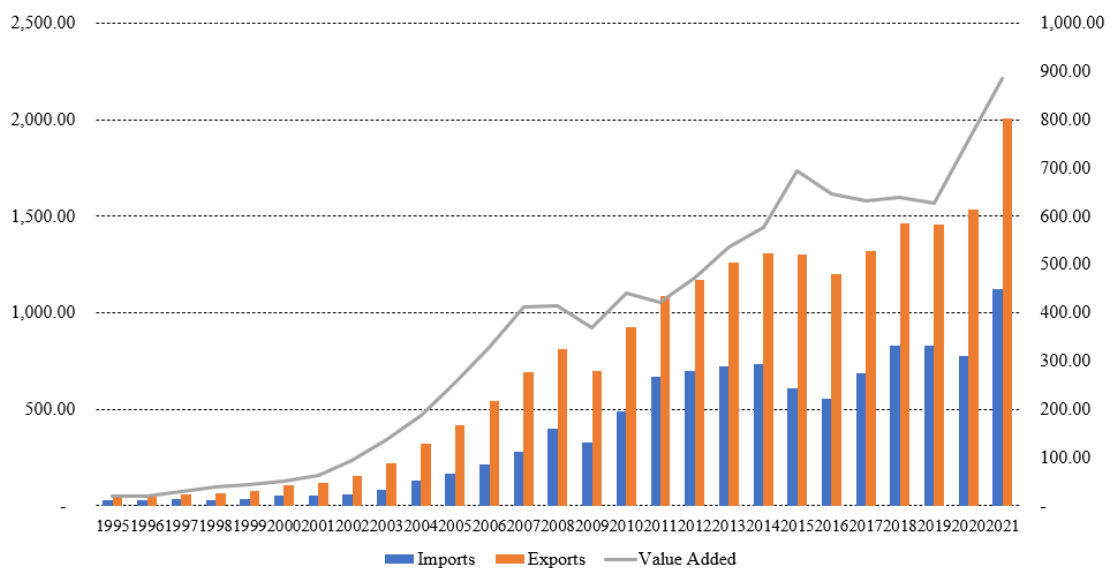


Fig. 2. China’s Raw Material Imports and Finished Product Exports, 1995–2021 (Unit: USD billion). Source: China Customs.

The trade volume of raw material imports and finished product exports showed an increase from 2008 to 2021 with the growth rate of raw material imports of up to 69% and that of exports of produced goods of 44%. The overall growth rate fluctuated, and the range of changes was similar to 2009. From 2010 to 2019, the growth rate slowed down and the total volume grew steadily. In 2021, it rose sharply during the epidemic period and the growth rate of finished product exports reached 31% (Fig. 3).



Fig. 3. Growth rate of China's raw material imports and exports of produced products from 1995 to 2021 (%). Source: China Customs.

China has long adhered to the strategy of “investment-oriented imports”, so the proportion of investment in production has been at a high level for a long time. From 1995 to 2003, the overall development of China's trade demand was slow, and trade was optimized by the function of resource allocation. After 2003, trade demand increased significantly. Export increased significantly owing to new companies and investment projects as the transformation and upgrading of China's industrial structure were promoted. With economic growth and the structural changes in the secondary industry, manufacturing products (especially medium and high-tech products) were replacing primary manufacturing products as the main products of China's exports. The increase in the number of manufacturing industries increased the overall added value of China and allocated resources more efficiently. Trade contributed to economic growth and the rapid development of the national economy and living standards. Tan (2014) pointed out that the purpose of trade in developing countries is not simply to enter the international division of labor for short-term static trade benefits but to use the “product-factor” transformation in the international market and achieve industrial development for long-term dynamic trade benefits in the sense of “development”. This “production-oriented” trade strategy for industrial development is of universal significance to developing countries.

REER is a weighted average of a country's currency to a basket of major trading partner currencies. The exchange rate obtained after removing the impact of inflation on the purchasing power of the currency reflects the external value and relative purchasing power of the currency comprehensively and objectively and the fluctuation of the national currency exchange rate. The exchange rate affects the country's trade and the added value of companies in the GVC. Many studies on the impact of exchange rate changes on international trade suggested that under the economic model assuming short-term ML, changes in a country's exchange rate significantly affect the country's trade volume and have a moderating effect on a country's GDP. Lu and Dai (2005) used the macro data from 1994 to 2003 and the VAR method to analyze the impact of RMB exchange rate changes on China's trade and concluded that changes in the REER of RMB significantly affect trade volume. Chen et al. (2007) explored the equilibrium relationship between exchange rate changes and the balance of payments through cointegration analysis and found that RMB appreciation balanced payments of countries through international trade. Exchange rate fluctuations affect capital flows and production distribution among transnational cooperations (TNCs) in GVCs and the added value of GVCs. Johnson and Noguera (2012) showed that the impact of exchange rate fluctuations on GVCs mainly comes from the pricing and production decisions of TNCs, which in turn affect companies' trade and trade relations in GVCs. However, changes in the REER have different effects on the positioning and added value of countries in different parts of GVCs. For example, Baldwin and Yan (2014) found that for export-intensive economies,

