

# Research on Sino-US Trade Based on GM(1,1) Model and AHP Method

Yijia Dai<sup>1,\*</sup>, Kengcheng Zheng<sup>2</sup>

*1 School of Economics and Management, Shanghai University of Political Science and Law, Shanghai 201701, China*

*2 School of business, Guilin University of Electronic Technology, Guilin 541004 China*

*\*Corresponding Author*

**ABSTRACT.** *China and the United States are two major economies in the world. The trade relations between the two countries have been in a changing form. In recent years, the Sino-US trade war has become more and more intense, which is not conducive to the peaceful and stable development of the two countries' economy and the world. In order to better study the development and changes of Sino-US trade relations, By building GM(1,1) model and AHP analysis method, this paper collects relevant data from 1999 to now, and draws the conclusion that 2007 is an important year of Sino-US trade relations. The increase of tariffs by the United States on Chinese commodities has a great impact on China's development. The tariff commodities are mainly light industrial products such as mechanical and electrical products, furniture and so on. According to the actual situation, we put forward some suggestions to promote the development of Sino-US relations.*

**KEYWORDS:** *Sino-US trade development; GM (1,1) model; AHP;*

## 1. Introduction

In recent years, with the adjustment of the global industrial structure and industrial division of labor, the low-end manufacturing industry has continued to shift to developing countries, resulting in the basic abandonment of manufacturing in the United States, mainly relying on technological innovation, service industries, traditional agriculture, established financial industries and industry of oil and gas and so on, while the US savings are extremely low [1], resulting in a situation of China's huge trade surplus with the United States. In 2017, China's trade surplus with the United States was 1.87 trillion, and Professor Ren Song of Renmin University of China believes that China The great trade surplus with the United States has led to the beginning of a trade war.

Miao Changqing (2018) mentioned that "China-US trade issue" mentioned that since China's accession to the WTO, the imbalance of Sino-US trade has been expanding, which has made the US economic powers dissatisfied. Therefore, the

United States restricts China's imports in various fields. The export of high-tech products is strictly regulated. In addition, China's export products have low technological content and small differences. The United States does not want to give up its vested interests, so it has frequently adopted protectionist measures against Chinese exports.

This paper analyzes the evolution of "China-US trade" from the data by collecting "China's total export data exported to the United States", "China's exports of various commodities in China" and "China's total export data". The GM (1,1) model and the AHP analysis method were studied.

## 2. Research and analysis

### 2.1 Exploration of Sino-US Trade Relations

By studying the trade volume data of China's exports to the United States in 1999-2017 and the total export volume data of China, the proportion of the total amount of goods exported to the United States between 1999 and 2017 is calculated, and the following figure is obtained:

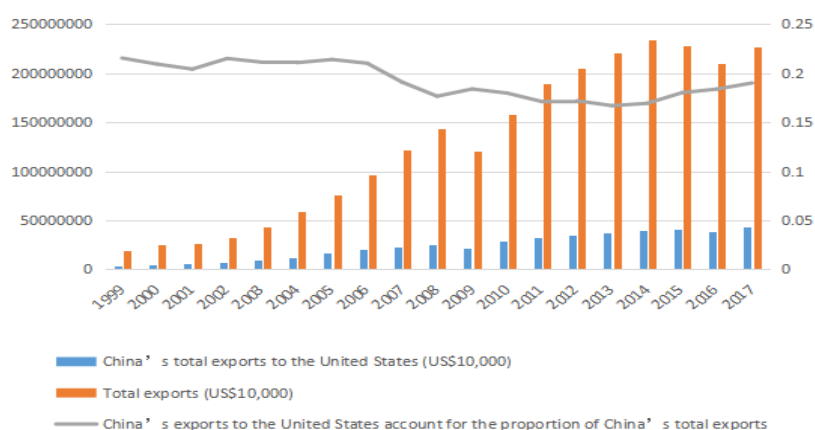


Figure.1 Trend chart of China's exports to the United States

Through the ratio of the total US merchandise exports to China to the total exports of China, it can be seen that since 1999, the ratio has been floating around 20%, as also shown in the figure, before 2006 (including 2006). The total amount of goods exported to the United States is more than 20%. Since 2007, the proportion has started to fall, and in recent years, it had not exceeded 20%. The proportion of China's exports to the United States is affected by the trade relationship between China and the United States. Therefore, in 2007, there may be a turning point in Sino-US trade relations. As Trump came to power, he will impose tariff sanctions on goods in China, which will increase the price of Chinese goods in the US market and

China's exports to the United States. The total value of goods will fall further.

