Financial Mathematics MSc Dissertation MTHM038, 2020/21

The impact of COVID-19 on China's foreign trade - based on ARIMA model and VECM model

Jizhe Chen, ID 200458139

Supervisor: Dr. Wolfram Just

A thesis presented for the degree of
Master of Science in *Financial Mathematics*

School of Mathematical Sciences
Queen Mary University of London

Declaration of original work

This declaration is made on September 6, 2021.

Student's Declaration: I Jizhe Chen hereby declare that the work in this thesis is my original work. I have not copied from any other students' work, work of mine submitted elsewhere, or from any other sources except where due reference or acknowledgement is made explicitly in the text, nor has any part been written for me by another person.

Referenced text has been flagged by:

1. Using italic fonts, **and**
2. using quotation marks "...", **and**
3. explicitly mentioning the source in the text.

Acknowledgements

Throughout the writing of this dissertation I have received a great deal of support and assistance. I would first like to thank my supervisor, Dr. Wolfram Just. This dissertation and research behind it would not have been possible with the exceptional support of him. I would also like to acknowledge my friends, Songyuan Wang, Menglin Sun and Bo Chen, for their wonderful collaboration. They provided me with the valuable opinions that I needed to successfully complete my dissertation.

Abstract

COVID-19 has shaken the current rules of economic globalisation and as a major player in the world economy China must seek changes in its foreign trade and economic strategy. The focus of this study is to explore the impact of the epidemic on China's imports and exports and to compare the magnitude of the impact of the three factors - logistics, investment and exchange rate - on it. The paper employs quantitative analysis, using R and Eviews to analyse Chinese import and export data, an analysis that focuses strongly on findings that are contrary to previous laws of economics. The analysis finds that changes in the source of orders and restrictions in international logistics have had the greatest impact on China's foreign trade. Finally, the analysis leads to countermeasures such as switching exports to domestic sales, fixing international logistics as soon as possible, and showing China's reliable means of prevention to attract foreign investment, as well as pointing out the shortcomings of the analysis.

Contents

Chapter 1

Introduction

The COVID-19 which began in early 2020 as a sudden international public health pandemic, has had a major impact on the world economy and globalization. To this day, countries are still struggling to find a solution to the epidemic. Although national vaccination programmes are on track, the highly infectious and mutable nature of the COVID-19 has led to recurrent outbreaks. In some of the world's major developed economies, the outbreak is still relatively severe, and work stoppages and city closures have even had to be imposed to stop the spread of the epidemic (Fu&McMahon,2021). This may be an effective initiative, but it comes at the cost of slowing down economic development and even giving up some of the space for it.

The important impact of the pandemic on the world economy is also reflected in the issue of economic globalization, which is an important direction in assessing the consequences of the spread of this epidemic. The transnational production chains that depend on the import and export of raw materials and intermediate goods have been devastated by the impact of national embargo policies. According to the International Civil Aviation Organization (ICAO), for example, the overall decline in global shipping volume in the first quarter of 2020, when the outbreak began, was 39%-41%, with economic losses of around 4 to 5 billion dollars (ICAO,2021). In 2021, when the epidemic has recovered to some extent, it will also be very difficult to coordinate the pace of the resumption of work and production and sales by multinational chains, due to the different stages of the epidemic's spread, extent and response methods.

1.1 Research Background

According to the World Integrated Trade Solutions (WITS) database, China's participation in global industrial chains exceeded 50% as early as 2017 (WITS,2021). On 5 March 2020, Japanese Prime Minister Shinzo Abe stated at a conference on future investment in relation to growth strategies that Japan needed to try to gradually move back to its home country those chains that were more dependent on China(Jain,A,2021). The Trump administration made a similar policy request at the same time. The severe and recurring epidemic has made many economists pessimistic about the future development of economic globalization, which is why governments have started to gradually relocate transnational industrial chains back into the country(Xing, 2021). All of the above realities indicate that the attitude and demands for restructuring of economic globalization in many developed countries in the wake of the epidemic are already evident, and that global chains that used to be dominated by multinational enterprises from developed countries will undergo a violent reduction in size and change in form due to strategic contraction, reduced incentives, and a tendency for inward orientation of the population(Fu&McMahon,2021).

What needs to be emphasized is that economic globalization remains a major trend in economic development. Therefore, as an important member of the industrial chain, China must not return to an inward-looking economic trend in line with the reverse trend of economic globalization. This means that a new foreign trade strategy needs to be developed in response to the existing global economic situation.

1.2 Research aims and objectives

In this study, the ARIMA and VECM models were used to attempt an exploratory analysis of the impact of the epidemic on China's import and export data. The objective is to compare the trend and magnitude of changes in actual net exports compared to forecasts in order to determine the strength of the impact of the epidemic. In more depth, we explore which factors were affected by the epidemic and thus indirectly affected the import and export situation, and the magnitude of the impact of these factors on imports and exports. Through the above findings, we will also attempt to provide some recommendations for China's future export.

1.3 Dissertation Structure

In Section 3.1, we use monthly net export data from January 2010-December 2019 to forecast net exports from January 2020-June 2020 through an ARIMA model. This involves a time series stationarity and autocorrelation test, model sizing and testing, and a final time series forecast. the first half of 2020 is when the domestic epidemic in China is at its worst, and we expect a large difference between the forecast results obtained and the actual values, which is a reflection of the epidemic shock.

A five-dimensional time series is created in Section 3.2 using monthly data on total imports and exports, foreign trade cargo throughput, foreign industry-wide investment, PMI index and weighted exchange rates for January 2019-June 2021. Impulse response tests and variance decompositions are conducted through VECM models to compare the magnitude of the effects of the latter four on total imports and exports.

Chapter 2

Method

2.1 Data

The dataset used in this paper corresponds to the official monthly statistical results released by the government. The net export data used in the ARIMA model is from the National Bureau of Statistics of China (2021) and contains monthly data from January 2010 to January 2020.The total imports and exports (National Bureau of Statistics,2021), foreign industry-wide investment (Ministry of Commerce of China,2021), PMI index (National Bureau of Statistics,2021) and weighted exchange rate (State Administration of Foreign Exchange,2021) contain monthly data from January 2019 - June 2021. The main modelling tools for the data are R and Eviews.

2.2 Model

2.2.1 Autoregressive Integrated Moving Average(ARIMA)Model

The ARIMA model consists of an autoregressive (AR) process combined with a moving average (MA) process and can be considered as a composite model of a time series(Alam,2019). It consists of three components, AR, I and MA, with AR denoting the autoregressive model, MA denoting the moving average model, and

I denoting a single integer order. A certain number of non-stationary series will show the properties of a stationary series after differencing(Elsaraiti,M,2021). The ARIMA model is based on the principle of transforming a non-stationary series into a stationary series by differencing, and then regressing the dependent variable on its lagged values only and on the present and lagged values of the random error term.

The ARIMA (p,d,q) model is obtained by adding an autoregressive (AR) model of order p to a Moving Average (MA) model of order q, and formally defined as:

$$\left\{\begin{array}{c}\Phi(B)\nabla^d X_t=\Theta(B)\varepsilon_t \\ E\left(\varepsilon_t\right)=0, \operatorname{Var}\left(\varepsilon_t\right)=\sigma_{\varepsilon}^2, E\left(\varepsilon_t \varepsilon_s\right)=0, s \neq t \\ E\left(X_s \varepsilon_t\right)=0, \forall s<t\end{array}\right. \tag{2.1}$$

$\nabla^d = (1-B)^d; \Phi(B) = 1 - \emptyset_1 B - \cdots - \emptyset_p B^p$, is the autoregressive coefficient polynomial of the stationary reversible ARMA (p,q) model;Θ(B) $= 1 - \theta_1$ B $- \cdots - \theta_p$ B^q, is the moving average coefficient polynomial of the stationary reversible ARMA(p,q) model. (p,d,q) denote the autoregressive order, the difference order and the moving average order respectively(Elsaraiti,M,2021). The sequence after differencing of order d can be expressed as:

$$\nabla^d X_t = \sum_{i=0}^{d} (-1)^i C_d^i x_{t-i} \tag{2.2}$$

$C_d^i$is the weighted sum of a number of sequence values for which the differenced sequence is equal to the original sequence. Thus, (2.1) can be simplified as:

$$\nabla^d X_t = \frac{\Theta(B))}{\Phi(B)} \varepsilon_t \tag{2.3}$$

where$\{\varepsilon_t\}$is a zero-mean white noise sequence. In the pre-processing of the data, it was found that the time series contained very little seasonal influence and therefore could be predicted using the ARIMA model(Zhang,2021).

2.2.2 Vector Error Correction(VECM)Model

For a VAR model, if there are r cointegration relations for the n-dimensional vector y_{nt},there must be its corresponding VECM model form. For the higher order autoregressive case, the VECM model takes the form of:

$$\Delta Y_t = \pi Y_{t-1} + \sum_{i=1}^{p-1} \pi_i \Delta Y_{t-1} + e_t \tag{2.4}$$

$\pi Y_{t-1}$is the error correction term(Zhang,2021). For a matrix π of rank equal to r here, further define two$n \times r$matrices and that satisfy$\pi = \alpha\beta'$. where represents a matrix consisting of r covariates and represents a matrix consisting of speed adjustment coefficients. Hence, the VECM model can also be expressed as:

$$\Delta Y_t = \alpha\beta' Y_{t-1} + \sum_{i=1}^{p-1} \pi_i \Delta Y_{t-1} + e_t \tag{2.5}$$

$\beta' Y_{t-1}$denotes the r cointegrating relationships between sequences of n-dimensional vectorsy_{nt}(Zhang&Hu,2010).

The parameter vectors in the VECM model reflect the rate of adjustment to bring the equilibrium relationship between the variables back to equilibrium when it deviates from the long-run equilibrium, hence the name adjustment parameter array or correction parameter array. The vector of coefficients on all the difference terms used as explanatory variables responds to the effect of short-run fluctuations in each variable on the short-run changes in the variables used as explanatory variables.

