Application of improved recursive regression algorithm on I&O model under COVID-19

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Abstract. Regression algorithm is an important data prediction method of machine learning. It can establish calculation matrix through the existing data and obtain the hidden characteristics in the data and other valuable information. Due to the excellent data processing ability, regression is widely used in gray data prediction, algorithm model building, data analysis and other fields. In this paper, the multi-layer recursive regression is adopted and improved for the regression algorithm with double influence factors, which increases the processing ability of multi class data. Data of import and export trade between China and the United States in the past five years is collected to create the future prediction model when the epidemic does not occur. Meanwhile, the data of four months after the outbreak to calculate the condition of the future prediction model of the epidemic situation in COVID-19. Using two opposite conditions as different data of regression algorithm calculation, different prediction algorithm formulas are obtained. After multiple calculations, the average value increases the sensitivity of the model. The calculation results show that the improved recursive regression algorithm has higher stability and sensitivity.

1. Introduction
Since the establishment of diplomatic relations between China and the United States in 1972, the trade between China and the United States has been on the rise at a high speed. In 1979, the Bilateral Trade Agreement was signed Sino-U.S. Trade Agreement. The total two-way trade reached 2.45 billion US dollars in that year, and in 2019, the total two-way trade reached 541.223 billion US dollars, increasing by 220.9 times [1]. The period of peaceful trade between China and the United States lasted for a long time, and both sides gained tremendous benefits and development. In addition, the import and export trade between China and the United States is the main force of global trade growth, which has made a huge contribution to global economic growth and solved a large part of the employment problem worldwide, thus greatly promoting the global economic pattern. But there is no denying that we are always at a disadvantage in Sino-U.S. import and export trade. In Sino-U.S. trade relations, China has been in surplus for a long time, and the surplus of trade continues to expand, reaching 301.28 billion in 2019 [1]. The trade relationship between China and the United States is obviously unstable.

The COVID-19 outbreak in early 2020 will undoubtedly have a huge impact on the unstable Sino-U.S. import and export relations. In order to prevent and control COVID-19, some countries have successively adopted control measures on the Chinese mainland, which has greatly restricted China's...
import and export trade, greatly affected the production of residents, and made the vast majority of the global economy in a state of stagnation or even retrogression. As it can see from the global economic data following the outbreak, the International Monetary Fund (IMF) has revised down its forecast for global GDP growth in January from 3.3 percent to -3 percent due to the impact of COVID-19, making it the worst recession since the Great Depression of the 1930s. At the same time, the World Bank also lowered the GDP growth forecast for the East Asia-Pacific region in 2020 from 5.8 percent to 2.1 percent [2].

In view of the impact of the sudden outbreak of COVID-19 on the import and export trade between China and the United States, mathematical models and formulas were used to predict the future trade value, and the impact of the epidemic was discussed and Suggestions were put forward.

Aiming at the establishment of the mathematical model, it compare two commonly used methods for forecasting trade data: improved recursive regression calculation method and progressive regression modeling method [4-5].

Analysis of the advantages and disadvantages of the two prediction methods:

The first improved recursive algorithm is a more widely used method to predict trade, which was published in 2003 in CNKI, a total of cited 20+ , download 100+. The second step regression modeling method has been cited 20 times and downloaded 1000+ times. Compared with each other, it can be concluded from the above data that the effective utilization rate of improving the recursive regression law is higher than that of the progressive regression modeling method. After downloading, it is cited more frequently. The improved recursive regression algorithm is 20 percent more than the regression modeling method with 2 percent.

The amount of data needed to improve the recursive regression algorithm can be more or less, and the use of data is more flexible. For example, it can use data from any year in the past to build the model, which has greater freedom and wider width. However, compared with the stepwise regression modeling method, the algorithm is more complex due to its many steps and large data processing capacity. Based on this, the prediction data obtained by the improved recursive regression algorithm is more accurate and more in line with the development law curve of import and export trade in the future.

The improved recursive regression algorithm can predict the future with a large time span, and it can save more time than the stepwise regression modeling method in the case of more time calculation. For example, in the forecast data from 2021 to 2041, the improved recursive regression algorithm only needs to calculate the major parameters once, while the stepwise regression modeling research method needs to calculate the data for 20 times, and each time the data is based on the forecast data of the previous year, so the error will become larger and larger.

2. Principles and algorithms
The mathematical method is as follows: the principle and method of the improved multi-level recursive regression algorithm are used to establish the multi-level recursive model, then the multiple regression equations are established to solve the regression coefficient, and then the time-varying parameters are predicted according to the data [4]. Finally, a regression formula that can predict the import and export volume is established:
Figure 1. Schematic diagram of improved recursive algorithm.