In order to further study whether the Sino-US trade relationship in 2007 had an important impact on the economy, the GM (1,1) model is used to conduct relevant data prediction analysis.

## 2.2 GM (1,1) model construction and analysis

Using the GM (1,1) model to study the numerical changes in China's total exports to the United States under adverse development conditions, and to study the normal development of Sino-US relations based on data from 1999 to 2006. Next, the value of China's exports to the United States.

First, establish a time series of data on China's exports to the United States from 1999 to 2006:

$$x^{(0)} = (x^{(0)}(1), x^{(0)}(2), \dots, x^{(0)}(8))$$

Construct a GM (1,1) model:

(1) Adding the original data once:

$$x^{(1)} = [4194691, 9404613, 14832882, 21827461, 31074138, 43568341, 59857416, 80202258]$$

(2) Construct data matrix B and data vector Y:

$$B = \begin{bmatrix} -\frac{1}{2}(x^{(1)}(1)+x^{(1)}(2)) & 1 \\ -\frac{1}{2}(x^{(1)}(2)+x^{(1)}(3)) & 1 \\ \vdots & \vdots \\ -\frac{1}{2}(x^{(1)}(7)+x^{(1)}(8)) & 1 \end{bmatrix}, Y = \begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(8) \end{bmatrix}$$

(3) calculate:

$$\hat{u} = \begin{bmatrix} \hat{a} \\ \hat{b} \end{bmatrix} = (B^T B)^{-1} B^T Y = \begin{bmatrix} -0.2535 \\ 2.7914 \times 10^6 \end{bmatrix}$$

(4) Construct a model:

$$\frac{dx^{(1)}}{dt} + \hat{a}x^{(1)} = \hat{b}$$

Solve the equation:

$$x^{(1)}(k+1) = (x^{(0)}(1) - \frac{\hat{b}}{\hat{a}})e^{-\hat{a}k} + \frac{\hat{b}}{\hat{a}}$$

(5) Model prediction:

Solve sequence prediction values  $y^{(1)}(k+1)$  and model reduction values  $y^{(0)}(k+1)$ ,

Get the forecast of each year's data:

Table 1 Predicted result

No.	Year	Original value	Predicted value
1	1990	4194691	4194691
2	2000	5209922	4387300
3	2001	5428269	5653000
4	2002	6994579	7284000
5	2003	9246677	9385600
6	2004	12494203	12093000
7	2005	16289075	15583000
8	2006	20344842	20078000
9	2007	23267655	25871000
10	2008	25238355	33335000

Program with MATLAB:

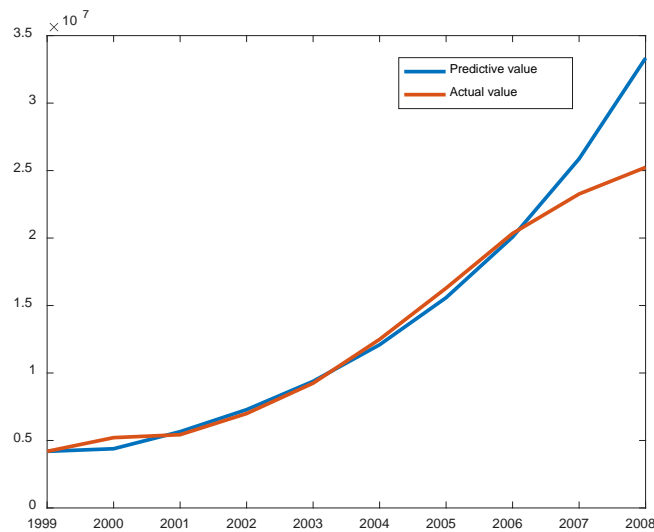
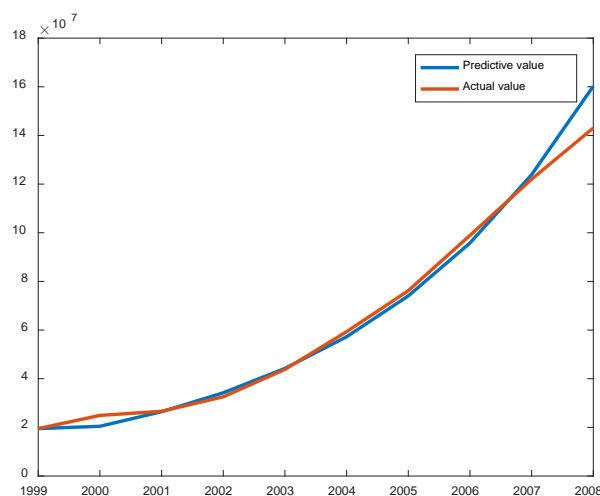