The cointegration test indicates the existence of a long-run equilibrium relationship between the variables, however equilibrium is non-constant in real economic data. Therefore, how to repair short-run deviations from equilibrium to equilibrium is the question that needs to be investigated in the VECM model(Davidson&MacKinnon,1993).

This chapter plans to use the ARIMA model to forecast net exports for the first half of 2020, which is a preliminary look at imports and exports, and from there discuss the impact of the epidemic on imports and exports. For ease of operation in R, we have set January 2010 as the first month and so on up to December 2019 as the 120st month.

Chapter 3

Empirical analysis

3.1 Forecasting China's net exports based on ARIMA model

3.1.1 Stationarity and autocorrelation tests

According to the principles of time series modelling, the first step is to analyse the stationarity of the data above. If the sample time series is stationary, then the fitted curve of the sample can continue in its current form ”inertia” for some time to come. Determining the stationarity of the sample series is therefore a primary requirement for modelling(Zhuravka&Filatova,2020). Stationarity can be initially determined by plotting time series, autocorrelation plots, etc. If the series is shown to be stable, then the ARMA model can be fitted directly; if the series shows non- stationary characteristics, then the ARIMA model is considered for fitting(Tyagi&Shah,2021).

For ease of operation in R, we have set January 2010 as the first month and so on up to December 2019 as the 120st month. First make a time series plot of the data:

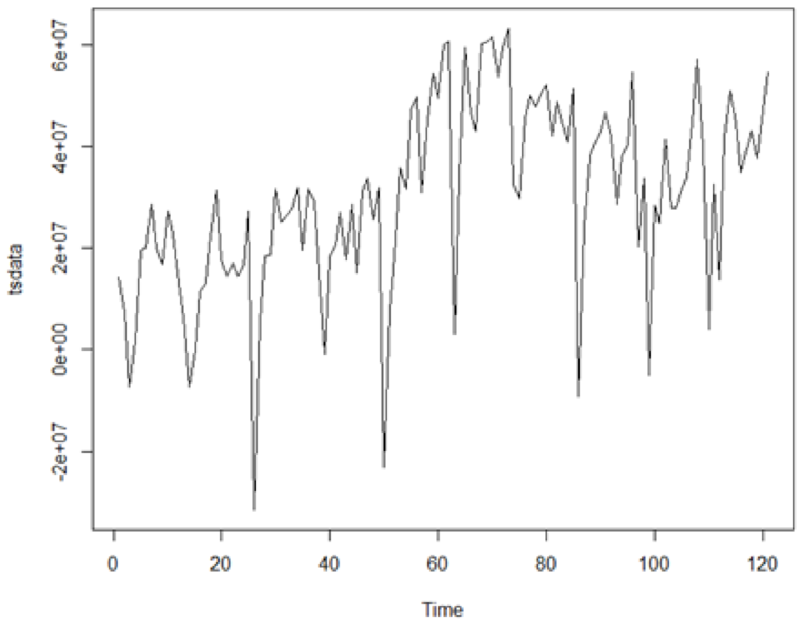


Figure 3.1: Plot of net exports January 2010-December 2019

From the time series plot, it can be evidenced that there is a slow growing long-term trend in the series, which is initially judged to be an unstable series requiring a score checking operation. As the ARIMA model contains an autoregressive (AR) model, which is a prediction based on data that is already available, it is required that the data must be autocorrelated. The autocorrelation of the series is next determined by the autocorrelation (ACF) test.

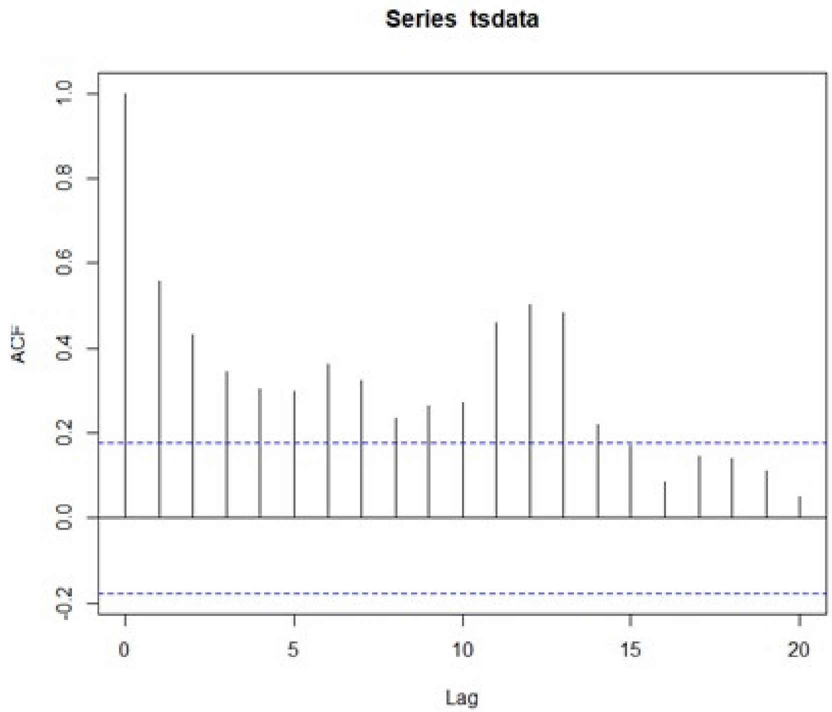


Figure 3.2: Autocorrelogram of net exports

Figure 3.2 indicates that the autocorrelation coefficients of the series are all located on the side of the zero axis, and are basically well above the 2 times standard deviation range, so it can be judged that the series is a non-stationary series with a certain monotonic trend. It can be judged that the ARMA model cannot be implemented directly and a difference operation is required for the series.

3.1.2 Data processing

Perform first-order difference operation on the sequence:

$$\nabla x_t = x_t - x_{t-1} \tag{3.1}$$

Then draw the sequence diagram:

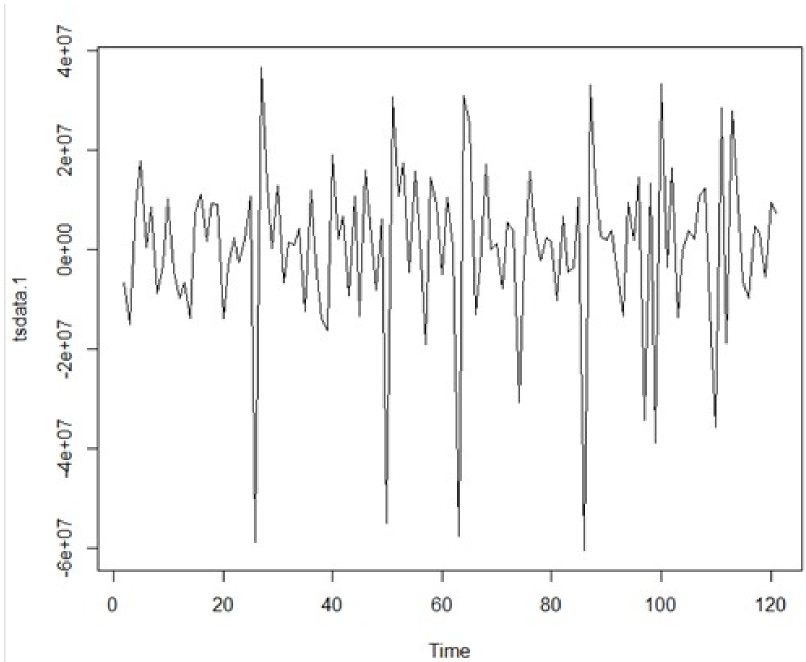


Figure 3.3: Plot of net exports after 1st order differencing

It can be observed that the series is basically stable and fluctuates around the zero axis, and is initially judged to have been transformed into a a stationary series(Siami-Namini&Tavakoli,2018). The following autocorrelation (ACF) test and partial autocorrelation (PACF) test were used again to determine the stationarity of the series.

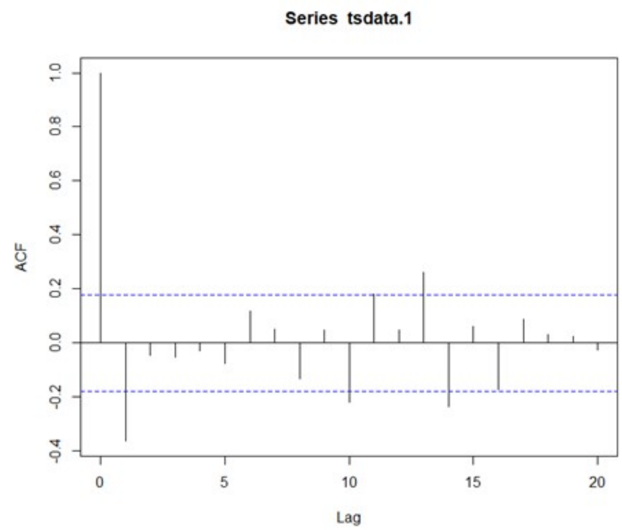


Figure 3.4: Autocorrelogram of net exports after 1st order differencing

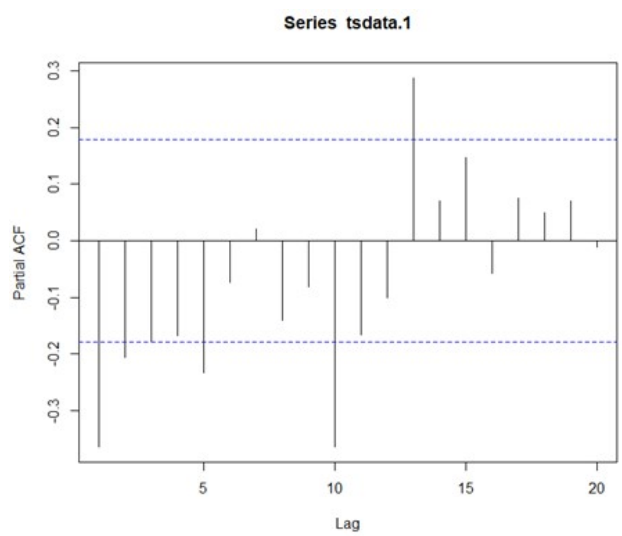


Figure 3.5: Partial autocorrelation diagram of net exports after 1st order differencing

Figures 3.4 and 3.5 indicate that the autocorrelation values and partial autocorrelation values after 1 order of lag are largely within the 2 times standard deviation boundary. Although there are outliers at orders 10-15, the singular values that are isolated and do not significantly exceed the boundary values do not affect the stability determination. In summary, it can be considered that the series tends to be stationary after the 1st order difference. Finally, a unit root (ADF) test is performed on the series to verify the final stationarity. The original hypothesis is that the series has a unit root, i.e. the series is non-stationary. The results of the unit root (ADF) test are as follows:

```
> ADF

        Augmented Dickey-Fuller Test

data:  tsdata.1
Dickey-Fuller = -8.0825, Lag order = 4, p-value = 0.01
alternative hypothesis: stationary
```

Figure 3.6: ADF test for net exports after 1st order differencing

The original hypothesis is rejected where the p-value = 0.01<0.05 (95% level of significance), i.e. the series transforms into a stationary series after 1st order differencing. At this point, all stationarity tests have been completed and the series transforms into a stationary series after 1st order differencing. With this, the autoregressive order p is determined to be 1.