currency depreciation improves the export competitiveness of their products and increases their share and added value in GVCs. For import-intensive economies, however, currency depreciation may lead to higher production costs and reduce their competitiveness and added value in GVCs. In addition, changes in the REER may affect the international division of labor and the mode of production and trade in GVCs. For example, Di Giovanni et al. (2014) stated that exchange rate changes promote the offshoring and repositioning of certain industries and affect production and trade patterns in GVCs.

Foreign direct investment (FDI) refers to direct investment activities carried out by multinational companies in a country by establishing subsidiaries, acquiring shares, and investing in joint ventures. In the GVC, FDI is an important mechanism to promote economic growth and trade and has a close relationship with GVC. On the one hand, FDI can optimize the resource allocation of companies on a global scale so that companies can participate in all links of the GVC more effectively and improve the added value in their industrial chain. It promotes the cross-border flow of technology and management experience and technological innovation to improve production efficiency. It also provides companies with a broader market and more resources, enhances competitiveness, and improves the status and contribution to the GVC. On the other hand, GVC attracts FDI inflows because the various links in GVC require cooperation and coordination between multinational companies. Multinational companies promote internationalization and globalization by establishing production bases in different countries to reduce production costs and expand markets. In general, FDI and GVC are mutually reinforcing and interdependent. FDI promotes the allocation and optimization of resources on a global scale and improves the status and contribution of companies in the GVC. GVC, on the other hand, provides a broader market and more resources for FDI and attracts the inflow of multinational companies.

The impact of GDP on the added value of GVCs is discussed from the following aspects. First, GDP has a significant impact on the size and complexity of GVCs. The higher a country's GDP, the more important its role in GVCs becomes. At the same time, countries with high GDP have more resources and technology, providing more high-value-added products and services and occupying higher positions in the GVC. For example, developed countries such as the United States and Germany play important roles in the GVC owing to advanced technology and high-quality products. Second, GDP has an impact on the division of labor and partnerships in the GVC. In the GVC, the division of labor and cooperation between countries and regions are needed to form a complete production chain, and the level of GDP affects the division and cooperation of labor in the economy. China plays an important role in the GVC because it has a clear competitive edge in manufacturing, while China's high GDP indicates that it has a large labor force and resources to provide more manufacturing services to other countries and regions in the GVC. Finally, GDP affects productivity and technology levels in GVCs. Countries with high GDP tend to have more advanced technologies and higher production efficiency and produce higher quality products at higher positions in the GVC. For example, Japan plays an important role in the GVC because it has a high level of technology in automobile manufacturing, while Japan's high GDP also indicates that it has a high level of technological innovation and production efficiency.

Prices are an important factor affecting the added value of GVCs. First of all, prices affect production costs which is one of the important factors affecting the added value of GVCs. High prices increase production costs and reduce corporates' profit margins and the added value of GVCs. Secondly, price affects market competitiveness. Low prices improve the market competitiveness of products, increase sales volume and profit margin, and improve the added value of the GVC of companies. Finally, price affects international trade. High prices increase the cost of exported products and reduce their competitiveness and the volume of exports and the added value of GVCs. To sum up, high prices reduce the profit margin of companies and the added value of GVCs, while low prices will help improve the market competitiveness of products and the added value of GVCs.

4. Empirical Analysis of the Impact of RMB's REER on China's GVC

4.1. Construction of Value-added Model and Data Source of China's GVC

In this study, the impact of REER on the added value of China's GVC is explored. Based on the availability, the data of the year 1995 to 2021 are selected from the official websites of UNCTADSTAT, BIS, China Customs, and other public websites. The added value in GVC is used as the explanatory variable (DXM) along with the difference between the export value of high-value-added products and the import value of raw materials, the REER of RMB is selected as the main explanatory variable. The control variables are FDI, GDP, and consumer price index (CPI). The four relevant variables are shown in Table 1. REER is expected to have a positive or negative impact on DXM, FDI, and GDP, while CPI is expected to have a negative impact on DXM.

Table 1. Model of explanatory variables.