Figure.2 Export to US data forecast results and actual data difference figure

Since consumption, investment, government purchases and foreign trade are the four main factors driving economic development, the normal development of Sino-US relations plays an important role in China's economic development and world peace. The economic situation is not good, and the unemployment rate is rising. In order to appease the mood of the Chinese people, the United States has turned its attention to Sino-US trade cooperation, especially in the article on commodity safety [2]. In the above grey prediction model, it can be seen that With China-US relations maintaining normal exchanges, China's total exports of goods to the United States will be more, and the trade of goods will be closer, which has also played a role in the development of the US economy. The deterioration of Sino-US trade relations had a certain impact on China's export commodities. The actual value of China's exports to the United States in 2007 and 2008 was significantly lower than the forecast. The United States was China's larger foreign market. The reduction in export quotas had a huge impact on China's trade, which in turn has an impact on the Chinese economy. Of course, this effect was mutual. The deterioration of Sino-US relations will have a negative impact on both economic developments.

Using the data of China's total exports from 1999 to 2006 as the raw data, the model is used to forecast the total export data of 2007 and 2008, and the following figure is obtained:



*Figure. 3 Total export volume forecast data and actual result difference figure*

According to GM (1,1) model, the forecast value of export volume for 2007 and 2008 is \$123873295.6 million and \$160232714.4 million. Under the forecasting conditions, the difference map between the proportion of US exports to total exports and the actual proportion is drawn.

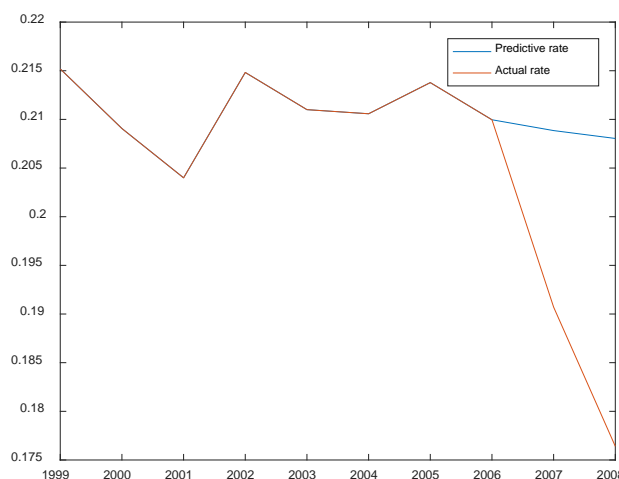


Figure. 4 Comparison of predicted and actual value of China's exports to the US

The result is that the predicted export ratio in 2007 and 2008 will still be greater than 20%, while the actual export ratio is less than 20%, so the Sino-US trade relationship has indeed brought certain impact.

Sino-US trade relations had been developing steadily. China had adopted a series of sanctions against the United States. In order to study the factors that had a greater impact on the Chinese economy in these sanctions, AHP analysis methods are used to conduct corresponding research.

### 2.3 AHP method construction and analysis

Analytic Hierarchy Process (AHP) is a combination of qualitative and quantitative methods. It is suitable for the target system of hierarchical and interlaced evaluation indicators. It is a popular research method.

