A GTAP Simulation-Based Analysis Method for Impact of the US Exit from WTO and China's Strategic Choice

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Abstract. In this paper, the GTAP model is used to simulate the impact of the withdrawal of U.S. from the WTO on China and even the global economy. It is found that the withdrawal of the United States from WTO has both positive and negative effects on China's economy and these effects expand with the rise of tariff level between the United States and WTO members. The positive influence comes from the fact that after the United States imposes tariffs on other WTO members, it will worsen the terms of trade between the United States and other WTO members, reduce import and export, and bring favorable effects to China. The negative effects are mainly due to the escalating trade war between China and the United States. The withdrawal of the United States from the WTO and the imposition of tariffs on China will lead to the deterioration of trade between China and the United States, which is not conducive to the export of Chinese products to the United States. We have obtained the import and export data of the world in recent three years. Based on the GTAP model and correlation analysis method, we analyze and model the data. Through the simulation experiment based on the GTAP model, we derive a decision-making model with great reference value.

Keywords: Sino-US trade · Tariff · Non-trade barriers · GTAP model · Grey relational analysis

1 Introduction

As emerging economies have joined the WTO and are continuously integrated into the global trading system, developed countries have begun to change their attitudes towards the WTO, and this major international trade organization. The more difficult it is to "knife tofu-two sides light" (Yunkun Zhang 2020). The international multilateral system is facing unprecedented challenges (Runting Jin 2019). Therefore, it is urgent for us to study in depth what challenges will be brought to Global trade by "the withdrawal of the United States from the WTO"? How to affect Chinese interests? Take precautions to avoid risks and seize opportunities. A small amount of studies have focused on two aspects: the motivation of the U.S. to withdraw from the WTO and the possible impact.

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Judging from the reasons for the withdrawal of the United States from the WTO, non-reciprocal or unequal trade is the root cause of the withdrawal of the United States from the WTO (Zhongying Pang 2018). In particular, the United States believes that China, as a "developing country" among WTO members, has taken advantage of tax rates, quotas and many other aspects, resulting in damage to the interests of the United States (Xinquan Tu and Xiaojing Shi 2019). It is an important reason for the United States to withdraw from the WTO to put pressure on the multilateral mechanism with the method of "retreat for progress" (Longyue Zhao 2018). The withdrawal of the United States from the WTO is the result of various reasons.

The reasons for Sino-US trade frictions are complex, including trade, investment, intellectual property rights and other economic and trade factors, but also contain US worries and fears about China's rise (Di Zhao 2020). The underlying reason is the collective decline of Western countries headed by the United States, and the collective rise of developing economies headed by China (Changbin Zhang 2019). The Sino-U.S. Trade war is essentially a manufacturing struggle, and curbing the development of China's manufacturing is an important reason for the U.S. to launch a trade war (Junjie Hong and Zhihao Yang 2019). The trade war cannot fundamentally improve the huge US trade deficit. In the export industry, China's transportation equipment, machinery and other manufacturing industries have a greater impact on exports, while the US agriculture, oil and other industries have a greater impact (Mengran Li 2020). It is expected that my country's GDP will fall by 0.06 to 0.07% points from 2018 to 2020, and the three industries of electrical and electronic products, mechanical equipment and transportation equipment manufacturing will have a greater impact (Yaxiong Zhang and Jifeng Li 2018). But overall, the impact of trade friction itself on China's macroeconomic economy is limited and controllable (Qing Guo and Weiguang Chen 2019).

Effective measures must be taken to reduce the factors of Sino-US economic and trade frictions (Chen et al. 2020). China will accelerate its mastery of core technologies, continue to maintain the strategic strength of comprehensive reform and opening-up in the "Belt and Road" initiative, and calmly deal with the various risks of the US initiating a trade war (Han Y.H. 2020). Due to the strong economic strength and trade volume of the United States, the comprehensive multilateral trade mechanism will be in disorder (Jingwei Zhang 2018), which will have a big shock to the global political and economic governance system, and the influence of the WTO on the global trade market will be completely overturned (Qingjiang Kong 2019). The United States may face huge economic costs, such as the loss of important global trade access arrangements, huge losses in service trade, trade-related intellectual property rights, trade-related investment issues and so on (Huifang Qiu 2017).