3.1.3 Ordering and fitting of ARIMA model

Order the time series using R:

```
> fit
Series: tsdata
ARIMA(1,1,1)

Coefficients:
         ar1      ma1
      0.2687  -0.8732
s.e.  0.1069   0.0514

sigma^2 estimated as 2.178e+14:  log likelihood=-2132.69
AIC=4271.38   AICc=4271.59   BIC=4279.72
```

Figure 3.7: ARIMA model fixed order results

It can be established that an ARIMA (1, 1, 1) model with an autoregressive order p of 1, a difference order d of 1 and a moving average order q of 1 can be built through the series. The accuracy of the ARIMA (1, 1, 1) model fit was tested using the accuracy function and the results were as follows

Table 3.1: Accuracy function fit results

result	ME	RMSE	MAE	MPE
Training set	1316748	14570953	10121432	-8.035198
result	MAPE	MASE	ACF1	NA
Training set	120.1774	0.830474	-0.01585518	NA

The MASE from the outcome of the accuracy function is taken as the main reference indicator. When the mean absolute error (MAE) is used as an indicator of the accuracy of the model prediction, when MASE>1, the prediction for out-of-sample is much worse than the plain prediction for the sample itself, i.e. the prediction value for out-of-sample is undesirable. For the test results of this model, MASE=0.83<1, which shows that the accuracy of the model prediction is within the acceptable range.

3.1.4 Model testing

The validity of the fitted model is also tested as necessary before the model is formally utilised for prediction. In this section the normality of the model is examined by plotting a quantile-quantile plot and the white noise of the residual series is examined using the Ljung-Box function(Farooqi,2014). The normality test was first performed and the results are shown below.

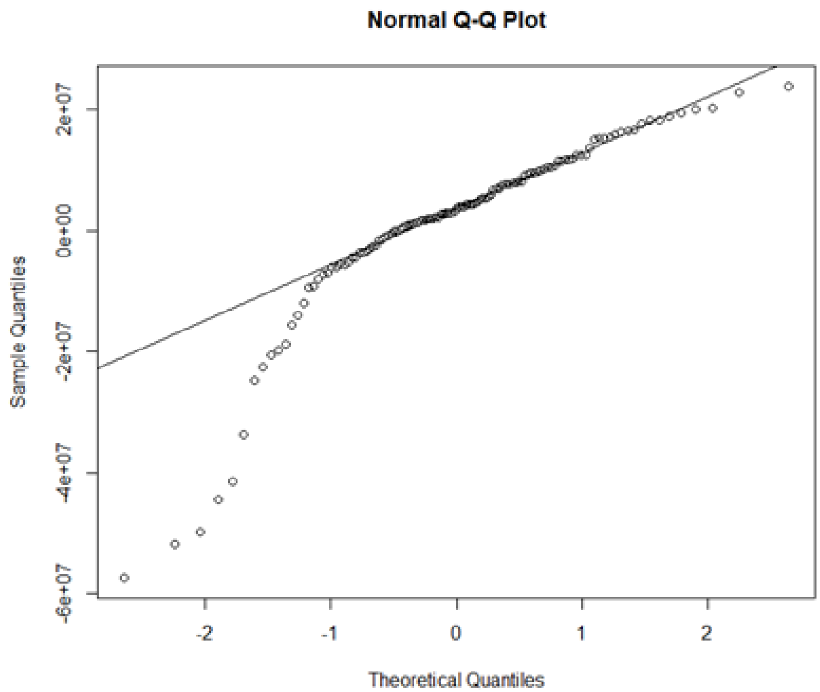


Figure 3.8: Q-Qplot

As can be noted from Figure 3.8, despite some deviations in the earlier period, the results are largely distributed on the 45° quantile and essentially conform to a normal distribution. The model was then tested using the tsidiag function and the results were as follows.

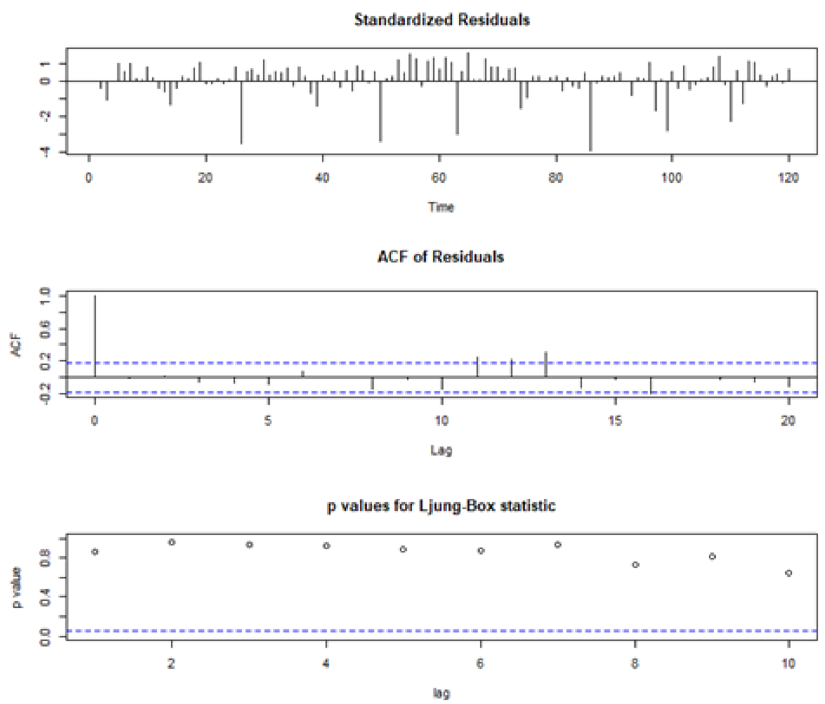


Figure 3.9: Result of tsidiag() function

As can be noticed from the figure, despite the presence of individual singular values, the standard deviation of the residuals largely remained within the range of [-1,1], the autoregressive values of the residuals were all close to 0, and the p-values of the Ljung-Box test were all well above 0.05. Therefore, the model was judged to be a high level of fit. At this stage, all tests of the ARIMA model are completed and the model is considered to be a satisfactory fit for forecasting.

3.1.5 Prediction with ARIMA model

With the construction and testing of the model completed, the model was next used to make forecasts. For ease of representation, in the modelling process we have represented the months January 2010 - December 2019 in the form of the 1st, 2nd, ... and 120th months. In the ARIMA model we therefore forecast the values for the next six periods, i.e. months 121 to 126, which represent the values of net exports from January 2020 to June 2020. The forecasts are as shown below.

```
> forecast(fit, 6)
    Point Forecast    Lo 80    Hi 80    Lo 95    Hi 95
121       40988735 22077420 59900050 12066375 69911095
122       39317100 18980147 59654053  8214415 70419786
123       38867937 18058599 59677275  7042800 70693074
124       38747248 17631626 59862871  6453690 71040807
125       38714820 17333277 60096362  6014572 71415067
126       38706106 17071085 60341128  5618196 71794016
```

Figure 3.10: Net export forecast for the first half of 2020(1)

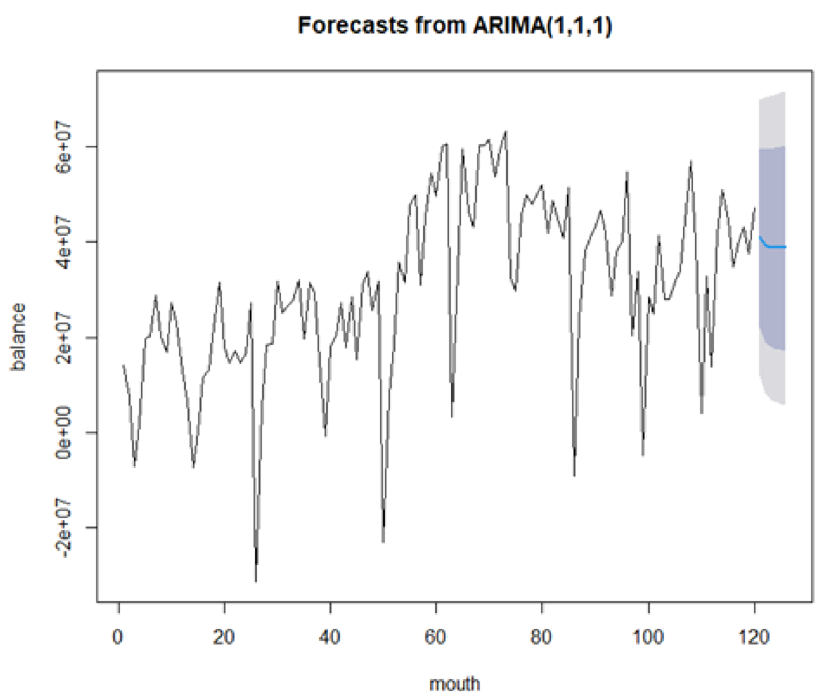


Figure 3.11: Net export forecast for the first half of 2020(2)