The basic principle of the analytic hierarchy process: The analytic hierarchy process breaks down the problem into different constituent elements according to the nature of the problem and the overall goal to be achieved, and according to the interrelated influences and affiliation between these elements, the elements are different. The hierarchy is aggregated to form a multi-level analytical structure model, which ultimately categorizes the problem into the determination of the relative importance of the lowest layer relative to the highest layer and the ranking of the relative merits of these strategies. The calculation steps of the analytic hierarchy process are as follows:

First of all, to establish a hierarchical structure model, the decision-making objectives, decision-making criteria and decision-making objects should be divided

into the highest layer, the middle layer and the lowest layer according to the mutual relationship between them, and the hierarchical structure diagram should be drawn. The highest level in the structure diagram is the problem to be solved by the decision, the middle layer is the factor to be considered and the decision criterion, and the lowest level is the alternative to the decision. As shown below:

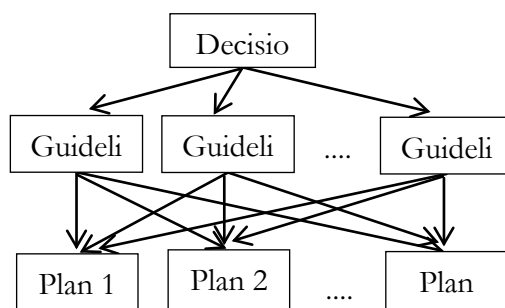


Figure.5 Analytic hierarchy process

Secondly, constructing the judgment matrix, when determining the weight between the various factors at each level, if it is only qualitative analysis, it is not acceptable, so it is necessary to add quantitative analysis based on qualitative analysis, so different factors are needed. Perform a pairwise comparison and rank the level according to its importance. For example,  $a_{ij}$  is the comparison result of the factor  $i$  and the factor  $j$ . The nine importance levels of the comparison result and their assignments are as follows:

Table 2 Importance Value Table

Quantitative value	Factor comparison importance
1	Equally important
3	slightly important
5	stronger
7	strongly important
9	extremely important

Finally, the largest eigenvalue of the matrix and the corresponding eigenvector are obtained, and the eigenvectors are normalized. The value of the corresponding position of the normalized eigenvector is the weight of the corresponding factor. This process is called Sorting the hierarchical order, as to whether the hierarchical ordering can be confirmed, the consistency check of the matrix is also required. The so-called consistency check is the allowable range for determining the inconsistency of the matrix. The unique non-zero eigenvalue of the  $n$ -order uniform matrix is that the largest eigenvalue  $\lambda$  of the  $n$ -th order positive reciprocal matrix is greater than or equal to  $n$ , and the matrix is a uniform matrix if and only if  $\lambda$  is equal to

$n$ . The consistency test for the matrix can be measured by the consistency index  $CI$ .

The calculation formula of  $CI$  is  $CI = \frac{\lambda - n}{n - 1}$ . When  $CI$  is equal to 0, it means

that it has complete consistency. The closer the  $CI$  is to 0, the better the consistency. Large, it means that the inconsistency is more serious. In order to measure the size of  $CI$ , the random consistency index  $RI$  is introduced. Considering that the deviation may be caused by random reasons, when the test matrix has the consistency, the  $CI$  and the random consistency index  $RI$  need to

be compared. The test coefficient  $CR$  is obtained, that is  $CR = \frac{CI}{RI}$ . If  $CR < 0.1$ ,

the matrix is considered to have passed the consistency test, otherwise the consistency test is not satisfied. In order to facilitate the operation, matlab software can be used to construct the judgment matrix and perform related consistency check.

In order to better study the degree of influence of various US policies on China since the Sino-US trade war, the analytic hierarchy process was used for research. In January 2018, Trump announced that it would adopt a four-year period for importing large washing machines and photovoltaic products. And the three-year global safeguards, and the highest tax rate of 30% and 50% respectively," since then Sino-US trade friction kicked off. On March 22 of the same year, Trump imposed a \$50 billion tariff on Chinese goods and imposed investment restrictions on the grounds of "infringement of intellectual property rights". Subsequently, it gradually entered the stage of escalating trade wars. On April 4, 2018, the US government announced a list of tariffed goods, which would impose a 25% tariff on China's 1,333 US\$50 billion exports to the United States. Step by step, on August 2, 2018, the US Trade Representative stated that it intends to increase the tax rate from 10% to 25%. For the Sino-US trade war, by studying the US's measures against China, we conclude that we mainly discuss the following four aspects: First, the US exports of goods to China increase by 10%-25%; Second, the US government plans Shorten the validity period of visas issued to some Chinese citizens; Third, accurately attack Chinese high-tech enterprises through intellectual property litigation; Fourth, restrict Chinese companies from investing in the United States.

Select the above four main measures to construct a relevant judgment matrix.