Variable	Representative Index	Expected Sign	Economic Meaning
REER	The REER of RMB	+/-	Refers to the weighted average of RMB relative to the currencies of its major trading partners, that is, exchange rate indicators that take into account exchange rate fluctuations and the relative importance of trading partners.
FDI	Foreign direct investment	+	Refers to the direct investment activities carried out by multinational companies in a country by establishing subsidiaries, acquiring shares, investing in joint ventures, <i>etc.</i> in that country.
GDP	Gross domestic product	+	The higher the gross domestic product, the higher the level of a country's economy, which will affect the division of labor and cooperation between countries and regions and the production efficiency and technology level in the GVC.
CPI	Consumer price index	-	High prices will reduce the profit margin of companies and the added value of GVCs, while low prices will help improve the market competitiveness of products and the added value of GVCs.

The descriptive statistics for the relevant variables in the model are shown in Table 2. The value of each variable is controlled in the close two-digit to four-digit range by adjusting the unit of DXM, FDI, and GDP in billion USD. Table 3 presents the correlation analysis among these variables where the correlation coefficients among them are relatively high and the *p* value is significantly less than 0.05, indicating that the correlation among these variables are very strong.

Table 2. Descriptive statistics on the added value of China's GVC. Source: UNCTADSTAT.

Variable	REER	GDP	FDI	DXM	CPI
Mean	82.5630	620.8255	93.4597	362.8754	98.6064
Median	78.3000	459.4342	94.0650	412.1767	96.8055
Maximum	103.9000	1,729.86	180.9570	886.2165	129.1074
Minimum	62.0000	73.4485	37.5205	19.7094	74.0285
Std. Dev.	12.8115	529.7518	43.1179	266.6364	17.6058
Observations	27	27	27	27	27

Table 3. Correlation analysis on the added value of China's GVC.

	REER	GDP	FDI	DXM	CPI
REER	1.0000				
GDP	0.9324	1.0000			
t-Statistic	12.8982	-			
<i>p</i> -value	0.0000	-			
FDI	0.8784	0.9624	1.0000		
	9.1909	17.7232	-		
	0.0000	0.0000	-		
DXM	0.8702	0.9554	0.9834	1.0000	
	8.8314	16.1776	27.0869	-	
	0.0000	0.0000	0.0000	-	
CPI	0.9320	0.9909	0.9761	0.9678	1.0000
	12.8612	36.7091	22.4702	19.2133	-
	0.0000	0.0000	0.0000	0.0000	-

4.2. Process and Outcome Analysis

4.2.1. Unit Root Tests

The unit root test is used to assess whether a time series variable follows a unit root process. A unit root refers to a situation where a variable is non-stationary and exhibits a stochastic trend, meaning its mean and variance change over time. Many statistical models such as autoregressive integrated moving average (ARIMA) models assume stationarity of the variables involved. Stationarity implies that the statistical properties of a variable remain constant over time, including its mean, variance, and autocovariance structure. Unit root tests are used to determine whether a variable is stationary or non-stationary. If a variable is non-stationary, it needs to be transformed or differenced to achieve stationarity before applying certain models or statistical analyses. Table 4 shows the result of the unit root test.

Table 4. Results of the stationary test for each variable*.

Variable	Type of Test (C, T, K)	ADF Test Statistic	5% Critical Value	p-value**	Stability
DXM	(C, T, 3)	-4.2419	-3.6220	0.0144	Stable
REER	(0, 0, 0)	2.0477	-1.9544	0.9879	Not stable
FDI	(C, T, 0)	-2.3603	-3.5950	0.3898	Not stable
GDP	(0, 0, 3)	0.7759	-1.9564	0.8741	Not stable
CPI	(0, 0, 0)	5.7488	-1.9544	1.0000	Not stable
D(REER)	(0, 0, 0)	-3.5374	-1.9550	0.0011	Stable
D(FDI)	(C, 0, 0)	-5.0700	-2.9862	0.0004	Stable
D(GDP)	(0, 0, 2)	1.0997	-1.9564	0.9241	Not stable
D(CPI)	(0, 0, 2)	-0.7840	-1.9564	0.3654	Not stable
DD(GDP)	(0, 0, 1)	-8.5095	-1.9564	0.0000	Stable
DD(CPI)	(0, 0, 1)	-7.3621	-1.9564	0.0000	Stable

* The test type (C, T, K) indicates that the test equation contains constant terms, trend terms, and lagging orders, respectively.

D represents first-order differences and DD represents second-order differences.

** MacKinnon one-side p-value.

The absolute value of the ADF value of DXM is less than the critical value of a 5% significance level so the null hypothesis that the original sequence has one unit root is rejected, that is, this variable is stationary. The absolute values of ADF values of REER, FDI, GDP, and CPI are all less than the critical values at the significance level of 5%, so the null hypothesis that the original sequence has one unit root cannot be rejected, that is, the above variables are not stationary. However, with the first-order difference, REER and FDI become stationary sequences. That is, the first-order differences of each variable are first-order monolithic sequences at a significant level of 5%, and GDP and CPI are still unstable. With the second-order difference, the GDP and CPI squares become stationary sequences, that is, the second-order differences of the above two variables are second-order sequences at a significant level of 5%.