3.1.6 Analysis of predicted results

A comparison of the predicted results with the actual data produces the following figures:

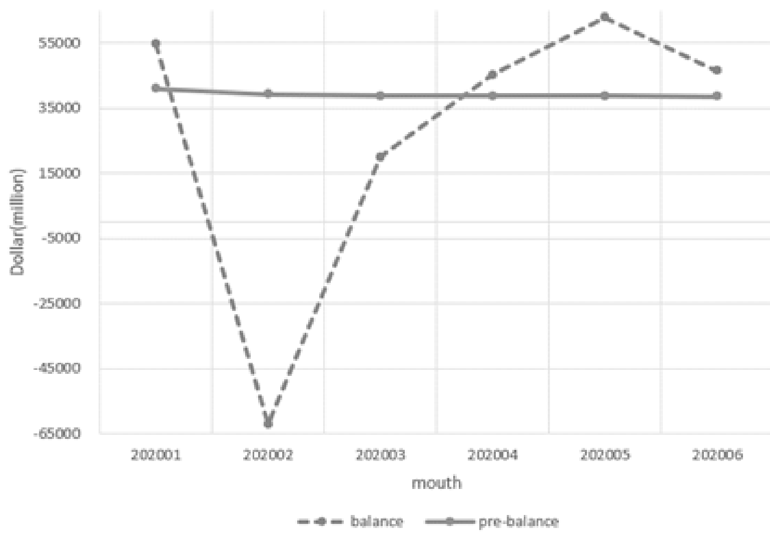


Figure 3.12: Results of comparison of predicted and actual values (balance represents actual values, pre-balance represents predicted values)

As can be appreciated from the figure, the ARIMA model predicts that the value of net exports in the first half of 2020 remains at a relatively large scale of over US$35,000 million and shows a very flat downward trend. This indicates that China's import and export trade remains as active as in previous years and continues its export-oriented economic policy. In contrast, the value of real net exports has shown great volatility. In particular, it fell to a low of -62,119 million USD in February 2020. This is a very rare situation in China's long-term export and import trade. This phenomenon is linked tightly to the covid-19 outbreak that exploded in the first half of the year. In December 2019, multiple cases of viral pneumonia began to emerge in Wuhan, Hubei Province, China. The outbreak has since begun to spread at an alarming rate, with 40,235 cases confirmed and 909 deaths in China as of 10 February (National Health Commission of the PRC,2021). In order to stop the further spread of the epidemic, the government took swift and vigorous measures, including locking down cities, halting work and production, and imposing strict traffic controls. As a result the actual net exports in February were the month that differed most from forecasts, with export trade almost suspended and instead large quantities of medical supplies were imported to ease the pressure of the epidemic, resulting in a negative net export value. The epidemic has since been reversed, and after April the nationwide closure was lifted and production began to resume. By this time, however, COVID-19 had begun to spread globally and China's foreign trade shifted from importing to exporting supplies, so that the net export value in April and May even exceeded the forecast(Tyagi&Shah,2021). As of June 2021, the epidemic has still not been eliminated globally, and it is clear that the global economy will still have to live with COVID-19 for a considerable period of time. As a result, China's foreign trade has to think about the future direction of its transformation after this crushing blow.

3.2 A further examination based on the VECM model

On the basis of the results of the ARIMA model, we can clearly perceive the fierce impact of the epidemic on foreign trade. Despite the pessimism of economic globalisation, it is undeniable that globalisation is still an inexorable trend and that it is almost impossible for countries to return to a self-production and self-selling model(McKibbin&Fernando,2020). It is therefore a matter for all countries to consider how to adjust their foreign trade strategies in the face of a future that is likely to coexist with the COVID-19 virus in the long term. This chapter selects several factors that are closely related to import and export trade, explores the strength of their impact on China's imports and exports, and then discusses what strategies China should adopt to participate in economic globalisation in the future.

3.2.1 Variable selection and data sources

This study uses monthly time series data for the econometric analysis. To avoid the effects of pseudo-regressions caused by heteroskedasticity, the data for selected indicators are logarithmically treated.

1.Predicted variable The sample was selected from the current values of total imports and exports (US$ million) from January 2019 to June 2021 published by the Ministry of Commerce of China(2021), and is denoted by Y in subsequent citations.

2.Explanatory variable Since the Chinese government quickly adopted a robust epidemic prevention policy the outbreak was brief in scale within China, until April 2020 there was less than 40 new confirmed cases per day in China (National Health Commission of the PRC,2021). However, the pandemic situation varies widely across the country, with small outbreaks still occurring in individual provinces. At the moment, the COVID-19 is intensifying globally and the epidemic situation varies from country to country. Therefore, a direct analysis of China's import and export situation using data related to the epidemic is difficult to reflect the true situation. This study considers the impact of the epidemic on China's imports and exports by examining the indirect impact of the epidemic. The impact of the epidemic on the economy is multifaceted, and combining the factors that have a greater impact on net exports, this paper focuses on three explanatory variables, including logistics, investment and exchange rate.

(1)Selection of logistics indicators. The impact of an epidemic on logistics is most obvious. In order to prevent the spread of epidemics across borders, countries have imposed certain restrictions on cross-border logistics, such as airline bans, restrictions on the variety of goods and severe sterilisation restrictions. At the same time, cross-border logistics is an integral part of foreign trade. For the sake of ease of access to indicator data, the current value of foreign trade cargo throughput (million tonnes) (National Bureau of Statistics,2021), denoted by X1, has been chosen as a measure of international logistics.

(2)Selection of investment indicators. The epidemic has restricted the movement of people and goods between countries and, more seriously, the disruption of cross-border logistics caused by the epidemic has led to a dismal assessment of overseas investment in some countries. As the epidemic spread, nationalism began to show a resurgence(Albertoni&Wise,2021), with many countries planning to relocate production lines of important industries back home. In summary, the strength of an economy's outward investment can visually reflect its assessment of and attitude towards the future of economic globalization. Therefore, regarding the measure of investment, this paper first selects the amount of China's outward all-industry investment (Ministry of Commerce of China,2021), denoted by X2. Compared to the financial sector, the non-financial sector has been hit harder by geographical constraints due to the epidemic. Therefore, manufacturing-related indicators are also able to capture the impact of China's imports and exports. The Purchasing Managers' Index (PMI), as an important macroeconomic indicator, is a more comprehensive response to economic conditions and also has a strong forward-looking effect on exports. In this paper, the Purchasing Managers' Index (PMI) is chosen as the second indicator in terms of investment (National Bureau of Statistics,2021), denoted by X3.

(3)Selection of exchange rate indicators. In the survey conducted by the United Nations Conference on Trade and Development (UNCTAD)(2021), the four economies with which China's foreign trade is most closely linked and their shares are as follows:

Table 3.2: The four economies most affected by China's slowdown through global value chains

Country	Proportion
European Union	15.597
United States	5.779
Japan	5.187
Korea,Republic of	3.816

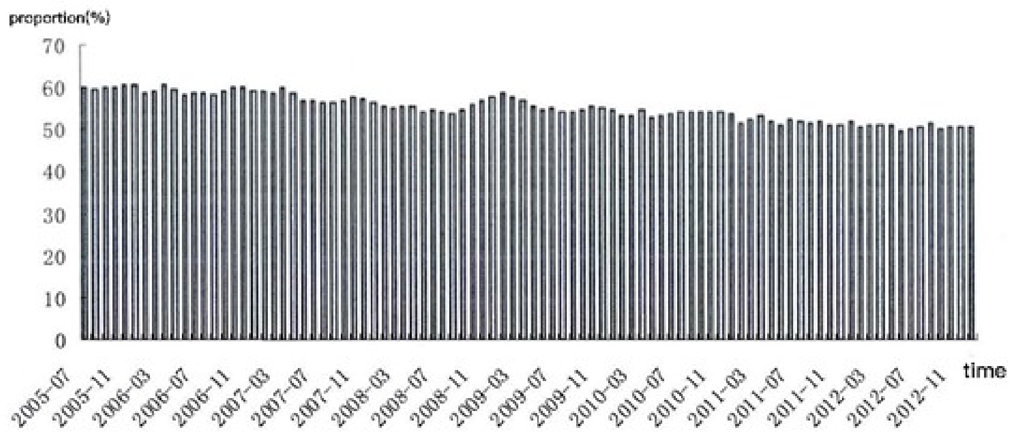


Figure 3.13: Proportion of EU, US, Japan and Korea in China's total imports and exports(National Bureau of Statistics,2021)

As seen from the above two figures, these four economies are inextricably linked to the degree of China's foreign trade prosperity. firstly, the monthly average of the daily median exchange rates released by the Chinese Foreign Exchange Bureau (2021) was selected. And then the magnitude of the impact in Figure 3.15 was used as the weight, and the weighted average of the exchange rates of the Euro, US Dollar, Japanese Yen and Korean Won against the RMB was used, with the final weighted exchange rate obtained as the sample series The exchange rate data used (using the direct mark-up method), is denoted by X4.

Table 3.3: Variable description table

Variable	Economic meaning
Y	total imports and exports
X1	foreign trade cargo throughput
X2	foreign industry-wide investment
X3	PMI index
X3	weighted exchange rate

3.2.2 Descriptive statistics and correlation analysis

Table 3.4: Descriptive statistics

Variable	LNX1	LNX2	LNX3	LNX4	LNY
Mean	10.52279	4.645674	3.961169	6.466402	8.280574
Median	10.51843	4.598145	3.977811	6.467242	8.284504
Maximum	10.617	5.390897	4.01998	6.484553	8.539542
Minimum	10.32299	4.252772	3.363842	6.440632	7.709308
Std.Dev.	0.072287	0.232458	0.114295	0.012509	0.170293
Observations	30	30	30	30	30

Table 3.5: Correlation analysis

Variable	LNX1	LNX2	LNX3	LNX4	LNY
LNX1	1	NA	NA	NA	NA
LNX2	0.549331	1	NA	NA	NA
LNX3	0.563789	0.329473	1	NA	NA
LNX4	0.413361	0.429316	0.029002	1	NA
LNY	0.823206	0.615585	0.685732	0.206609	1

Through analysis of covariance, the correlation coefficients of LnY with LnX1, LnX2, LnX3 and LnX4 were obtained as 0.8232, 0.6156, 0.6857 and 0.2066 respectively, among which the correlation coefficients with LnX1, LnX2 and LnX3 were relatively large, and the preliminary judgment was that the correlation between Y and X1, X2 and X3 was more significant.