*Table 3 Measures and symbolic representations*

Symbol	Representative measure
$B_1$	US imposes tariffs on Chinese products
$B_2$	Combate China's high-tech industry
$B_3$	Restrict Chinese companies from investing in the US
$B_4$	Shorten the validity of visas for Chinese citizens

Get the following table:



Table 4 Construct a matrix

	$B_1$	$B_2$	$B_3$	$B_4$
$B_1$	1	3	5	7
$B_2$	$\frac{1}{3}$	1	2	4
$B_3$	$\frac{1}{5}$	$\frac{1}{2}$	1	5
$B_4$	$\frac{1}{7}$	$\frac{1}{4}$	$\frac{1}{5}$	1
CR = 0.066044				

Therefore, the consistency test is passed, and the normalized feature vector is obtained at the same time:

$$[0.5697, 0.22329, 0.15415, 0.05207],$$

$$\text{Get the model as: } Y = 0.5697x_1 + 0.22329x_2 + 0.15415x_3 + 0.05207x_4$$

In the course of the trade war, the United States imposed tariffs on a large number of Chinese products, which directly affected China's import and export, thus affecting the development of China's economy, with the greatest impact. Secondly, the United States had cracked down on China's high-tech products, US restrictions on Chinese companies' investment mergers and finally the visa's validity period had been shortened.

#### **2.4 Analyze the specific impact of tariffs on the economy from the United States' tariff increase on Chinese commodities.**

China is the world's second largest economy in addition to the United States now. In recent years, China has become the world's largest exporter. Statistics showed that its electronic products were more famous, while China's exports were mainly concentrated in low-tech manufactured goods such as clothing. Toys, textiles, etc. and electronic power products such as motors, electrical machinery, etc. [3].

In 2016, the United States imported 462.81 billion US dollars from China, down 4.2%, accounting for 21.1% of total US imports, down 0.3 percentage points. The US trade deficit of 347 billion US dollars, accounting for 47% of the total US deficit, down 5.5%, was also a direct cause of increasing trade protectionism [4]. China was also the first source country for US mechanical and electrical products, textiles and raw materials, base metals and products and plastics and rubber, and has a strong competitive advantage. In 2017, China's exports to the United States totaled US\$505.60 billion, an increase of 9.3%, accounting for 21.6% of total US imports, an increase of 0.4 percentage points. The US trade deficit was 375.23 billion US dollars, an increase of 8.1%. China's furniture, shoes and umbrellas and other light industrial products and leather goods bags had a strong competitive advantage. The competitors of Chinese products were mainly from Mexico, Vietnam and Italy.

China was also the first source of imports for US mechanical and electrical products, textiles and raw materials, base metals and products and plastics and rubber. In order to more clearly compare the types of export products, we have compiled the data for the four years from 2016 to 2019. As shown in Table 5, we find that the toy light industry and mechanical and electrical products had always occupied a large proportion, and the fluctuation between the various products were not very large.

*Table 5 The Ranking Table of China's Total Exports to the US*

<b>2016</b>			
Ranking	Commodity Name	Amount (\$100 million)	Proportion
1	Mechanical and Electrical Products	2264.2	39%
2	Electrical machinery and electrical products	1290.1	22%
3	Mechanical equipment	974.1	17%
4	Furniture toys	561.9	10%
5	Textiles and raw materials	395	7%
6	Base Metals and Products	232.6	4%
<b>2017</b>			
Ranking	Commodity Name	Amount (\$100 million)	Proportion
1	Mechanical and Electrical Products	2566.26	51%
2	Furniture toys	605.78	12%
3	Textiles and raw materials	389.94	8%
4	Base Metals and Products	253.81	5%
5	Plastics, Rubber	198.13	4%
6	Light industrial products such as shoes, boots and umbrellas	179.96	4%
7	Chemical products	150.96	3%
8	Optics, clocks, medical equipment	132.54	3%
9	Leather products bags	74.55	2%
10	Cellulose Pulp and Paper	54.53	1%
11	Food, beverage and tobacco	29.75	1%
<b>2018</b>			
Ranking	Commodity Name	Amount (\$100 million)	Proportion
1	Mechanical and Electrical Products	2685	50%
2	Furniture, toys, miscellaneous articles	649	12%
3	Textiles and raw materials	405	8%
4	Base Metals and Products	282	5%
5	Plastics, Rubber	233	4%
6	Transportation equipment	184	3%
7	Chemical products	183	3%
8	Footwear, umbrella and other Light industrial products	181	3%
9	Optics, clocks, medical equipment	138	3%
10	Cellulose Pulp and Paper	59	1%
<b>2019</b>			
Ranking	Commodity Name	TEU	Year-on-year growth rate