In summary, although the academic community has conducted some research on the reasons and impact of the US withdrawal from the WTO, the current research results mainly use qualitative research, and there are few articles using data model to analyze the impact of the U.S. withdrawal from the WTO, especially those of "Analysis of China's Economic Impact". In view of this, this paper uses GTAP model to simulate and analyze the tariff level changes between the United States and other WTO members caused by the withdrawal of the United States from the WTO, studying how the major "black swan"

timing of the United States' withdrawal from the WTO will affect Chinese economic interests.

2 Simulation Scheme and Modeling Analysis

"Withdrawing from the WTO" means that the United States does not have to abide by the principles and agreements of WTO, and is no longer subject to the requirements of the most-favored-nation and binding tax rate in the WTO agreements, but will increase the tariff rate of foreign trade for its own interests. In the face of the changes of US tariff policy, other WTO member states will also impose retaliatory tariffs on US. For example, after the United States imposed a 25% tariff on steel exported to the United States by Canada, Mexico and the European Union, The European Union and Canada also impose tariffs to varying degrees on US imports. Therefore, the first scheme assumes that the tariffs between the United States and developed countries among WTO members will increase after the United States withdraws from the WTO. Compared with tariff, non-tariff measures have the characteristics of diversity, flexibility and concealment. According to the TBT agreement of WTO, once the United States withdraws from WTO, serious non-tariff barriers will be produced. Therefore, the second scheme assumes that the United States and WTO member states will mutually enhance their non-tariff barriers after withdrawing from the WTO. When the WTO was established, it provided preferential policies to China and India.

With the rise of developing countries, the United States thought that the trade with developing countries is very disadvantageous. As the largest trade deficit country of the United States, China was bound to be imposed punitive tariffs by the United States once the United States withdraws from the WTO. Therefore, the third scheme assumes that the United States will impose punitive tariffs on China after withdrawing from the WTO. Based on the above analysis, three schemes are set up to simulate impact variables of tariff and non-tariff barriers in this paper.

The classification of production factors in this paper adopts five basic element classification methods of land, unskilled labor, skilled labor, capital and natural resources. This article divides the product sector into the following three groups based on the GTAP industry sector database combined with the characteristics of US tariffs: agriculture, manufacturing, and service industries. The specif ic division is shown. This article also divides the 121 country data and 20 regional collections collected in the GTAP (10th Edition) database into the following 14 groups: China, Japan, United Kingdom, Germany, South Korea, Canada, United States, Mexico, France, Belgium, Singapore, India, other countries and regions in the world. Through grouping, we analyze the impact of the US withdrawal from the WTO and the corresponding strategies of our country.

According to the simulation results (Table 1), under the three simulation schemes, the withdrawal of the US from the WTO will not only have an impact on its own GDP, terms of trade and welfare, but also on other member countries of the WTO. In scheme 1, most countries and regions show negative changes in.

GDP, terms of trade and welfare, while the U.S. GDP, terms of trade and welfare are still in positive changes, which is inseparable from the strong economic and national strength of the United States. Among the countries and regions with negative changes,

Table 1. Changes in GDP, terms of trade and welfare.

Country or region	GDP change (unit: %)			Change in terms of trade (in %)			Changes in benefits (in millions of US dollars)		
	Scheme 1	Scheme 2	Scheme 3	Scheme 1	Scheme 2	Scheme 3	Scheme 1	Scheme 2	Scheme 3
CHN	2.27	− 0.30	− 8.75	1.69	− 0.75	− 4.96	28833.52	− 14676.44	− 123046.55
JPN	− 4.99	0.03	0.18	− 4.35	− 0.70	0.85	− 34475.79	− 5784.22	4115.87
GBR	− 2.54	0.37	0.35	− 1.99	− 0.10	0.44	− 17791.07	− 891.98	3385.86
DEU	− 2.00	0.32	0.10	− 1.53	− 0.14	0.23	− 22774.59	− 2153.50	1231.32
KOR	− 4.10	− 0.24	− 0.19	− 2.57	− 0.58	0.33	− 13326.42	− 3534.75	1130.03
CAN	− 19.53	− 0.46	3.63	− 15.02	− 0.97	1.86	− 70950.16	− 4577.76	8420.90
USA	4.30	0.12	2.29	4.85	− 0.49	2.30	112983.46	− 11474.19	40003.02
FRA	− 1.64	0.32	0.06	− 1.13	− 0.16	0.16	− 10983.38	− 1415.45	471.97
BEL	− 2.00	0.20	0.04	− 0.75	− 0.13	0.04	− 3873.89	− 889.22	146.54
SGP	− 4.48	0.56	− 0.27	− 2.28	0.01	0.15	− 4931.77	43.47	− 85.92
IND	1.33	− 0.20	0.29	0.83	− 0.80	0.52	2780.11	− 3602.22	733.14
MEX	6.28	− 0.37	3.94	3.69	− 0.99	2.48	8912.59	− 2848.60	6211.73
NLD	− 1.65	0.25	0.10	− 0.95	− 0.19	0.21	− 3897.14	− 765.70	119.18
Other	0.81	− 0.11	0.18	0.64	− 0.63	0.34	35475.57	− 47743.43	15449.92