4.2.2. Cointegration Analysis

Cointegration analysis is a time series analysis method and is used to study long-term relationships between two or more nonstationary time series. The cointegration test determines whether a linear combination of a set of nonstationary sequences has a stable equilibrium relationship. A special case of pseudoregression is found when the trend component of two time series is the same. This common trend correction regression makes the regression reliable. In the real economy, time series are usually non-stationary (data needs to be checked for stationarity, including a unit root test and ADF test). To make the analysis stable and differential, the long-term information on the total amount necessary for analyzing the problem may be lost so cointegration is used to solve this problem (Xung et al., 2016). The results of the cointegration analysis of each variable of China's value-added GVC model are shown in Table 5.

Table 5. Johansen cointegration test results.

Null hypothesis	Eigenvalue	Trace Statistic	5% Critical Value	p-value**
None*	0.7986	89.5189	69.8189	0.0006
At most 1*	0.6736	49.4513	47.8561	0.0351
At most 2	0.3516	21.4635	29.7971	0.3294

* Rejection of the null hypothesis at the 5% critical value. ** MacKinnon-Haug-Michelis p-values.

The null hypothesis of no cointegration relationship between the explanatory variables and the interpreted variable is rejected according to the result. In the test of eigenvalues and trace statistics, the trace statistic of the first stage is 89.5189, which is greater than 5% of the critical value of 69.8189, thus rejecting the null hypothesis. In the second stage, the trace statistic is 49.4513, which is greater than 5% of the cut-off value of 47.8561, which also rejects the null hypothesis. Finally, the trace statistic in the third stage is 21.4635, which is less than 5% of the critical value of 29.7971, so it is impossible to reject the null hypothesis that “there are at most 2 cointegration equations”. Therefore, there is a long-term stable relationship between the explanatory variable and the interpreted variable, that is, there is a cointegration relationship.

4.2.3. Granger’s Causality Test

Granger’s causality test is a causality test to determine whether a causal relationship exists between a set of variables. The results of the cointegration test show that there is a long-term equilibrium relationship between DXM and REER, FDI, GDP, and CPI. To further verify whether there is a causal relationship between the variables, the Granger’s causality test is required. A Granger’s causality test model is established by using the REER and DXM as independent and dependent variables. Then, the unit root test is performed on the dependent and independent variables to determine whether they are stable. Then, by calculating the F value of the regression equation of the independent variable, it is judged whether the independent variable has a significant predictive ability for the dependent variable. Finally, according to the results of Granger’s causality test, it is required to determine whether the REER has a significant impact on the DXM and explain the reasons. Table 6 shows Granger’s cause of FDI and CPI and that of REER on GDP and CPI. The REER of RMB does not have a Granger causal relationship with the added value of China’s GVC, and the added value of GVC does not have a Granger causal relationship with the REER of RMB.

Table 6. Granger’s causality test results.

Null hypothesis	F-statistics	p-value	Conclusion
REER does not Granger Cause DXM	0.6533	0.5311	Cannot reject
DXM does not Granger Cause REER	2.3934	0.1170	Cannot reject
GDP does not Granger Cause DXM	1.3628	0.2787	Cannot reject
DXM does not Granger Cause GDP	2.2362	0.1329	Cannot reject
FDI does not Granger Cause DXM	2.2580	0.1306	Cannot reject
DXM does not Granger Cause FDI	4.8450	0.0192	Reject
CPI does not Granger Cause DXM	1.2001	0.3220	Cannot reject
DXM does not Granger Cause CPI	3.5130	0.0493	Reject
GDP does not Granger Cause REER	5.4863	0.0126	Reject
REER does not Granger Cause GDP	1.8771	0.1790	Cannot reject
FDI does not Granger Cause REER	3.2486	0.0600	Cannot reject
REER does not Granger Cause FDI	0.9280	0.4117	Cannot reject
CPI does not Granger Cause REER	6.7010	0.0059	Reject
REER does not Granger Cause CPI	3.3919	0.0539	Cannot reject
FDI does not Granger Cause GDP	1.8680	0.1804	Cannot reject
GDP does not Granger Cause FDI	0.4095	0.6694	Cannot reject
CPI does not Granger Cause GDP	3.1178	0.0663	Cannot reject
GDP does not Granger Cause CPI	1.3177	0.2900	Cannot reject
CPI does not Granger Cause FDI	0.2199	0.8046	Cannot reject
FDI does not Granger Cause CPI	3.2648	0.0593	Cannot reject