The final mathematical model of the improved multi-layer hierarchical regression is:

\[ y(k) = \sum_{i=0}^{m} a_i \beta_i(k)u'(k) + e(k) \]  

(1)

The hierarchical method of multi-layer AR model is adopted to predict time-varying parameters. The model is as follows:

\[ \beta_i'(k) = a_i(k)\beta_i'(k - 1) + a_{i-1}(k)\beta_i'(k - 2) + a_{i-2}(k)\beta_i'(k - 3) + a_{i-3}(k)\beta_i'(k - 4) + a_{i-4}(k)\beta_i'(k - 5) + e(k) \]  

(2)

The hierarchical method of multi-layer AR model is adopted to predict time-varying parameters. The model is as follows:

\[ \beta_i'(k) = a_i(k)\beta_i'(k - 1) + a_{i-1}(k)\beta_i'(k - 2) + a_{i-2}(k)\beta_i'(k - 3) + a_{i-3}(k)\beta_i'(k - 4) + a_{i-4}(k)\beta_i'(k - 5) + e(k) \]  

(3)
Then get $a(i,k)$ Evaluate the sequence, and then use the mean approximation method $a(i,k)$

According to the above equation, the time-varying parameters can be further obtained $\beta'(k)$ The predicted value of one step forward

$$\beta'(k) = a(k)\beta'(k-1) + a(k)\beta'(k-2) + a(k)\beta'(k-3) + a(k)\beta'(k-4) + a(k)\beta'(k-5) + e(k) \quad (4)$$

Based on the above model and formula, the predicted value of the current year's time-varying parameters can be obtained, and then the regression equation can be obtained to predict the system state.

Examples are as follows: The above equation can be used to obtain the predicted value of time-varying parameters in 1999. The data are as follows: $k=15$

$$\beta'1(k) = 0.0025, \beta'2(k) = 0.0018, \beta'3(k) = 0.0019, \beta'4(k) = 0.3171, \beta'5(k) = 1.5463;$$

$$y(k) = 1289.44 + 0.47\beta'1(k)u'(k) + 1.25\beta'2(k)u'(k) + 6.43\beta'3(k)u'(k) + 1.54\beta'4(k)u'(k) + 760.73\beta'5(k)u'(k)$$

In 1999, $k=15$, the predicted value in 1999 is $y(15)=3560.9$

3. Experimental results and discussion

Experiment design principle: the following data can be told to the years before the actual development trend of import and export trade of China and the United States, and then according to the above the first quarter for multi-degree regression algorithm for the improvement of it can predict the short-term and long-term value of import and export trade volume between China and the United States, by the actual value under the outbreak of the import and export trade volume, and epidemic situation of import and export trade data not occurring[4]. To further determine what factors affect the value of import and export volume.

Data on Imports and exports between China and the US before the outbreak:

In U.S. dollar terms, the total value of bilateral trade between China and the United States in 2018 was US $633.52 billion, up 8.5 percent year on year, said Li Kuiwen, spokesman for the General Administration of Customs. Exports totaled US $478.42 billion, up 11.3 percent. Imports of US $155.1 billion, up 0.7 percent. The trade surplus was US $323.32 billion, up 17.2 percent year on year. According to customs statistics, China's imports and exports to the US totaled 4.18 trillion in 2018, up 5.7 percent year-on-year. Exports to the US totaled 3.16 trillion, up 8.6 percent. Imports from the US reached 1.02 trillion, down 2.3 percent. The trade surplus reached 2.14 trillion, an increase of 14.7 percent. In US dollar terms, the total value of bilateral trade between China and the US was US $633.52 billion in 2018, up 8.5 percent year on year. Exports totaled US $478.42 billion, up 11.3 percent. Imports of US $155.1 billion, up 0.7 percent. The trade surplus was US $323.32 billion, up 17.2 percent year on year. In 2018, the trade surplus between China and the United States expanded. This shows that China and the United States are at different stages of development and reflects the complementarity of our two economies.