1	Furniture and lighting equipment	154468	0%
2	Machinery and appliances	84020	20%
3	Electrical equipment	58875	1%
4	Plastics and resins	56244	35%
5	Iron and steel products	43451	60%
6	Toys and sports equipment	36878	29%
7	Motor vehicle	30589	10%
8	Tissues and rags	22274	55%
9	Shoes	18282	-15%
10	Clothing, Knitting	17149	-19%

As for China's total exports to the world, we find that in 2017, apart from ASEAN, the European Union and other Asian countries, the United States was still China's largest exporter, as shown in Figure 6.

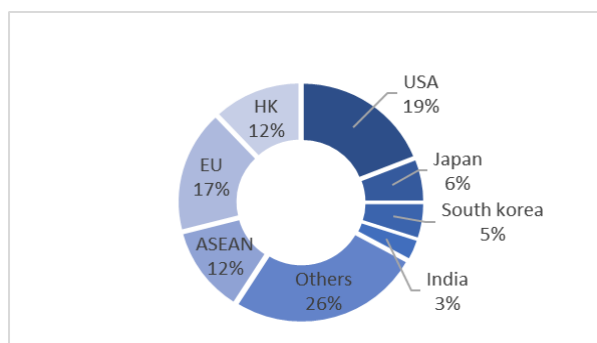


Figure. 6 Proportion of China's Export Areas in 2017

Tariffs imposed by the United States generally lead to an increase in domestic commodity prices, which in turn reduced demand. If the change in export volume was analyzed, the elasticity of the export volume to the export price should be measured [5]. Figure 7 is a comparison of the total export value of China's goods and the total exports to the United States from 2014 to 2019. China's exports to the United States accounted for about 16% to 18% of total exports, indicating that the United States is China's largest exporter. The US government's tariff on Chinese goods will inevitably cause huge fluctuations in US domestic prices.

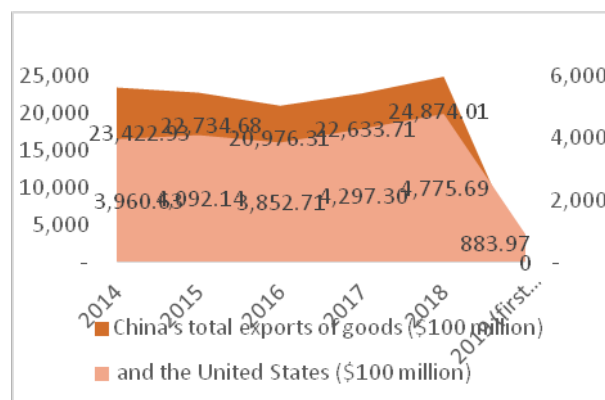


Figure.7 China's Export Amount in 2014-2019

According to the study, the price of thousands of products had risen even more than the inflation rate, which had caused consumers to bear higher prices and lower consumption. The trade war had ultimately increased the burden on American consumers. The US Global Trading Partner Consulting Company A study showed that the trade war had led to an increase in the average annual expenditure of American households by \$2,300 [6]. The imposition of tariffs on Chinese goods had caused the domestic market to adhere to consumer purchasing power and reduced the degree of freedom in the US market. Plan, prices will rise again, Americans will pay more for tariffs, not only the risks faced by consumers become higher, but also the business leaders will be hit hard. This was also a problem repeatedly emphasized by American economists.

### 3. Conclusion

The form of Sino-US relations is complex and changeable. The United States wanted to trade with China unilaterally and did not want to see the rise of China. From 1999 to 2017, China's exports to the United States had a large amount of merchandise trade data. The decline was in a downward trend and the downward trend lasted longer. Through the GM (1,1) model and the AHP, we will study the related issues of Sino-US trade, and analyze the specific commodities that the United States imposed on China's tariffs. Finally, We have come to the conclusion that for China and the United States, cooperation will promote the common development of the two countries, and the struggle will cause both countries to suffer losses.

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