4.2.4. VAR Model

The vector autoregressive model (VAR) is a multivariate time series analysis method based on the statistical properties of the data to establish a model with each endogenous variable in the system as a function of the lag value of all endogenous variables. The model generalizes the univariate autoregressive model to the “vector” autoregressive model composed of multiple time series variables. In the time series model, if the model setting and identification are inaccurate, the model cannot accurately reflect the dynamic characteristics of the economic system, nor can it be used for dynamic simulation and policy analysis. Therefore, VAR models usually use minimal economic theoretical assumptions with the statistical characteristics of time series as a starting point and perform impulse-response analysis of economic systems to understand the dynamic characteristics and shock transmission mechanisms of economic systems (Zhang et al., 2010). In this study, variables of China’s GVC model are used in the vector autoregressive model. The AR model is essentially an n -th order difference equation, and the solution of the difference equation is the series, and when the series converges, the time series is stationary and the model is stable. By understanding the structure of the solution of the difference equation, a differential equation is a convergent solution only if the root of the characteristic equation is within the unit circle. As shown in Fig. 4, most of the reciprocals of all root modules of the vector autoregressive model in this study are less than 1 in the unit circle, showing that this model is stable.

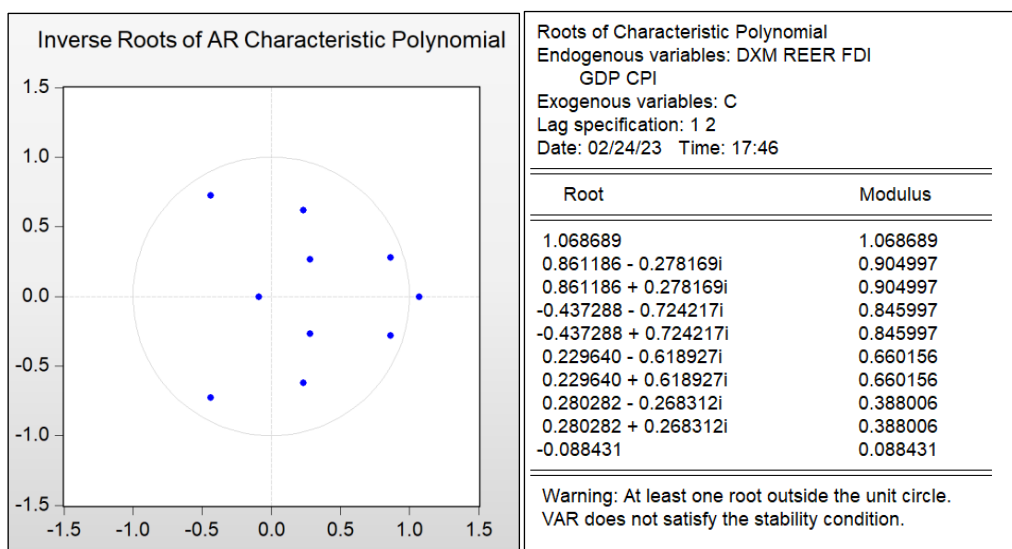


Fig. 4. Inverse roots of AR Characteristic Polynomial of China’s GVC model.

4.2.5. Regression Model

The multiple regression model is used for test analysis and is constructed as follows:

$$DXM = \beta_0 + \beta_1 REER + \beta_2 FDI + \beta_3 GDP + \beta_4 CPI + \varepsilon \quad (1)$$

where DXM represents the added value of the GVC, REER represents the REER of RMB, FDI, and GDP, and CPI represents a foreign direct investment, gross domestic product, and consumer price index, respectively. , β_0 and β_i ($i = 1, 2, 3, 4$) are constant as a regression coefficient, and ε is the error term.

Fig. 5 presents that the trend of REER and DXM before 2008 is different from that after 2008. Taking 2008 as the dividing line, the correlation between REER and DXM before 2008 becomes uncertain. The trend after 2008 is relatively similar to that in previous years. REER has a significant positive effect on DXM as shown in the scatter plot in Fig. 6. Assuming that 2008 is a breakpoint, the Chow test is introduced to test the data, and the results show that the F statistic is 14.0498 and the Probability of F(5,17) is 0.0000, which is lower than the significant level of 0.01. The Chow test results indicate that 2008 is a time node.