In recent years, the value of imports and exports between China and the United States without the impact of the epidemic can be seen from the value of trade is stable and continuous growth. In particular, the value of imports and exports increased the most in 2018.

| Year  | Total exports | Total imports | Total import and export | Balance of trade |
|-------|---------------|---------------|------------------------|-----------------|
| 2019.1| 15039         | 12378         | 27417                  | 2661            |
| 2019.2| 9234          | 8962          | 18196                  | 273             |
| 2019.3| 13391         | 11260         | 24651                  | 2131            |
| 2019.4| 13011         | 12130         | 25142                  | 881             |
Table 1, cont

| Year   | Total Exports | Total Imports | Total Import and Export | Balance of Trade |
|--------|---------------|---------------|-------------------------|------------------|
| 2020.1-2 | 20431         | 20846         | 41277                   | -415             |
| 2020.3   | 12929         | 11536         | 24465                   | 1393             |
| 2020.4   | 14070         | 10889         | 24960                   | 3181             |

Unit: 100 million

**Figure 2.** Histogram of the actual import and export volume from January to April in 2019 and 2020.

Table 1 above reflects the value of import and export trade in each month in 2019 and 2020. The table can be compared with the predicted values of the above regression equation. According to the difference between the two, the impact of COVID-19 on import and export trade can be obtained.

**Table 2.** Forecast of import and export trade in 2019 and January-April 2020 without the outbreak of COVID-19.

| Year   | Total Exports | Total Imports | Total Import and Export | Balance of Trade |
|--------|---------------|---------------|-------------------------|------------------|
| 2020.1-2 | 23385         | 21966         | 44351                   | 1419             |
| 2020.3   | 14821         | 13629         | 28450                   | 1192             |
| 2020.4   | 15731         | 12157         | 27888                   | 3574             |

Unit: 100 million
Figure 3. Forecast of import and export trade in 2019 and January-April 2020 without the outbreak of COVID-19.

The above table is the predicted value of the import and export trade between China and the US in the absence of COVID-19 in Table 1. The impact of COVID-19 on national enterprises can be obtained intuitively by the improved hierarchical regression algorithm.

4. Results and discussion

4.1. Short-term analysis and suggestions on the import and export trade between China and the US under COVID-19

Due to the sudden outbreak of COVID-19, it is extremely difficult to control the epidemic. In a short time, the epidemic has had a tremendous impact on all walks of life. The impact on the import and export trade volume is particularly prominent. It can be roughly divided into the following factors: difficulties in resuming work, interruption of overseas supply chain of intermediate products, obstruction of personnel and material circulation channels, national control and control and other comprehensive factors. The following is the ratio of the impact of various factors on the import and export trade in the short term.
4.1.1. Short-term analysis of import and export trade between China and the US under COVID-19. Since the outbreak of COVID-19, China's export of goods has suffered a sharp decline due to a combination of factors such as difficulties in resuming work, interruption of overseas supply chain of intermediate products, obstruction of personnel and material circulation channels, and state control and control. According to the data released by the General Administration of Customs, in the first quarter of 2020, the total volume of China's foreign trade was 943.2 billion US dollars, a year-on-year decline of 8.4 percent, among which the export dropped by 13.3 percent, a drop of more than double digits. Imports fell 2.9 per cent. According to the analysis report of China Enterprise Confederation on top 500 manufacturing enterprises affected by the epidemic, in the first quarter of 2020, about 29.20 percent of domestic manufacturing enterprises significantly reduced their export volume, and about 41.24 percent of enterprises showed varying degrees of decline in their export volume.[3]

According to the comparison of Sino-U.S. trade volume after the outbreak of COVID-19 in January 2020 and the data provided before, it can be found that COVID-19 has a great negative impact on our import and export trade. Not only has the value of import and export decreased significantly, but also the COVID-19 outbreak has caused a rare occurrence of the trade balance - 41.5 billion. Roughly speaking, it can be seen from both supply and demand.

Supply side: the flow of people is blocked, and the output of products is greatly reduced. The production chain at the supply side has been reduced, and the production has been greatly reduced. At the same time, in terms of transportation, there is also the phenomenon of controlling the spread of the epidemic and controlling the traffic.

Demand side: During the spread of the epidemic, a large number of stores and express delivery closed. Sales are down sharply. Leads to hoarding of goods. Thus, the working capital of enterprises and other enterprises is greatly reduced, which tests the living space of enterprises greatly and even leads to the bankruptcy of some poor companies.

Therefore, in general, it can be analyzed from both the supply side and the demand side. Both the supply side and the demand side of the epidemic have squeezed the living space of China's foreign trade enterprises.
4.1.2. Suggestions to reduce the short-term negative impact of the import and export trade between China and the US under COVID-19.

4.1.2.1. Actively urge factories and companies to resume work, increase the possibility of people returning to work:
As a result of the epidemic, millions of people have been left at home, and many have lost their jobs. Small and medium-sized enterprises are the backbone of China's economy, guaranteeing more than 80 percent of urban employment. China's per capital GDP has reached $8,000, which is almost the same as the United States in the 1980s and Canada in the 1990s. But after the outbreak, 85 percent of companies had cash flow problems and had only three months of cash on their books. If it want to restore the value of imports effectively in the short term, we first need to increase our productivity at the source. After returning to work due to the previous leisure, the enthusiasm of the workers should be very high. Secondly, it can also reduce the production tax of enterprises to encourage the initiative of enterprises, thus increasing jobs, increasing GDP, and finally increasing the value of import and export trade.