Canada has the largest absolute value of negative changes in GDP, terms of trade and welfare. In scheme three, if the United States withdraws from the WTO and imposes punitive tariffs on China, the US GDP growth rate will reach 2.29%, the terms of trade improvement will be 2.30%, and the welfare will increase by 40003.02 million US dollars, while China's GDP, terms of trade, and welfare will show negative changes, which shows that the United States, as China's largest trading partner, can levy punitive tariffs on China and benefit from it.

The probability of item set A and B occurring simultaneously is the support degree (relative support degree) of association rules is as follow.

$$Support(A \Rightarrow B) = P(A \cup B) \tag{1}$$

The probability of occurrence of item set B is the confidence degree of association rules is as follow.

$$Confidence\ (A \Rightarrow B) = P\ (B|A) \tag{2}$$

For the data in Table 1, a can represent GDP change (unit: %), and B represents change in terms of trade (in %) or changes in benefits (in millions of US dollars). Then (1.1) the formula can be changed into the following form.

$$Support\ (\mathrm{A} \Rightarrow B) = \frac{Support\_count\ (A \cap \mathrm{B})}{Total\_count\ (\mathrm{A})} \tag{3}$$

$$Confidence\ (A \Rightarrow B) = \frac{Support\_count\ (A \cap B)}{Support\_count\ (A)} \tag{4}$$

where $Support\_count(A \cap \mathrm{B})$ represents the number of times A and B grow simultaneously. Through the Apriori algorithm, we can calculate the relationship between the

change of GDP and the change of trade, and the relationship between the change of GDP and the changes in benefits.

Based on the above data, we can use the grey correlation method to analyze the change relationship between different schemes in different countries and regions. Grey relational analysis is a quantitative description and comparison method for the development and change trend of a system.

The specific calculation steps of grey correlation analysis are as follows:

Step 1: determine the analysis sequence. The reference sequence as follow.

$$Y = \{Y(k)|k = 1, 2, ..., n\} \tag{5}$$

The comparison sequence as follow.

$$X_i = \{X_i(k)|k = 1, 2, \Lambda, n\}, i = 0, 1, 2, \Lambda, m \tag{6}$$

Step 2: dimensionless variables.

$$x_i(k) = \frac{X_i(k)}{X_i(l)}, k = 1, 2, \Lambda, n; i = 0, 1, 2, \Lambda, m \tag{7}$$

Step 3: calculate the correlation coefficient.

The correlation coefficient of $x_0(k)$ and $x_i(k)$ is as follow.

$$\xi_i(k) = \frac{\min_i \min_i |y(k) - x_i(k)| + \rho \max_i \max_k |y(k) - x_i(k)|}{|y(k) - x_i(k)| + \rho \max_i \max_x |y(k) - x_i(k)|} \tag{8}$$

Step 4: calculate the correlation degree.

$$r_i = \frac{1}{n} \sum_{k=1}^{n} \xi_i(k), k = 1, 2, \Lambda, n \tag{9}$$

Step 5: ranking of relevance degree.

Through the grey relational analysis model, we can calculate the correlation degree between different schemes in different regions and countries. According to the simulation results (Table 2), if the United States withdraws from the WTO, it will have a significant impact on various industrial sectors such as agriculture, manufacturing, and service industries in China and the United States.

Judging from the export situation of various industries in China, in Option 1, if the United States withdraws from the WTO and raises the tariff rate on developed countries, the developed countries will also impose retaliatory tariffs on the United States, thus triggering an increase in tariffs among developed countries.