Equation (2) is a new model that considers variables.

$$DXM = \beta_0 + \beta_1 DUM + \beta_2 REER + \beta_3 DUM * REER + \beta_4 FDI + \beta_5 GDP + \beta_6 CPI + \varepsilon \quad (2)$$

The model introduces the dummy variable DUM, and the setting of DUM is set in 2008 where 0 in 1995–2008 and 1 in 2009–2021, indicating that the regression is carried out before 2008 and after 2009, respectively. The regression results are shown in Table 7, the R^2 and \bar{R}^2 of the original model are 0.9687 and 0.9630, respectively, indicating that the regression results of the

original model are quite well-matched. The Durbin-Watson value implies the possibility of autocorrelation between random error terms.

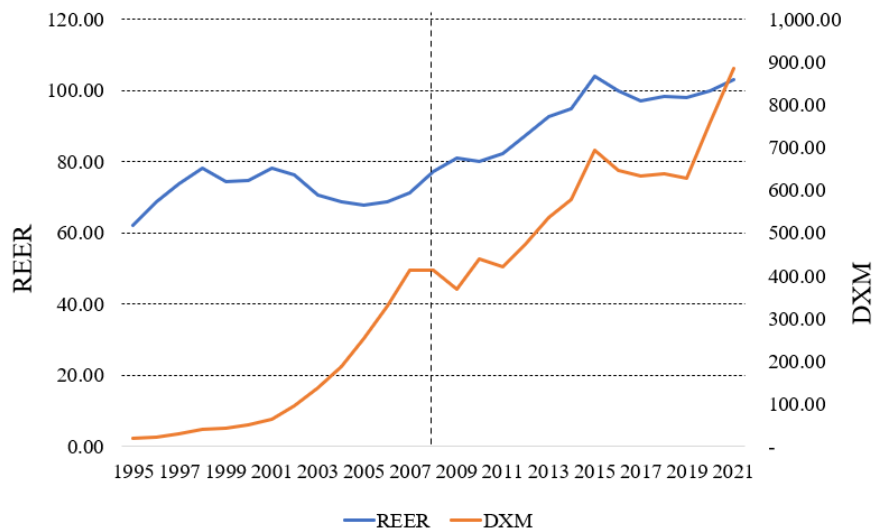


Fig. 5. Line chart of REER and DXM.

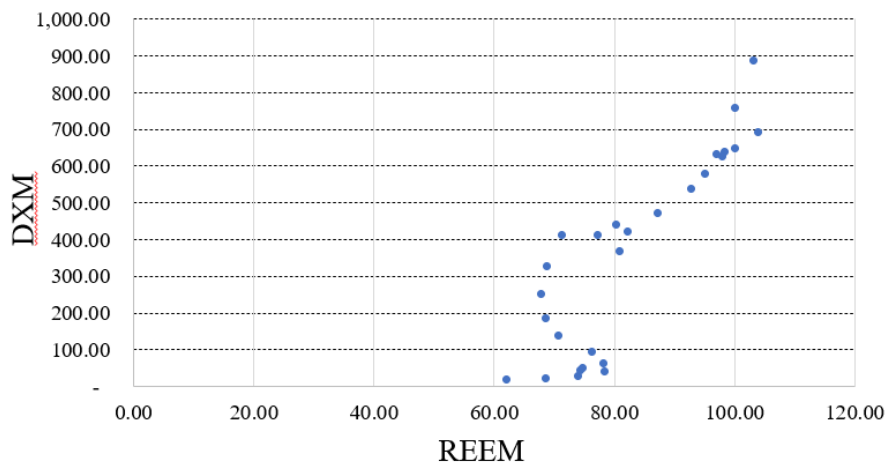


Fig. 6. Scatter diagram of REER and DXM.

The regression results of the original model show that the effect of REER on DXM is negative, that is, every 1 unit increase in REER increases 1.1834 units of DXM, and the effects of other control variables FDI, GDP, and CPI on DXM are positive. When the data are regressed after adding DUM, the regression model with structural breakpoints becomes superior to the initial model considering the intercept and slope. Every 1 unit increase in REER causes DXM of -5.2824 units before 2008 and a positive impact on DXM of 6.797 (= 12.0794 - 5.2824) units after 2009. This result is consistent with the previous assumptions, showing that 2008 is a structural breakpoint, and the increase in REER before 2008 is not conducive to improving DXM. After a financial crisis in 2009, the global economy underwent tremendous changes. China's trade developed against the trend in the crisis and revitalized imports and exports. The changes in the exchange rate decrease the import cost of raw materials in China's manufacturing industry and present a strong competitive advantage in the economic crisis. The rise of China's REER increases the added value of the GVC after 2009.

Table 7. Multiple regression model results considering a structural break.