4.1.2.2. Actively restore overseas production chains and seek new production chains for new products:
As a result of the devaluation of the renminbi, China's total foreign trade in goods fell 1 percent in 2019 in dollar terms from a year earlier. But over the same period, the total value of U.S. trade in foreign goods also fell, by 1.5 percent -- bringing the total value of U.S. imports and exports to $4213.998 billion in 2019, with U.S. exports of $1645.527 billion and imports of $2568.471 billion. Many overseas products want to enter our Chinese market, but they do not have the opportunity to enter our Chinese market. The epidemic is a crisis for us, but at the same time it will also bring us a lot of opportunities. it can vigorously promote the benefits of our Chinese market and relax some policies to introduce more import and export products.

4.1.2.3. Improve the precision of state control.
Due to the sudden outbreak of the epidemic, even though it has introduced a lot of policies and made a response, there are still many places that have not been taken into account, so it still need to refine national control policies. Government departments have elaborated policies, which can not only help enterprises recover their vitality before the epidemic, but also greatly simplify the difficulty of import and export between China and the United States.

4.2. Long-term analysis and Suggestions on the import and export trade between China and the US under COVID-19
Figure 5. Influence factors on import and export trade in the long run.

The influencing factors in figure 5 above are respectively the state's control over the import and export of enterprises. And the price fluctuations of various commodities in the importing and exporting countries affected by the epidemic. Finally, enterprises themselves are affected by the impact of the epidemic. Not only will the flow of people be reduced by the spread of the epidemic, but also transportation will become more difficult.

Table 3. Actual forecast of import and export volume in 2021-2025 (without epidemic outbreak).

| Year | Total exports | Total imports | Total import and export | Balance of trade |
|------|---------------|---------------|------------------------|-----------------|
| 2021 | 158334        | 136608        | 294942                 | 21726           |
| 2022 | 166498        | 148966        | 315464                 | 17532           |
| 2023 | 163894        | 140802        | 304696                 | 23092           |
| 2024 | 178687        | 170623        | 349310                 | 8064            |
| 2025 | 170623        | 159867        | 330490                 | 10756           |

Unit: 100 million
4.2.1. Long-term analysis of data-based import and export trade. Predicted from above if the outbreak did not occur within the next five years to the value of the import and export trade volume between China and the United States can be seen that the development trend of the future is very good, it have import and export trade volume and stable growth in 2021 and 2023 of the import trade volume of 15.8334 trillion and 16.3894 trillion and 2024 export trade volume of 17.0623 trillion, and poor trade also has significant improvement, such as 2024, 806.4 billion rise is larger than the rest of the years. However, the change of our trade volume in the short term during the epidemic period: the trade volume of import and export decreased significantly: the import and export volume of 20431 billion and 2084.6 billion in January-February 2020 were not as big as the trade volume of 2019. And the difference in trade volume has even turned negative for the first time.

Can predict: outbreaks become an excuse for some countries implement trade protection and weapons, to a certain extent, contributed to the closed orientation, racial discrimination, populism, and the rise of nationalism could be fundamentally shake the political foundation of economic globalization, the global trade friction intensified and fracture in the global value chain. Moreover, due to the epidemic situation, China is facing the situation of breaking of the overseas supply chain of intermediate products. In the "post-epidemic" stage, in the process of value chain reconstruction, transnational corporations may no longer only consider the efficiency of resource allocation as “rational economic man”, but may pay more attention to the stability, security and resilience of value chain, so as to redistribute the industrial chain in domestic or geographically close economic regions. Given that large transnational enterprises are mainly concentrated in developed countries in Europe and America, once the above trend emerges, China will face the risk of "de-China-ization" of global value chain, and China may be marginalized by global industrial chain [3].

4.2.2. Suggestions to reduce the long-term negative impact of import and export trade under the epidemic. When hit by an epidemic, the wrong response of policy and business can cause permanent damage to the trading system. The United States' growing trade frictions with all of its trading partners and the potential disruption of supply chains from the COVID-19 outbreak could combine to push the U.S.'s supply chain back. In view of the long-term impact of the epidemic on the import and export trade, the following improvement measures are proposed:
4.2.2.1. It can increase the profits of the enterprises' import and export commodities, or reduce their import and export duties.