In view of the impact of different strategies on different schemes, we can use the method of association analysis to analyze. As before, we use the Apriori algorithm for analysis and modeling. First, we define the Minimum support as follow. Minimum support: a user or expert defined threshold to measure support, which represents the lowest statistical importance of a project set.

Table 2. Changes in import and export of various industries in China and the United States (unit: %).

Industry	US export/China Import			US import/China export		
	Scheme 1	Scheme 2	Scheme 3	Scheme 1	Scheme 2	Scheme 3
Agriculture	– 13.28	– 9.36	– 24.16	5.93	– 5.99	– 136.31
manufacturing industry	– 24.45	– 1.78	– 34.09	48.76	– 2.13	– 150.73
Service industry	– 8.19	– 0.72	– 23.14	4.50	0.72	– 62.09

Then we can calculate according to the data in the table the Minimum support between agriculture and manufacturing industry is:

$$Support\ (agric \Rightarrow manuf) = \frac{Incease\_count\ (agric \cap manuf)}{Total\_incearse\_count\ (agric)} \tag{10}$$

Minimum support between manufacturing industry and service industry as follow:

$$Support\ (manuf \Rightarrow serv) = \frac{Incease\_count\ (manuf \cap serv)}{Total\_incearse\_count\ (manuf)} \tag{11}$$

Minimum support between agriculture and service industry as follow:

$$Support\ (agric \Rightarrow serv) = \frac{Incease\_count\ (agric \cap serv)}{Total\_incearse\_count\ (serv)} \tag{12}$$

Based on the above, we can analyze the correlation support among agriculture, industry and service industry. Furthermore, we can analyze the degree of their correlation in time.

3 Simulation Results and Analysis

By calculating the degree of association between changes in GDP and change in terms of trade, we calculate the proportion of the number of times changes in GDP and change in terms of trade increase at the same time in the total number of changes in GDP growth in three schemes. Similarly, in order to calculate the correlation between changes in GDP and changes in benefits, we also calculate the proportion of the number of times changes in GDP and changes in benefits increase at the same time in the total number of changes in GDP growth. Using our association analysis algorithm, we can calculate the degree of association between changes in GDP and change in terms of trade, and between changes in GDP and changes in benefits in different countries and regions. As shown in Fig. 1, we calculate the association between changes in GDP and change in terms of trade and changes in benefits in different countries.

We calculated the correlation degree between import and export transportation. We used grey correlation analysis method to calculate the correlation degree of every two

schemes located in import and export transportation respectively. As shown in Fig. 2, we can see that the direct correlation degree of schemes in the same period tends to be one, while the correlation degree between schemes in different periods is relatively low. For schemes of different periods, we can see that their correlation is at a low level, which reflects that the fluctuation of import and export does not have a strong time correlation, that is, the impact of import and export fluctuations on future import and export fluctuations cannot be predicted. Based on this, we can conclude that there is a great correlation between import and export transportation in terms of time. For China US trade, a big import and export country, it is more important to create new opportunities to increase the volume of import and export trade than to observe the past. This is also an important conclusion of our analysis of time correlation.

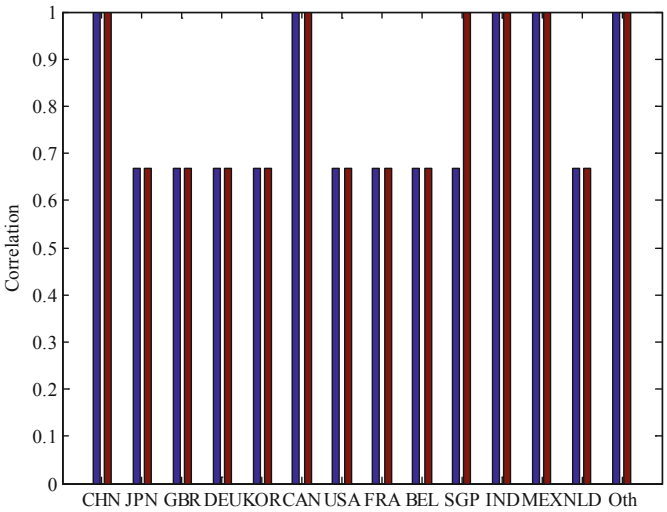

Fig. 1. The correlation between GDP and trade or benefits

We use the correlation analysis model to calculate the support between different industries. According to different schemes of import and export, we can plot their changes in different industries. To facilitate display, we use a three-dimensional diagram to show our information, as shown in Fig. 3. From the figure, we can see that the overall trend of the three industries is consistent in different schemes, which indicates that the time correlation between agriculture, industry and service industry is high. From the figure, we can also see that the fluctuation of the three major industries of scheme in different periods is quite different, which reflects a trend of economic change. Although it is difficult to predict this trend, it can be predicted according to the time correlation of different industries. Through past increases and fluctuations, we can predict the probability of future changes in agricultural, industrial, and service output values. Based on the above