Variable	Initial Model	Model with Structural Break		
		Intercept	Slope	Intercept and Slope
C (t-statistics)	-323.27 (-0.8254)	-493.05 (-1.2913)	-469.51 (-1.1923)	-356.29 (-1.1413)
DUM		-81.8910 (-1.8766)		-1010.02 (-3.4741)**
REER	-1.1834 (-0.4969)	0.0447 (0.0190)	0.1882 (0.0754)	-5.2824 (-2.0628)*
DUM*REER			-0.8609 (-1.4863)	12.0794 (3.2176)**
FDI	4.8677 (4.1377)**	5.4622 (4.7150)**	5.2977 (4.4844)**	6.1670 (6.2408)**
GDP	0.0207 (0.1440)	-0.0080 (-0.0587)	0.0162 (0.1158)	-0.2708 (-1.9318)
CPI	3.2053 (0.5841)	3.9162 (0.7149)	3.5547 (0.6323)	7.0704 (1.5171)
R ²	0.9687	0.9732	0.9717	0.9823
Adjusted R ²	0.9630	0.9668	0.9650	0.9771
Durbin-Watson stat	1.0755	1.6627	1.5180	1.8245

* Represent reject the null hypothesis at the 0.05 level; ** Represent reject the null hypothesis at the 0.01 level.

4.2.6. Impulse Response Analysis

Impulse response analysis is conducted to understand the impact of changes in variables. The dynamic reaction time and duration of the interpreted variables are analyzed with the standard deviation from the random error term. When studying the short-term and long-term effects of the RMB's REER on the added value of China's GVC, the impulse response function shows the dynamic reflection trajectory changes formed when China's added value of GVC (DXM) is impacted by the four variables of REER, FDI, GDP, and CPI. Fig. 8 shows that REER has a negative impact on DXM in the first 10 periods, and its impact gradually increases and then decreases.

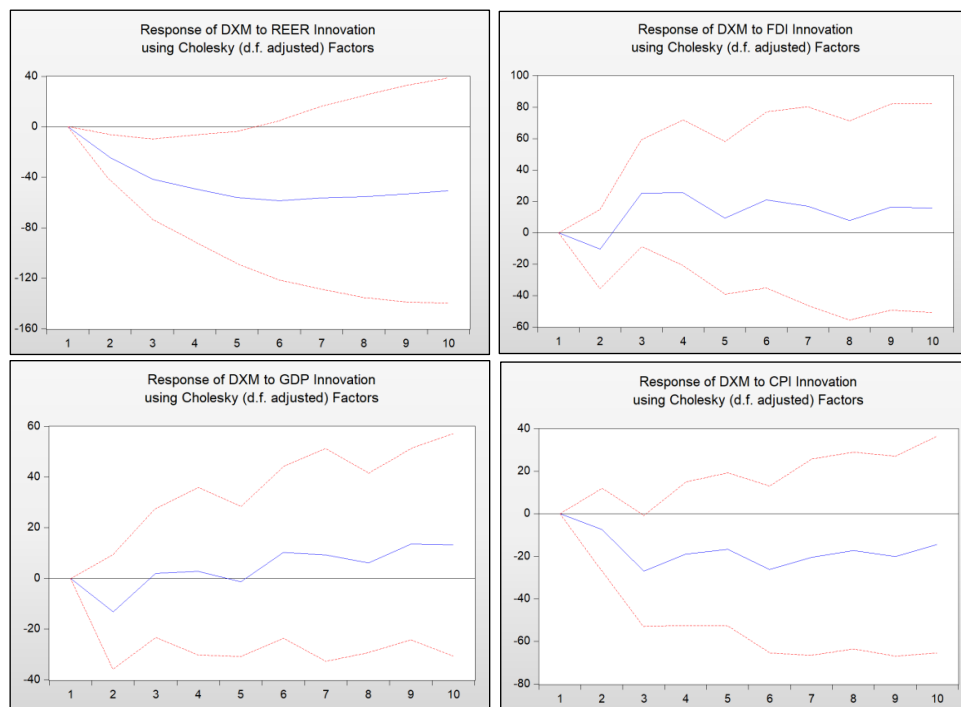


Fig. 8. Response of DXM to the innovation of REER, FDI, GDP, and CPI using Cholesky factors.

FDI has a negative impact on DXM in the first two periods, and after the third period, it has a positive effect and is stabilized as a long-term impact after the 10th period. GDP shows a negative impact on DXM in the first two periods with a steady growth trend. CPI presents a similar trend of REER on DXM and has a stable and long-term effect beyond 10 periods converging to the timeline. The analysis result shows that the added value of China's GVC is gradually adjusted through the REER, FDI, GDP, and

CPI. Generally, REER has significant impacts on China's GVC, contingent on the external impacts. In China's rapid economic recovery and foreign trade development, the appreciation of the REER of RMB increases the added value of the GVC, which is conducive to increasing the added value of export and strengthening the advantages of China's foreign trade. At the same time, during the economic recession caused by the global epidemic in 2019–2022, China's export volume of high-tech products showed a growth rate of 30.83% (Fig. 3) compared with -17.08% in 2008. China's exported products have high competitiveness and a strong ability to resist risks, and China has gradually transformed from a manufacturing country to a manufacturing power.