China has raised tariff rates on some imports from the United States since June 1, 2019. The State Council Tariff Commission imposed additional duties of 25 percent, 20 percent and 10 percent, respectively, on some items on the list of imports from the United States worth about $60 billion. Reduce enterprises import and export tariff policy, which can improve the enterprise's business motivation, and then disguised eliminating the negative impacts of the country to the import and export trade controls, which can promote the development of import and export tax rebate policy, decrease the difficulty of enterprise's financing guarantee medical circulation of medicines and other goods, under the global epidemic of negative effect can have a very good eliminate the effect, make small and medium-sized enterprises more likely to survive and crisis.

4.2.2.2. It will guide overseas investment, increase the capital of Chinese enterprises, and promote the reform of localized enterprises.

According to the data released by the General Administration of Customs, in the first quarter of 2020, the total volume of China's foreign trade was 943.2 billion US dollars, a year-on-year decline of 8.4 percent, among which the export dropped by 13.3 percent, a drop of more than double digits. Imports fell 2.9 percent. The localization of global value chain or irreversible trend, localization to comply with the manufacturing industry, our country should guide the conditional manufacturing enterprises to invest overseas actively, carry out strategic layout, fully absorbed, use overseas advanced technology and management experience, to speed up the overseas industrial park construction, enhance the level of overseas investment, operation and occupy the high-end market, continue to deeply embedded in the us and Europe developed countries give priority to guide the global innovation network and value chain. At the same time, for the traditional labor-intensive industries, in view of the rising domestic Labour costs, should be strengthened to direct investment in eastern Europe, southeast Asia and Latin America, with its labor cost advantage, relying on local Chinese "mother" factory technical support, to ensure that the low technology link of China in the global value chain are still continue to be an irreplaceable competitive advantage [3].

4.2.2.3. Increase the types and varieties of import and export commodities and reduce restrictions on some import and export commodities. Import accelerate the resumption of value of import and export trade.

The import trade volume in 2021 and 2023 is 15833.4 billion, while the export trade volume in 2024 and 16389.4 billion is 17062.3 billion, and the trade difference also has a significant increase. For example, the trade volume in 2024 is 806.4 billion, which is larger than that in other years. Before the outbreak of the epidemic, China had a certain amount of control over the import and export of enterprises, such as tobacco and alcoholic commodities. Some conditions can be relaxed appropriately after the epidemic, which will not only stop the loss of enterprises during the epidemic period, but also a good way to restore the value of import and export trade. However, it can't just let it go. We need to introduce some clear regulations to relax control, so as not to cause adverse consequences.

5. Conclusions

Short term: In the first quarter of 2020, the total volume of China's foreign trade was 943.2 billion US dollars, a year-on-year decline of 8.4 percent, among which the export fell 13.3 percent, a drop of more than double digits; Imports fell by 2.9 percent. The overall import and export volume has dropped significantly, indicating that the epidemic has affected the flow of people and controlled the overseas transport industry chain. The sudden outbreak of the epidemic has led to a significant decline in China's import and export trade. So in general, it can analyze from the supply side and the demand side. Both the supply side and the demand side of the epidemic have squeezed the living space of China's foreign trade enterprises.
Long-term: The outbreak of the epidemic has become a pretext and weapon for some countries to implement trade protection. To a certain extent, it has aggravated the rise of closed orientation, racial discrimination, populism and nationalism, and may fundamentally shake the political foundation of economic globalization, leading to the aggravation of global trade frictions and the rupture of global value chain. According to the established mathematical model, the import and export volume of enterprises affected by COVID-19 decreased significantly in the short term. However, according to the prediction model and national policies, the value of import and export volume rose slowly and recovered steadily. In particular, the total value of import and export trade in 2023 and 2025 is particularly outstanding.

References
[1] Zhang Wenwen. Influence of Sino-U.S. Trade Friction on China's Import and Export Trade: Theoretical Analysis and Empirical Research [J].Journal of Inner Mongolia university of finance and economics,2020,18(03):64-67
[2] Li xiu-yu. Impact of COVID-19 on China's import and export trade [J]. Journal of huanggang vocational and technical college,2020,22(05):100-104
[3] Zhang Huihui. Analysis on the impact of COVID-19 on China's international trade and countermeasures [J]. Business Economics, 2020(08):58-59+92
[4] Wu Wei-ying, Xiang Yang, Cui Jia-bao. Journal of Shandong University of Science and Technology (Natural Science edition),2003(01):54-57
[5] Wang Hong, Tong Hengqing, Wei Ping. Research on regression Modeling of Import and Export Volume Forecast [J]. Statistics and Decision-making,2006(02):80-82