3.2.3 Stability test

The Augmented Dickey-Fuller (ADF) Test was applied to the above variables in three test forms to test for stationarity, if the p-value was 5% then the series was stationary, otherwise it was not. The results of the tests are as follows:

Table 3.6: ADF test result

Variable	Test forms	ADF statistic	5% significant	p-value	Conclusion
LnY	(C,T,0)	-4.170069	-3.574244	0.013800	stationarity
LnX1	(C,0,1)	-2.095339	-2.971853	0.247800	unstationarity
LnX2	(C,T,1)	-4.708061	-3.580623	0.004100	stationarity
LnX3	(C,0,0)	-5.129871	-2.967767	0.000300	stationarity
LnX4	(C,0,0)	-2.498396	-2.967767	0.126200	unstationarity
D(LnY)	(0,0,0)	-8.299949	-1.953381	0.000000	stationarity
D(LnX1)	(0,0,0)	-12.306460	-1.953381	0.000000	stationarity
D(LnX2)	(0,0,1)	-6.901908	-1.953858	0.000000	stationarity
D(LnX3)	(0,0,0)	-8.826863	-1.953381	0.000000	stationarity
D(LnX4)	(0,0,0)	-5.025924	-1.953381	0.000000	stationarity

D indicates difference; ADF test form (C, T, L) indicates (intercept, time trend, lag order); lags are selected based on the principle of minimum AIC and SC; results are tested at the 5 % significance level. It can be found that the original series LnX1,Lnx4 are non-stationary, but after the first-order difference treatment, they all become stationary at the 5% level of significance, so the above five variables are all single integers of the first order.

3.2.4 Determining optimal lag order

The results of the unit root test show that all five variables obey the I(1) process after taking logarithms as described above. The analysis of the lag order is as follows:

Lag	LogL	LR	FPE	AIC	SC	HQ
1	213.4518	NA	6.09e-13*	-13.95939*	-12.75955*	-13.60262*
2	232.7285	24.27427	1.10e-12	-13.53544	-11.13574	-12.82188
3	254.4537	19.31131	2.36e-12	-13.29286	-9.693318	-12.22253

Figure 3.14: Optimal lag order of the VAR model (* indicates that it was chosen by this judgment criterion)

The optimal lag order is 1 for accordance with the 5 detection criteria of LR, FPE, AIC, SC and HQ.

3.2.5 Johansen test

To determine whether there is a long-run equilibrium relationship between the variables, this paper uses the Johansen cointegration test for each set of data to see the number of cointegrating equations that may be available:

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.772154	89.73594	69.81889	0.0006
At most 1 *	0.583454	48.32157	47.85613	0.0452
At most 2	0.382123	23.80032	29.79707	0.2090
At most 3	0.218038	10.31927	15.49471	0.2570
At most 4	0.115379	3.432680	3.841466	0.0639

Figure 3.15: Trace test result(* denotes rejection of the hypothesis at the 0.05 level)

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

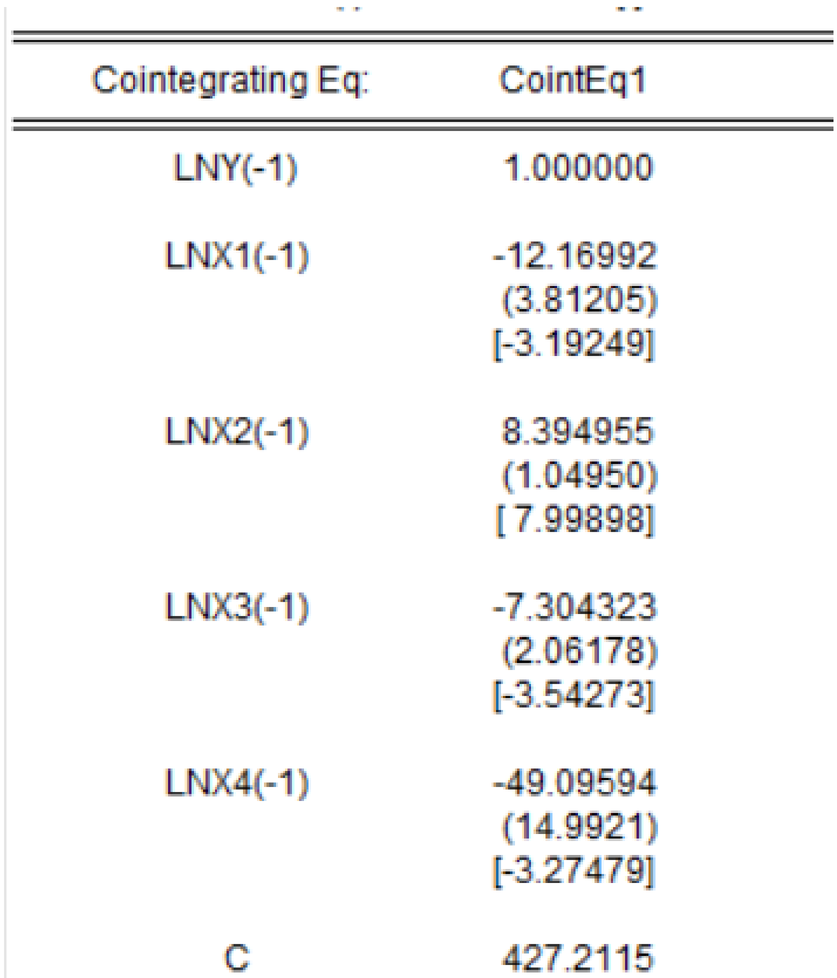
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.772154	41.41437	33.87687	0.0052
At most 1	0.583454	24.52126	27.58434	0.1176
At most 2	0.382123	13.48105	21.13162	0.4090
At most 3	0.218038	6.886590	14.26460	0.5026
At most 4	0.115379	3.432680	3.841466	0.0639

Figure 3.16: Maximum characteristic root test results(* denotes rejection of the hypothesis at the 0.05 level)

In accordance with the choice of test accuracy, at least one co-integration equation exists at the 5% critical value level based on the results of the trace test. Therefore, there is a co-integration relationship between Y, X1, X2,X3 and X4, and each variable has a long-run equilibrium relationship.

3.2.6 Vector Error Correction Model(VECM)

A co-integration relationship is obtained between the variables so that the VECM model is constructed:



Cointegrating Eq:	CointEq1
LNY(-1)	1.000000
LNX1(-1)	-12.16992 (3.81205) [-3.19249]
LNX2(-1)	8.394955 (1.04950) [7.99898]
LNX3(-1)	-7.304323 (2.06178) [-3.54273]
LNX4(-1)	-49.09594 (14.9921) [-3.27479]
C	427.2115

Figure 3.17: VAR model coefficients

Error Correction:	D(LNY)	D(LNX1)	D(LNX2)	D(LNX3)	D(LNX4)
CointEq1	-0.049927	-0.008960	-0.196556	-0.016004	0.001140
	(0.02243)	(0.00953)	(0.03855)	(0.02407)	(0.00179)
	[-2.22576]	[-0.94053]	[-5.09860]	[-0.66496]	[0.63594]
D(LNY(-1))	0.592433	0.267764	0.914133	0.951740	-0.028642
	(0.31236)	(0.13266)	(0.53682)	(0.33513)	(0.02497)
	[1.89666]	[2.01848]	[1.70286]	[2.83989]	[-1.14723]
D(LNX1(-1))	-2.245602	-1.102437	-3.035605	-1.867013	0.024947
	(0.48197)	(0.20469)	(0.82833)	(0.51712)	(0.03852)
	[-4.65918]	[-5.38582]	[-3.66471]	[-3.61041]	[0.64757]
D(LNX2(-1))	0.180283	0.085823	0.416951	0.012430	0.003434
	(0.13401)	(0.05691)	(0.23031)	(0.14378)	(0.01071)
	[1.34532]	[1.50798]	[1.81039]	[0.08645]	[0.32064]
D(LNX3(-1))	-0.380752	-0.063202	-0.845864	-0.755116	-0.001267
	(0.22755)	(0.09664)	(0.39107)	(0.24414)	(0.01819)
	[-1.67329]	[-0.65401]	[-2.16296]	[-3.09297]	[-0.06966]
D(LNX4(-1))	5.723379	1.983162	6.845827	6.701121	-0.082194
	(2.64206)	(1.12207)	(4.54071)	(2.83471)	(0.21118)
	[2.16626]	[1.76741]	[1.50765]	[2.36395]	[-0.38922]
C	0.012879	0.006413	0.007108	-0.012350	0.001560
	(0.02220)	(0.00943)	(0.03816)	(0.02382)	(0.00177)
	[0.58004]	[0.68011]	[0.18627]	[-0.51842]	[0.87924]

Figure 3.18: VECM parameter estimates (values in parentheses are t-statistics)

From Figure 3.17-Figure 3.18, the VECM model takes the form of

$$LNY = -12.16\,\mathrm{Ln}\,X1 + 8.39\,\mathrm{Ln}\,X2 - 7.30\,\mathrm{Ln}\,X3 - 49.09\,\mathrm{LnX}\,4 + 427.21 \quad (3.2)$$

As seen in Figures3.18, the adjusted coefficient for total exports and imports (-0.0499) is negative, so it is not statistically significant and does not have much impact on repairing the equilibrium. The coefficients of foreign trade goods throughput, foreign investment and PMI index are -0.0089, -0.1965 and -0.016 respectively, all negative, indicating a drift towards disequilibrium(Zhang&Hu,2010). The coefficient of 0.0011 for weighted foreign exchange provides the strength of the impact of the shift towards equilibrium.