5. Discussion and Conclusions

The result of this study implies that the REER of RMB is positively correlated with the added value of China's value chain. With the world's second-largest economy, China's exchange rate policy has a profound impact on the global economy. Changes in the exchange rate of RMB have a huge impact on the stability and development of China's economy and the global economy. As a result, China has influenced the RMB's REER on the added value of GVC at all levels. From an economic point of view, changes in the exchange rate of the RMB impact China's industrial structure and value chain. If the RMB appreciates, the price of export goods rises, which in turn reduces the competitiveness of Chinese products in the global market. However, it pressures China's export and manufacturing industries. Conversely, if the RMB depreciates, export commodity prices become more competitive to boost export growth and trade surpluses and improve China's competitiveness. Therefore, China needs to maintain moderate exchange rate fluctuations to stabilize the RMB exchange rate with monetary policy and market intervention for the development of China's economy. Over the past few years, the appreciation of the RMB has put a lot of pressure on China's export and manufacturing industries, so the government has taken a series of measures to stabilize the exchange rate. By strengthening the supervision and management of the foreign exchange market, speculation is prevented. The stability of the RMB exchange rate improves China's competitiveness in the international market and promotes the growth of China's export and trade surplus and the added value of China's value chain.

Currency exchange rate fluctuations need to be optimized for trade and the value-added capacity of the industry. When the RMB appreciates, the price of exporting products rises, causing exports to decrease. Therefore, the government must strengthen trade cooperation with developing countries, reduce dependency on developed country markets, and diversify foreign trade to reduce sensitivity to changes in the RMB exchange rate. On the other hand, the depreciation of the RMB raises the cost of China's imports, increases domestic production, and improves the competitiveness and efficiency of domestic production. At the same time, through the further development of high-tech industries, the position in the GVC is strengthened increasing added value and technological content, and product competitiveness. China's position in the GVC is expected to increase by promoting scientific and technological innovation and developing high-end manufacturing, which increases the added value and technological content of products. At the same time, it is necessary to strengthen economic cooperation with developing countries, expand export markets, reduce dependence on the markets of developed countries, and diversify foreign trade. This reduces sensitivity to changes in the RMB exchange rate. In addition, it is critical to promote financial market reform, strengthen the status of the RMB in the international monetary system, improve the international recognition and utilization rate of RMB, and promote the stability and internationalization of the RMB exchange rate are also very important means.

At present, with the rapid development of China's economy and the acceleration of RMB internationalization, the appreciation of the RMB exchange rate becomes obvious. With a negative impact on Chinese exporters, it has also a positive impact on GVC embedding. The appreciation of the RMB can promote China's imports, especially high-end technology products and the development of China's high-tech industries, which improves the level of China's industrial value chain and increases China's position in the GVC. Therefore, it is important to accelerate the development of high-tech industries. Second, China needs to optimize the status quo of trade through North-South cooperation and South-South cooperation. Through economic cooperation with developing countries, China can expand its export markets, reduce its dependence on developed country markets, diversify its foreign trade, and finally reduces its sensitivity to changes in the RMB exchange rate. At the same time, strengthening economic cooperation with developing countries promotes the global extension of the industrial value chain of Chinese companies and improves the international competitiveness of Chinese companies. Finally, China needs to adapt to the expected appreciation of the RMB by restructuring its industrial value chain. The challenge for China's manufacturing and export industries is the price competitiveness of Chinese exports in the global market due to rising costs. Therefore, China must restructure the industrial value chain and improve the added value of its products to improve product competitiveness.

In summary, the positive impact of the RMB's REER on the value-added of China's GVC is exploited in this study. Accompanied by a series of measures conducive to economic development, measures such as promoting the internationalization of the RMB and stabilizing the exchange rate must be taken to maintain a reasonable level of the RMB exchange rate at the national policy level. At the economic and trade level, the scale of foreign trade markets needs to be expanded through multilateral and

bilateral trade cooperation, and the added value of export products must be increased. At the level of restructuring the industrial chain, the development of high-end manufacturing needs to be strengthened, and product quality and technical content must be improved to increase added value and upgrade the GVC. It is necessary to be aware that the appreciation of the RMB exchange rate may also bring negative effects such as the decline in the profit margin of export companies and the reduction of jobs. Therefore, it is necessary to accelerate industrial transformation and optimize and upgrade the economic structure to achieve more stable and sustainable economic growth while securing the internationalization of RMB and exchange rate stability.

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