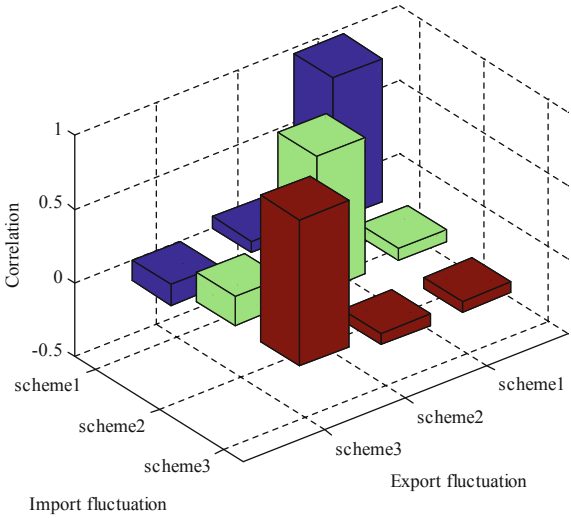

Fig. 2. Time correlation between import and export transportation

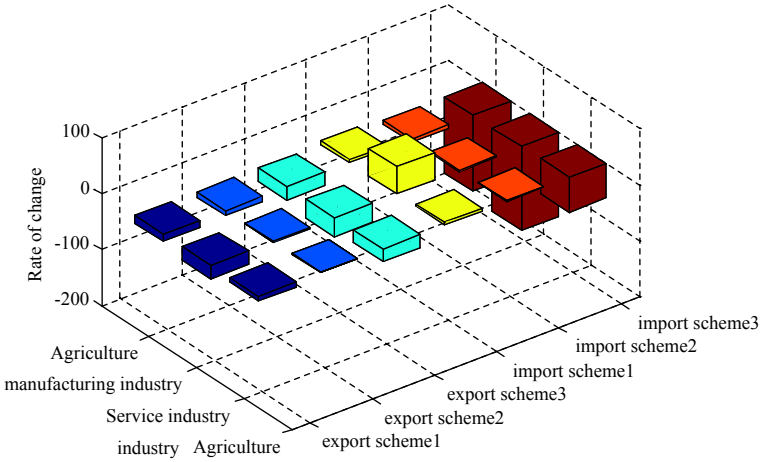

Fig. 3. Time correlation of agriculture, industry and service industry

analysis, we can conclude that the growth of Sino US trade changes is extremely time-dependent, which has sufficient reference value for predicting the changes of output value of different industries and import and export trade.

4 Conclusions

This paper uses the GTAP model to simulate the economic impact of tariff barriers and non-tariff barriers re-established between the United States and other WTO members

after the United States withdraws from the WTO, and analyzes its impact on GDP, trade and welfare status, import and export and bilateral structure, as well as the relationship between the import and export of goods between China and the United States. Using Apriori algorithm, we analyze the relationship between GDP change, trade change and welfare change. From the analysis results, we can see that the latter two have strong correlation with the former. At the same time, we use the grey relational analysis model to analyze the import transportation and export. Finally, we use the correlation analysis model to analyze the relationship between agriculture, industry and service industry, and calculate the support between them. We can see that the three also show a strong time correlation. Through the above analysis, we can draw the following conclusions: the withdrawal of the United States from the WTO, together with the tariff imposed by WTO members, will have a significant impact on the world's GDP, economic welfare, terms of trade, import and export and other macro indicators. China should actively promote one belt, one road strategy, closely link with other countries, promote the negotiation of regional comprehensive economic partnership (RCEP) and the Asia Pacific Free Trade Area (FTAAP), promote economic integration in the Asia Pacific region and facilitate the liberalization and trade of regional trade.

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