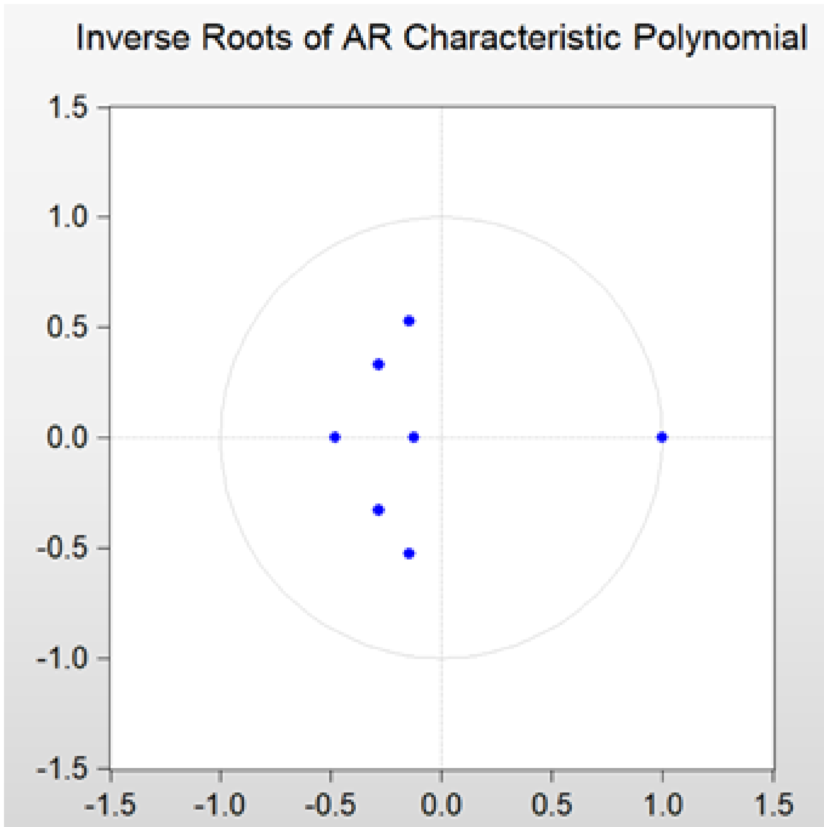


Figure 3.19: Discriminating the stability of the VECM model(1)

Root	Modulus
1.000000	1.000000
1.000000	1.000000
1.000000	1.000000
1.000000	1.000000
-0.144095 - 0.527166i	0.546505
-0.144095 + 0.527166i	0.546505
-0.478395	0.478395
-0.284636 - 0.331887i	0.437226
-0.284636 + 0.331887i	0.437226
-0.124550	0.124550

Figure 3.20: Discriminating the stability of the VECM model(2)(VECM specification imposes 4 unit root(s).)

As shown in Figure 3.19-Figure 3.20, all the eigenvalues of the accompanying matrix fall within the unit circle, except for the unit root assumed by the VECM model itself, so the model is stationary.

3.2.7 Dynamic impact analysis: impulse response analysis

The impulse response function can be used as a time-domain description of the system's characteristic properties, analysing the impact on the system's dynamics when the model is subjected to some kind of shock. It describes the effect that a shock to a variable has on the current and future values of the model's endogenous variables, and can also be interpreted as the effect of a standard deviation shock on the endogenous variables. The impulse response results for the variables in this paper are as follows:

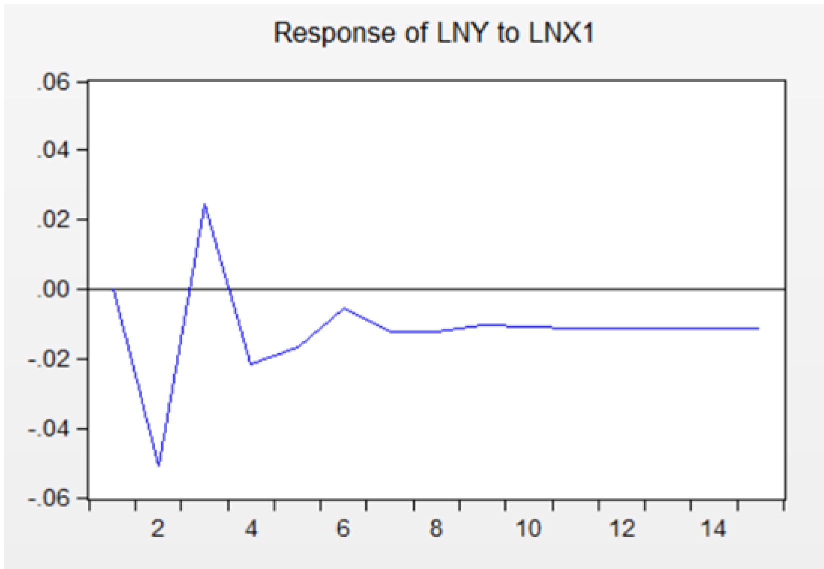


Figure 3.21: Response of total imports and exports to foreign trade cargo throughput

As can be illustrated in Figures3.21, giving a positive shock to foreign trade cargo throughput has its largest negative impact on total exports and imports in period 2, with a strong positive impact in period 3, and then remains negative and stable at around equilibrium point -1. The results indicate that there is a negative impact of foreign trade cargo throughput on total exports and imports in the short term. This result is contrary to previous economic studies, and this phenomenon needs to be considered in light of the specificity of the sample data. In previous statistics on total exports and imports, the amount of cross-border transactions accounted for a significant proportion of the total. However, due to the impact of the epidemic, China's domestic industry almost came to a halt and cross-border logistics were severely restricted, with cross-border goods being mainly donated medical supplies, which were not counted in the calculation of import and export amounts(Žiković& Tomas Žiković,2014). The negative impact of this anomaly gradually diminished as the epidemic recovered and normal trade goods regained a larger proportion.

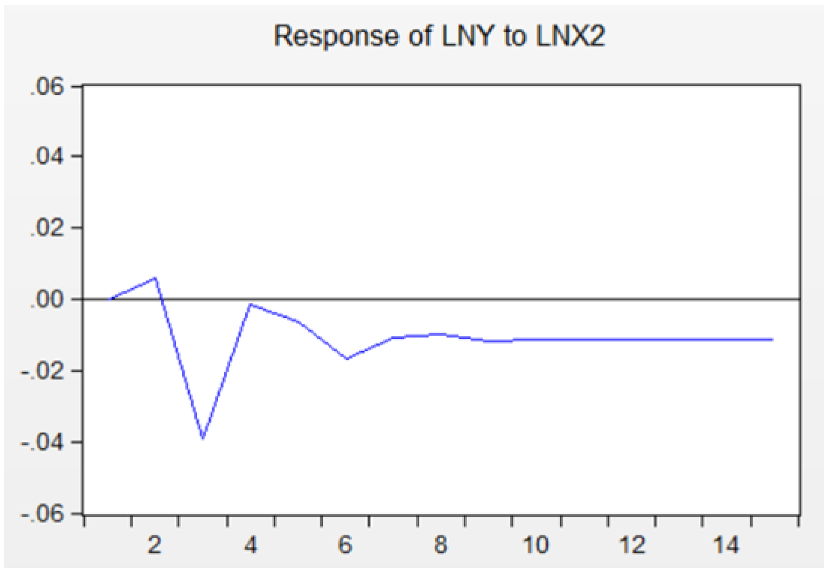


Figure 3.22: Response of total imports and exports to foreign industry-wide investment

Giving a positive shock to the amount of outward sector-wide investment, its impact on total exports and imports is slightly positive in period 2 and then stays negative. Of these, the largest negative impact exists in period 3 and then gradually plateaus and stabilises at the equilibrium point of -1. This phenomenon, which is contrary to previous economic patterns, still stems from the impact of the epidemic. According to statistics released by China's Ministry of Commerce, outward non-financial investment accounted for 93.6% in 2019 and has previously remained at a similar level. outward non-financial investment fell to 86.3% in 2020 and continued to fall to 75.86% in the first half of 2021 (Ministry of Commerce of China,2021). The epidemic has led to significant restrictions on both the exchange of goods and people across borders(Anh&Song,2021). In addition, the gradual inward relocation of industrial chains by countries to mitigate the impact of the epidemic has also contributed to the decline in outward non-financial investments. Compared to the real economy, financial investments are less affected by geographical factors and spatial constraints. Therefore, despite the rise in outward sector-wide investment, the contribution of the real economy transactions contained therein to total exports and imports is diminishing, ultimately showing a negative impact.

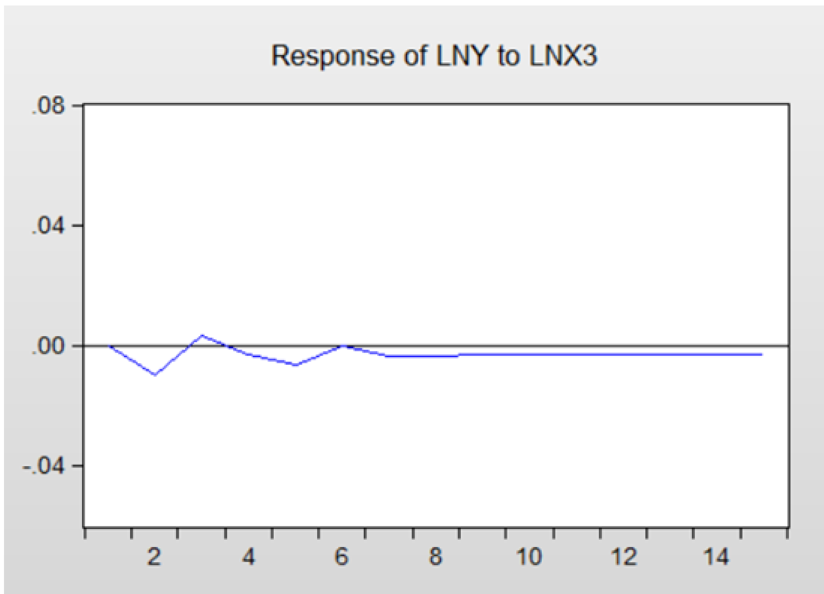


Figure 3.23: Response of total imports and exports to PMI index

When the PMI is subject to a positive shock, it has a slight negative impact on total exports and imports, with only a weak positive impact in period 3. The PMI is calculated by weighting five diffusion indices, namely the new orders index, the production index, the employment index, the supplier delivery time index and the raw material inventory index. The weighting of each index is determined by its degree of prior influence on the economy and is 30%, 25%, 20%, 15% and 10% respectively. In previous economics studies, the PMI index is an important economic predictor. When the PMI index is greater than 50, the manufacturing sector can be considered to be in a period of expansion. At the same time, the PMI index is also an important indicator for assessing the level of exports and imports, and when the PMI index is greater than 50, foreign trade and economic exchanges are also in a boom phase. The reasons why the forecast results differ from previous economic patterns, as in Figure 3.23, mainly consider the impact of the epidemic. Restrictions on cross-border logistics and moves by various domestic relocation chains have reduced overseas orders. Concerned by these phenomena, the number of domestic manufacturing firms choosing to trade across borders has decreased. At the same time, the rapid improvement of the epidemic in China has brought domestic trading back to active levels. As a result, although the PMI indicates a buoyant manufacturing sector, the switch in domestic and international trading partners has led to a decline in total exports and imports(Curran&Jamrisko,2021). In addition, although having the entire production chain in the same country can counter the impact of the epidemic, the globalisation of the economy is still an inexorable trend. Cross-border production chains are effective in reducing costs and reducing the risk of a single partner and therefore the negative impact of the PMI on total exports and imports is relatively weak.

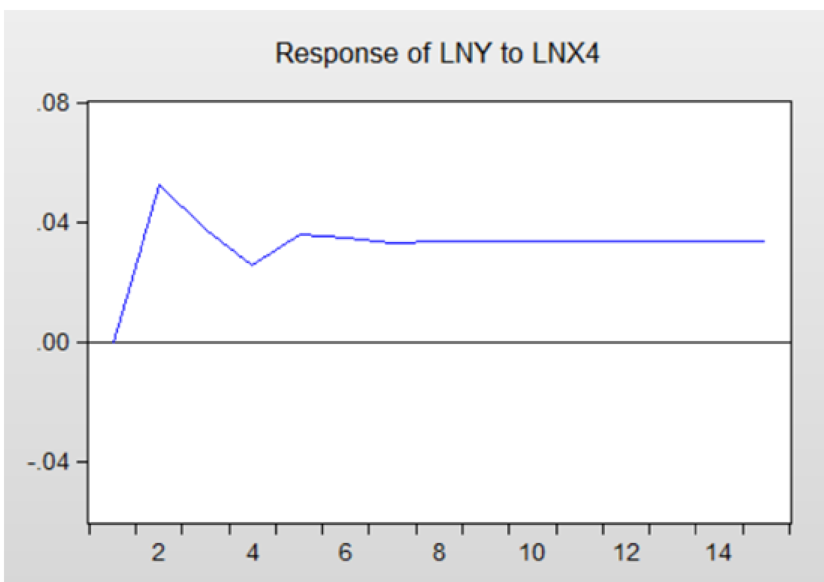


Figure 3.24: Response of total imports and exports to weighted exchange rate

Over the period 0-15, the weighted exchange rate continued to have a positive impact on the growth of total exports and imports. And compared to the other three variables, the weighted exchange rate has a stronger impact on total exports and imports. In this paper, the exchange rate is expressed using the direct markup method, which uses the amount of RMB that can be purchased with 100 units of foreign currency as the exchange rate value. Thus when the exchange rate increases, the RMB actually depreciates, at which point the amount of exports increases and the amount of imports decreases. The results in the graph are therefore generally consistent with the relationship between exchange rates and changes in the value of imports and exports.

3.2.8 Dynamic impact analysis: variance decomposition

To improve the analysis of the importance and contribution of each shock to the endogenous variables, a further variance decomposition is required. The main idea behind variance decomposition is to break down the fluctuations in each endogenous variable in the sample series into the components associated with each explanatory variable in the equation according to their causes. This gives an idea of the relative importance of each variable to the endogenous variables(Zhang&Hu,2010). The variance decomposition results represent the degree of contribution made by the decomposition of the predicted mean squared error of the endogenous variables into the random shocks to each variable in the model. Where the horizontal axis represents the number of lags of the effect of the shock (in months) and the vertical axis represents the contribution (%). The results of the variance decomposition are shown below:

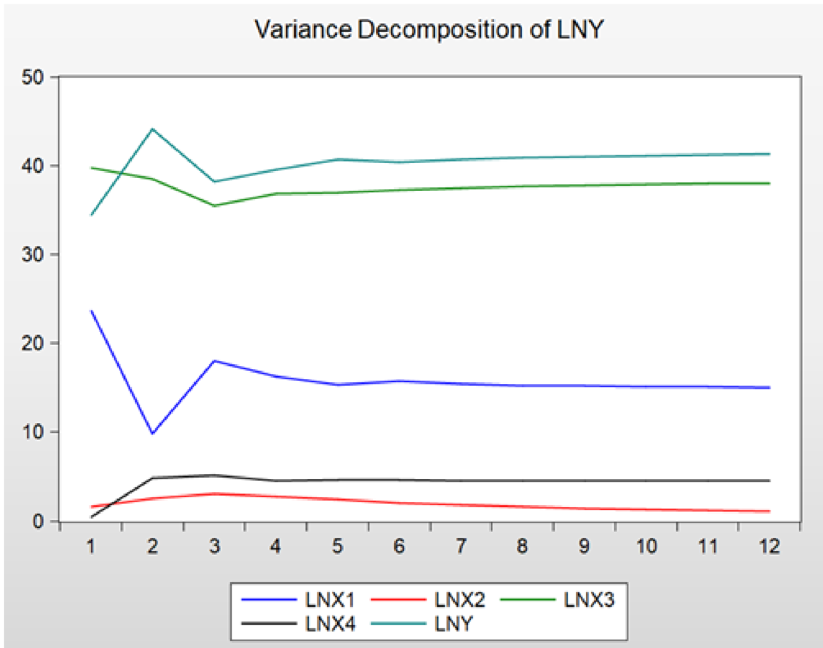


Figure 3.25: Variance decomposition results(1)

Period	S.E.	LNX1	LNX2	LNX3	LNX4	LNY
1	0.048797	23.66342	1.654064	39.76486	0.458062	34.45959
2	0.060980	9.845831	2.574182	38.56453	4.858007	44.15746
3	0.078319	18.05948	3.109871	35.50827	5.126389	38.19598
4	0.085539	16.23520	2.801300	36.89611	4.535516	39.53187
5	0.092665	15.31441	2.403722	36.93016	4.612514	40.73919
6	0.100390	15.71047	2.032524	37.25313	4.627137	40.37674
7	0.107007	15.47312	1.787272	37.46576	4.561583	40.71226
8	0.113096	15.27772	1.606575	37.63055	4.538247	40.94691
9	0.119070	15.22606	1.447567	37.75623	4.528350	41.04179
10	0.124720	15.15640	1.321701	37.86537	4.512741	41.14379
11	0.130093	15.08546	1.219593	37.95192	4.499633	41.24339
12	0.135268	15.03411	1.132484	38.02609	4.490314	41.31700

Cholesky Ordering: LNX1 LNX2 LNX3 LNX4 LNY

Figure 3.26: Variance decomposition results(2)

As can be gleaned from Figures 3.25-3.26, the short term imposes positive shocks on foreign trade goods throughput, foreign industry-wide investment, PMI index and weighted exchange rate, with PMI index and foreign trade goods throughput contributing the most to the change in total exports and imports. They reached 38.02% and 15.03% respectively in the 12th period. The logistics situation is a fundamental element affecting imports and exports, and the PMI index is an important indicator for judging the level of imports and exports, so their contribution is also the largest. Secondly, the contribution of exchange rate to the change of total import and export reached 4.49%. Previous economics studies have shown that exchange rates have an intuitive impact on the direction of import and export transactions. When the national currency depreciates it stimulates consumption abroad and tightens domestic consumption; an appreciation of the national currency produces the opposite result. The fact that the explanatory variable is gross exports and imports rather than net exports masks the change in the direction of export and import transactions to some extent, but since the two are not in perfect equilibrium, we can still find the effect of the exchange rate on gross exports and imports in the variance decomposition results. Finally, the contribution of foreign sector-wide investment is the smallest, at 1.13%. This is partly due to the fact that international logistics severely limits outward real economy investment.

Chapter 4

Discussion

4.1 Results analysis

In this report, the ARIMA model and the VECM model are chosen to describe the changes in China's exports and imports under the epidemic from a unidimensional and multidimensional perspective respectively. In Section 3.1, the results of the ARIMA model based on net export data up to 2020 show that in 2020 China, as an export-oriented country, continues to have large and stable exports and imports, with net exports remaining at a high level in previous years. However, the actual statistics show that in February and March, when the epidemic first broke out, China's net exports took a huge hit and turned negative, showing an import orientation, and after April, when the domestic epidemic improved, net exports returned to positive values and rebounded, exceeding the forecast by 16%. This comparison clearly demonstrates that the epidemic did have a strong impact on net exports and that the subsequent rebound was related to a change in China's external economic engagement strategy. In Section 3.2, three factors that have a significant impact on exports and imports are considered: logistics, investment and exchange rates. Four variables are selected and their magnitude of impact on export and import volumes is compared through a VECM model. The analysis reveals some interesting results that are at odds with the previous laws of economics, and these anomalous results coincide with the indirect impact of the epidemic on net exports. On the logistics side, the throughput of foreign trade goods shows a negative correlation with the value of exports and imports. This anomaly is somewhat related to the shift in the type of goods imported and exported, from predominantly economic exchange goods to predominantly anti-epidemic medical equipment. In terms of investment, foreign sector-wide investment showed a negative correlation with the volume of imports and exports. This anomaly is related to the restrictions on international logistics, and although total investment has increased, the share of financial investment has increased significantly, while investment in manufacturing, which relies on logistics, has decreased. On the other hand, the PMI is also negatively correlated with imports and exports as the share of domestic orders increases due to both logistics and the negative attitude of other countries towards cross-border transactions. In terms of exchange rates, the weighted exchange rates obtained by combining the exchange rates of the four economies with which China has the closest economic ties (EU, USA, Japan and Korea) continue to show a negative correlation with the value of imports and exports, in line with the previous pattern of economics.

4.2 Implications

The results of ranking the four variables in descending order of their impact on the value of imports and exports are: PMI (38.02%), foreign trade cargo throughput (15.03%), exchange rate (4.49%) and foreign sector-wide investment (1.13%). These data demonstrate China's strategy to cope with the epidemic shock: a shift from an external to a domestic demand-based economy; and a shift from a real to a non-real economy. In line with this shift, we can derive some strategies for coping with the epidemic:

(1) Improving income distribution and relying on the domestic economic cycle to achieve a "market-enhancing chain" strategy. In the past, China's economic globalization was export-oriented, taking advantage of the markets offered by the West. Today's international environment of counter-globalization makes it increas-

ingly difficult for China to maintain this strategy. At the same time, with the rapid improvement of the domestic epidemic, the resurgence of economic growth and the formation of a domestic mega-market, China's participation in economic globalization may need to shift towards the use of domestic demand markets as an alternative to export orientation, i.e. the future high level of China's economic opening may take the form of an economic globalization model based on domestic demand.

(2) Vaccination and other means to mitigate and control the epidemic and restore normal operations of international logistics as soon as possible. Logistics is the foundation of international trade, and the reduction in trade flows due to logistics stoppages is the main reason why imports and exports have been affected(Milea,2020).

(3) exploiting the direct impact of the exchange rate on exports and imports. Adjusting the RMB exchange rate to keep it low by adjusting foreign exchange reserves, buying and selling foreign currency (direct mark-up method), etc., thus stimulating exports.

(4) Another factor that has affected China's foreign trade is the export bans and restrictions imposed by other countries to counteract the impact of the epidemic. In response, it is important to take advantage of the "soft power" demonstrated by the rapid recovery of the domestic manufacturing sector from the epidemic, and to use the clusters of industrial chains that have been formed or will be formed in the country to attract foreign investment, which is the basis for the global high-end manufacturing chain to settle in China(Pan,2020).

Chapter 5

Conclusion

5.1 Conclusion

China joined the WTO in 2001 and in the two decades since then its position in the global economy has been on the rise. Part of this dynamic status stems from its position as an important producer and exporter of consumer goods, and part from China's role as a major supplier of intermediate goods in international production chains. According to statistics, prior to the onset of the new pneumonia crisis, China was supplying goods for almost 20% of the global intermediate goods trade, compared to just 4% in 2002(WTO,2021). A reduction in the supply of Chinese exports could therefore affect the production of any one country, depending on the extent of its dependence on Chinese exports. WTO statistics show that global trade in goods continued its weakness in the first quarter of 2020, weakening further after being affected by the COVID-19 outbreak (WTO,2021). However the weakness in global goods is only the initial manifestation of the epidemic, it is the ensuing changes in the supply and demand side of the world economy that are the challenges that China needs to seriously consider. In this paper, the ARIMA and VECM models are used to investigate the impact of the epidemic on imports and exports, comparing the magnitude of the impact of each factor on foreign trade and analysing the causes of the anomalies. In addition, a series of countermeasures are proposed based on the results of the analysis, such as shifting to a domestic demand-based economy, reducing the spread of COVID-19 and resuming international logistics as soon as possible, and showing the excellent performance of the Chinese economy in the face of the shock to attract foreign investors.

5.2 Limitations

In reaching these conclusions, we still need to acknowledge that there are some limitations to the study in this paper. This study was conducted during the course of the ongoing pandemic, and therefore some of the source data have not been fully established or statistically verified and adjusted. Due to the impact of the pandemic, many of the official data released by the government had many missing values, which prevented their combination with data from previous years to form a time series. The choice of data for the sample was also somewhat limited, and we had to discard some data that gave a more intuitive picture of the reality of the changes. The search for complete foreign data also encountered many difficulties.

5.3 Recommendations

In the following study, an attempt can be made to analyse the relationship between the direct data of the epidemic (cumulative number of confirmed cases, daily number of new confirmed cases, etc.) and imports and exports. In the data selection section of this paper, an attempt was made to analyse the relationship between epidemic data and imports and exports, however, the results were not satisfactory due to the small values. Foreign epidemic data is difficult to use due to the different statistical methods and standards between countries. A combination of epidemic data and import/export comparisons could be considered in the next study. Another noteworthy aspect is a more in-depth disaggregation of the explanatory variables. Using the PMI index as an example, the changes in the five calculated indicators are explored and then they are modelled and analysed in relation to import and export volumes. A more precise determination of the factors influencing imports and exports can be derived. The statistics demonstrate the rapid response and flexibility of the Chinese economy in response to epidemic shocks, and we suggest examining China's response to previous crises, such as the 2008 financial crisis, and comparing it with the current one to explore the strengths and weaknesses of the Chinese economic model in the face of global economic shocks.

Bibliography

Alam, T. (2019), 'Forecasting exports and imports through artificial neural network and autoregressive integrated moving average', *Decision Science Letters* **8**(3), 249–260.

Albertoni, N. & Wise, C. (2021), 'International trade norms in the age of covid-19 nationalism on the rise?', *Fudan Journal of the Humanities and Social Sciences* **14**(1), 41–66.

Curran, J. (2021), 'Asia manufacturing powers ahead, even as china pmi cools', *Bloomberg* .

Davidson, R., MacKinnon, J. G. et al. (1993), 'Estimation and inference in econometrics', *OUP Catalogue* .

Duc Anh, D., Song, Y. & Li, M. (2021), 'The relationships between foreign direct investment, state-owned investment, private investment, import, export and economic growth in vietnam', *The Singapore Economic Review* .

Elsaraiti, M., Ali, G., Musbah, H., Merabet, A. & Little, T. (2021), Time series analysis of electricity consumption forecasting using arima model, *in* '2021 IEEE Green Technologies Conference (GreenTech)', IEEE, pp. 259–262.

Farooqi, A. (2014), 'Arima model building and forecasting on imports and exports of pakistan', *Pakistan Journal of Statistics and Operation Research* pp. 157–168.

Fu, J. & McMahon, J. A. (2021), 'The global scramble for ppe amid covid-19: Lessons from the eu export restrictions and import facilitation through regulatory cooperation on ppe', *Asian J. WTO & Int'l Health L & Pol'y* **16**, 25.

Icao.int. (2021), https://www.icao.int/Pages/default.aspx. Accessed September 5, 2021.

Jain, A., Sukhdeve, T., Gadia, H., Sahu, S. P. & Verma, S. (2021), Covid19 prediction using time series analysis, *in* '2021 International Conference on Artificial Intelligence and Smart Systems (ICAIS)', IEEE, pp. 1599–1606.

McKibbin, W. & Fernando, R. (2021), 'The global macroeconomic impacts of covid-19: Seven scenarios', *Asian Economic Papers* **20**(2), 1–30.

Milea, C. (2020), 'Consequences of covid-19 on the international trade in goods and services: Forecasts, developments, restrictions', *Financial Studies* **24**(4 (90)), 29–40.

Ministry of Commerce / People's Republic of China. (2021), http://prcministryofcommerce.weebly.com/. Accessed September 5, 2021.

National Bureau of Statistics of China (2021), https://data.stats.gov.cn/easyquery.htm?cn=C01. Accessed September 5, 2021.

National Health Commission of the People's Republic of China (2021), http://www.nhc.gov.cn/xcs/xxgzbd/gzbd_index.shtml. Accessed September 5, 2021.

Pan, T. (2020), Study on the impact of new crown epidemic situation on china's foreign trade enterprises and the countermeasures, *in* '2020 International Conference on Big Data, Artificial Intelligence and Internet of Things Engineering (ICBAIE)', IEEE, pp. 388–392.

Sasa Zikovic, I. T. Z. & Grdinic, M. (2014), 'A vecm approach to detangling growth, exports, imports and fdi knot in selected cee countries', *Croatian Operational Research Review* pp. 161–175.

Siami-Namini, S., Tavakoli, N. & Namin, A. S. (2018), A comparison of arima and lstm in forecasting time series, *in* '2018 17th IEEE International Conference on Machine Learning and Applications (ICMLA)', IEEE, pp. 1394–1401.

State Administration of Foreign Exchange. (2021), https://www.safe.gov.cn/en/. Accessed September 5, 2021.

Statistics| UNCTAD. (2021), https://unctad.org/statistics. Accessed September 5, 2021.

Tyagi, A. & Shah, U. (2021), 'Modeling the direction and volume of trade flows in global crisis, covid-19', *Journal of The Institution of Engineers (India): Series B* pp. 1–7.

World Integrated Trade Solution (WITS) | Data on Export, Import, Tariff, NTM. (2021), https://wits.worldbank.org/. Accessed September 6, 2021.

World Trade Organization - Global trade. (2021), https://data.wto.org/. Accessed September 5, 2021.

Xing, Y. (2021), *DECODING CHINA'S EXPORT MIRACLE: A Global Value Chain Analysis*, World Scientific.

Zhang, J., Hu, W. & Zhang, X. (2010), The relative performance of var and vecm model, *in* '2010 3rd International Conference on Information Management, Innovation Management and Industrial Engineering', Vol. 2, IEEE, pp. 132–135.

Zhang, Q., Di, P. & Farnoosh, A. (2021), 'Study on the impacts of shanghai crude oil futures on global oil market and oil industry based on vecm and dag models', *Energy* **223**, 120050.